AUTOMATED SOLAR TRACKING SYSTEM

19EEE381 – OPEN LAB

Report

Submitted by

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Amrita School of Engineering

Department of Electrical and Electronics Engineering

Program Educational Objectives (PEOs)

PEO1: Graduate can demonstrate electrical and electronics engineering problem solving skill along with proficiency in communication and professional excellence in project management and execution.

PEO2: Graduate can be employable in engineering services including ICT enabled sectors and also motivated for entrepreneurship.

PEO3: Graduate will be competent for higher studies in world class universities and research in industrial organizations.

PEO4: Graduate will manifest social commitment, environmental awareness and moral and ethical values in professional and other discourses.

Program Specific Outcomes (PSOs)

PSO1: Build and manage electro dynamic systems using Knowledge on electrical technology and semiconductor devices for allied services.

PSO2: Use computational tools and network dynamics for design, analysis and control of power systems integrated with renewable energy and Electric Vehicle.

PSO3: Leverage digital technologies employing state-of- the art control techniques and embedded controllers for industrial applications.

BONAFIDE CERTIFICATE

This is to certify that the open lab project report entitled **Automated Solar Tracking System,** submitted by

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is in partial fulfillment of the requirements for the award of the **Degree of Bachelor of Technology** in **"Electrical and Electronics Engineering"** and is a bonafide record of the work carried out at Amrita School of Engineering, Coimbatore.

Internal Examiner

External Examiner

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I. ABSTRACT

Automated Solar Tracking System is a cutting-edge system that strives to maximize the harvesting of solar energy through the dynamic tilting of solar panels. The project addresses inefficiencies in fixed mounts of solar panels with a double-axis solar tracker mechanism. Real-time monitoring of the solar tracking system is done with the Blynk IoT platform. The system includes an ESP32 microcontroller, 4 LDR sensors, and a CJMCU-219 INA219 Power Sensor. All-day tracking of the sun's position improves the efficiency of the system by optimizing the duration of incidence of the Sun towards the solar PV panel.

The primary objective of this project is to improve the overall solar power generation efficiency. The Sun's incidence towards the solar PV panel is ensured by the two-axis driver that dynamically manifests the elevation and azimuth angles of the solar panels in concern to actual light intensity values obtained from all 4 LDR sensors. This LDR data is handled and managed by the ESP32 microcontroller. INA219 is used for power supply monitoring and immediate feedback through voltage, current, and power readings through an OLED display. Remote monitoring is made possible through Blynk, where users can monitor performance readings as well as history.

Experimental results show greater efficiency in energy production than conventional stationary solar panels. The ability of the system to keep its orientation towards the sun optimally throughout the day ensures it delivers a consistent performance. Scaling down the system for mass deployment as well as its use of high-end prediction for weather compensation are areas of ongoing research. The project proves feasibility in the usage of embedded systems and IoT technology in renewable energy optimization.

II. INTRODUCTION

Solar power is a dominant source of clean energy because it is so abundant and sustainable. Yet traditional static solar panels are inefficient because they cannot follow the moving position of the sun. To address this limitation, this project proposes an Automated Solar Tracking System that changes the position of the panel dynamically to maximize sunlight exposure.

Dual-axis solar tracker employs two servos to modify the azimuth (horizontal) and elevation (vertical) of the solar panel. The LDR sensors detect the intensity of light in various directions and give live updates to the ESP32 microcontroller. The system calculates the optimum orientation based on differences in intensities. Accurate measurement of power is provided by the INA219 sensor, and local monitoring as well as remote monitoring is performed with the OLED display and Blynk IoT platform, respectively.

The drive for this project stems from the requirement to enhance solar power efficiency and minimize the utilization of non-renewable sources of energy. By tuning the solar panel orientation, the system achieves maximum energy harvesting, hence maximizing the sustainability of solar power systems. Problem statement, methodology, results, and future potential are addressed in the subsequent sections.

III. PROBLEM STATEMENT

Fixed solar panels are inefficient since they are fixed in one place. This means that there is maximum absorption of sunlight only during the daytime. Once the sun changes position during the day, fixed panels are unable to change optimal angles and, as a result, have high energy losses. The inefficiency is even more pronounced during brief days and irregular weather patterns. Apart from these, climatic factors such as dust accumulation, shading, and varying temperatures also significantly degrade the performance of the solar panels. These even limit the energy output of the stationary panels, and even maximum output is difficult to attain.

The objective of this project is to design and develop an Automated Solar Tracking System which will overcome such weaknesses. By constantly orienting the solar panel towards the sun, the system should be able to attain the highest amount of intake of energy during the day. With a dual-axis tracking system in place, the solar panel will be set in horizontal and vertical movements and will be at its most effective position as per the sun's position.

