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Smart Solar Panel System

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Abstract: The Smart Solar Panel System is designed to maximize the utilization of solar energy by automatically adjusting the position of the panel according to sunlight availability. Traditional solar panels are fixed in one direction, which limits their ability to absorb sunlight efficiently throughout the day. To overcome this issue, the proposed system uses an Arduino Uno microcontroller to control the movement of the solar panel based on real-time light intensity readings.Four Light Dependent Resistors (LDRs) are placed around the panel to identify variations in sunlight direction. The collected data is processed by the controller, which activates a servo motor to rotate the panel toward the strongest light source. In addition, a DHT11 sensor is employed to record surrounding temperature and humidity, allowing observation of environmental conditions that may influence energy production. The electrical power generated is stored in a 5V rechargeable battery to ensure continuous operation during periods of reduced sunlight. System performance details such as output voltage, temperature, humidity levels, and panel orientation are displayed on an LCD module, enabling easy monitoring by the user. The overall design focuses on simplicity, low power consumption, and affordability, making it suitable for residential use, academic demonstrations, and small industrial setups.By automating solar tracking, the system reduces human effort while improving energy capture efficiency. Future enhancements can include IoT integration for remote supervision, data storage, and system diagnostics, allowing scalability for larger installations. This project presents a practical, economical, and environmentally responsible solution for enhancing solar energy harvesting and supporting sustainable energy development.
Keywords: Solar Power, Automated Tracking, Arduino Controller, Light Sensors, Servo Control, Green Technology

1. INTRODUCTION

The Smart Solar Panel System is developed to automatically regulate the orientation of a solar panel based on changing sunlight conditions throughout the day. The system uses multiple Light Dependent Resistors (LDRs) to sense variations in light intensity from different angles. These sensor readings are analyzed by an Arduino Uno controller, which drives a servo motor to continuously reposition the panel toward the most effective light direction, ensuring optimal exposure.Along with solar tracking; the setup includes a DHT11 sensor that records ambient temperature and humidity to study environmental factors affecting panel efficiency. The electrical power produced by the panel is stored in a 5V rechargeable battery, enabling uninterrupted operation for low-power applications during cloudy periods or night time. A liquid crystal display (LCD) presents real-time system information such as output voltage, environmental readings, and panel orientation, allowing users to monitor performance easily. The system is designed with an emphasis on affordability, low energy consumption, and adaptability, making it suitable for household use, academic experiments, and small-scale industrial applications. Through automation and intelligent control, the system enhances energy harvesting while reducing the need for manual adjustments. Furthermore, the architecture supports future expansion with Internet of Things (IoT) capabilities, allowing remote supervision, data analysis, and system optimization.In summary, the Smart Solar Panel System demonstrates an efficient and intelligent approach to renewable energy utilization. By combining embedded control and automation, it contributes to sustainable power generation and supports the transition toward environmentally responsible energy solutions.

2. RELATED WORK

Several studies have explored solar panel efficiency enhancement through tracking mechanisms and monitoring systems. Early research primarily focused on fixed solar installations with basic electrical monitoring, which provided limited improvement due to the inability of panels to follow the sun's movement. These systems mainly concentrated on voltage and current measurement using wired or PC-based interfaces, offering high accuracy but poor scalability and real-time adaptability.

With the advancement of embedded systems, Arduino-based solar trackers were introduced to dynamically adjust panel orientation. Many works implemented single-axis and dual-axis tracking using Light Dependent Resistors (LDRs) and servo or DC motors. Dual-axis trackers demonstrated a significant increase in energy output compared to fixed panels; however, they introduced higher mechanical complexity, increased power consumption, and greater maintenance requirements. Recent studies integrated Internet of Things (IoT) technologies to enable remote monitoring and data visualization through cloud platforms. These systems allowed real-time observation of electrical parameters and environmental conditions while supporting predictive maintenance. Although IoT-enabled designs improved scalability and monitoring efficiency, they were highly dependent on network availability and incurred additional setup and operational costs, making them less suitable for low-budget or educational environments.

Table 2.1 Comparative Analysis of Voltage Output at Varying Irradiance Levels

Paper Title	Advantages	Disadvantages	Reason for Platform / Technology Selection
Solar Power Monitoring System Using IoT	Enables real-time performance tracking; reduces manual inspection	Efficiency drops due to dust and weather dependency	IoT was selected to allow remote monitoring
IoT-Based Solar Tracking System for Efficient Power Generation	Achieves notable improvement in energy output; supports remote access	Increased system complexity; higher cost and maintenance needs	Arduino and IoT platforms were used for flexibility
Enhancing Solar Energy Harvesting Through IoT-Enabled Tracking	Scalable design; supports predictive maintenance	Initial investment is high; complex setup for beginners	IoT integration was chosen to enable advanced analytics
Enhanced Solar Tracking System Using IoT Technology	Produces higher energy than fixed panels	Internet dependency; sensitive to environmental variations	Node MCU and Arduino were used for low-cost wireless communication
Energy-Efficient Dual Axis Solar Tracking System Using IoT	Significant efficiency gain; automatic reset after sunset	More complex than single-axis systems	Dual-axis tracking and IoT were selected to maximize solar exposure

3. PROPOSED SYSTEM

The Smart Solar Panel System is proposed to create an automated and economical solution that improves solar power generation through intelligent tracking and continuous system monitoring. The project focuses on increasing energy efficiency while maintaining simplicity and ease of implementation.