Some of the most important challenges of the project are precise synchronization of the servo motors, processing of data in real-time, and stability of the system under conditions. Power management is also important as the system itself has to consume power in order to turn on the motors and sensors. Power consumption must be balanced with surplus power provided to supply net energy gains.

This project is not only focused on optimizing the harvesting of solar energy but also on showcasing the importance of the use of IoT and embedded systems in green energy. The efficiency of this system can be a significant contributor to the global implementation of solar energy by making it economically and environmentally viable. In light of these constraints, this project aims to demonstrate an efficient and scalable approach to renewable energy optimization.

IV. METHODOLOGY

The automated Solar Tracking System process involves a sequence of required steps such as component selection, hardware integration, software implementation, and performance testing. The process starts with component selection, i.e., the ESP32 microcontroller for computation purposes, LDR sensors for detection of light, servo motors for implementing dual-axis movement, and the INA219 sensor for power monitoring. They were selected based on compatibility, power usage, and accuracy.

Hardware integration is attained by placing LDR sensors in a cross-way to sense the level of light coming from the top, bottom, left, and right. ESP32 calculates this data to know the angular motions to be carried out. Elevation and azimuth angles are adjusted by servo motors to align the solar panel with the direction of the sun. To ensure efficient operation, a feedback loop mechanism has been implemented to modify on a constant basis as the sun's position continues to change.

Remote monitoring is being conducted by employing the Blynk IoT platform. The real-time current, voltage, and power values being sensed by the INA219 sensor are shown. Real-time feedback is also available through an OLED display. System software is executed using Arduino IDE with C++ as the programming language for rapid data processing as well as for controlling actuators. The control algorithm is executed while keeping minimum power consumption in mind without any spurious movement of the motor.

System performance is measured in terms of output energy per a reference solar panel over some given time period. It is also tested under different weather conditions to check for reliability and durability. Response time, alignment accuracy, and power consumption are all put to the test of the system. The outcome determines the degree of effectiveness in energy efficiency gains by automated solar tracking, with serious logging to enable future optimization data.

V. RESULTS

The Automated Solar Tracking System was subjected to exhaustive tests to determine its efficiency against static solar panels. The data collection was carried out over several days and exhibited a substantial increase in energy yield due to the system's ability to keep itself oriented toward the sun optimally. On average, the dual-axis tracking system has produced 20-30% more energy than the static system. Further analysis indicated that energy gained was more significant in early mornings and late afternoons when the angle of incidence was of utmost importance.

Continuous monitoring was done for voltage current and power using the INA219 sensor. The Blynk IoT platform provided remote data visualization, allowing users to visualize performance trends and make informed decisions. Instant on-site feedback was communicated through the OLED display, which enhanced system usability. Users could see in real-time how azimuth and elevation positions were adjusting to the intensity of sunlight.

The system maintained stability under all weather conditions, sustaining precise alignment while sunlight intensity was variable. The results imply that automated tracking greatly improves solar energy efficiency. Besides providing higher energy yield, the other huge benefit seen was the system's reliability to switch operations when there was a sudden change in the weather, like passing clouds. Feedback from the users has pointed out that installation and maintenance of the system were easy, and remote monitoring was useful.

Improvement could be made in the future to research predictive algorithms weather adaptive, scaling the system for larger solar installations. Advanced machine learning models could be implemented for predicting solar intensity patterns in optimizing efficient movement. The investigation of other possibilities for energy storage applications such as supercapacitors may also render the total sustainability of the system. The project was successfully implemented, thus suggesting a bright future for IoT and embedded systems in furthering renewable energy solutions.

VI. CONCLUSIONS & FUTURE WORK

By enabling the alignment of the solar panel with the sun-synchronous trajectory, the Automated Solar Tracking System deals with the limitations on the energy efficiency of static solar panels. Using LDR sensors, ESP32 microcontroller, servo motor, and IoT technology, the system could outperform the other energy collection systems. The dual-axis mechanism allows the system to keep constant energy input throughout the day as the sun's position changes.

Results showed clearly that using dual axes to track the sun would enhance the energy efficiency of the system by an estimated 20-30 percent from that of stationary panels, and it also gives insight into the performance of the system under different weather conditions confirming robustness and reliability. The Blynk IoT remote monitoring adds to practicality and usability. It also attempts to show the potential for using low-cost automation for renewable energy applications at a level that is not just theoretical but practical for small and medium-sized applications.

In the next phase of the work, we will scale up the system for larger installations, develop state-of-the-art weather forecast algorithms, and research new alternative energy storage technologies. Power management can improve the energy performance of the system further, where better optimization in servo motor control can advance it. This approach, integrating wind or geothermal energy with solar tracking, could produce an even better outcome since hybrid energy systems yield a more constant power output.

This project is an important step towards energy-related sustainability because it unlocks the potential of both embedded systems and IoT technology to solve energy issues globally. Ongoing research and development will further mature the system toward the global transition to renewable energy.

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