1. An automatic tracking unit is developed using an Arduino Uno and Light Dependent Resistors (LDRs) to dynamically adjust the solar panel's orientation so that it always faces the strongest source of sunlight during the day.
2. The system is designed to improve overall power output by maintaining optimal exposure to sunlight, thereby achieving better energy efficiency than conventional fixed-position solar panels.
3. Environmental parameters such as temperature and humidity are monitored using a DHT11 sensor, enabling evaluation of weather conditions and their influence on solar panel performance.
4. A real-time visualization interface is implemented using a 16×2 LCD display to show important system details including voltage output, temperature, humidity levels, and servo motor position, improving system awareness and usability.

4. METHODOLOGY

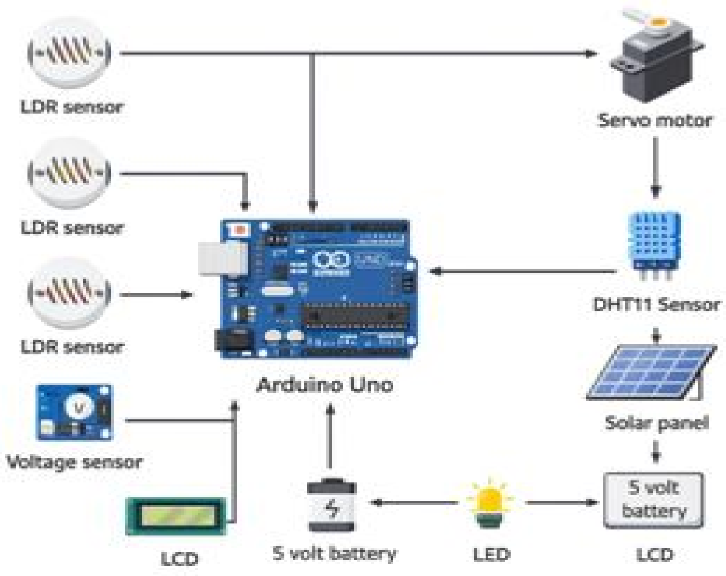
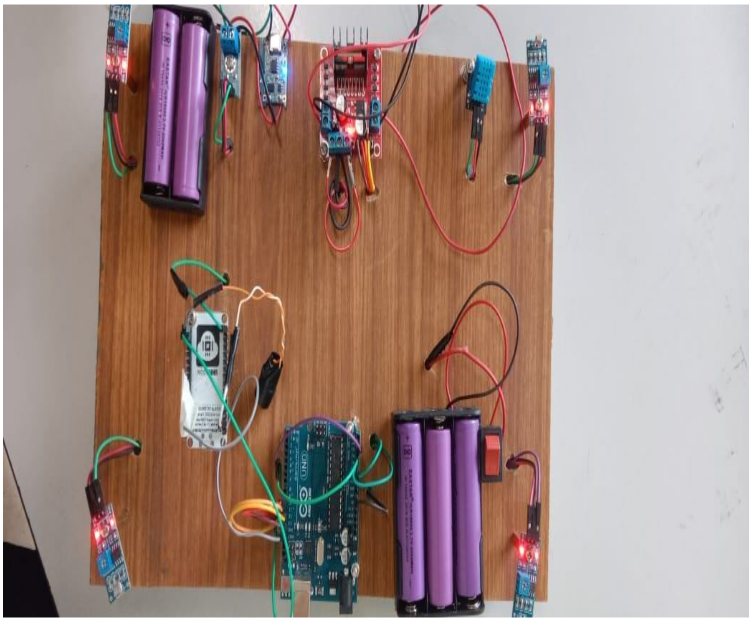


Fig: 1.1 Architecture

The above Fig. 1.1 presents the overall architecture of the Smart Solar Tracking System, illustrating how different hardware components work together to improve solar energy harvesting. The system employs four Light Dependent Resistors (LDRs) placed around the solar panel to sense variations in sunlight intensity from multiple directions. The readings collected from these sensors are sent to the Arduino Uno, which functions as the main control unit of the system. Based on the received light data, the Arduino processes the signals and controls a servo motor to rotate the solar panel toward the direction receiving the highest sunlight intensity. This continuous adjustment allows the panel to maintain optimal alignment with the sun throughout the day, thereby increasing energy capture efficiency. The solar panel converts the received sunlight into electrical energy, which is stored in a 5V rechargeable battery for later use.To ensure safe and effective operation, a voltage sensor is used to monitor the electrical output and battery charging status. Environmental conditions such as temperature and humidity are measured using a DHT11 sensor to analyze their influence on power generation. A 16×2 LCD module displays real-time system information including voltage levels, temperature, and humidity, enabling clear and convenient monitoring. An LED load powered by the stored energy demonstrates the system's ability to supply power to small devices. Overall, this architecture represents a compact, automated, and energy-efficient design that supports continuous monitoring, improved power generation, and user-friendly interaction.

5. RESULTS OF IMPLEMENTATION

The Smart Solar Panel System was implemented and evaluated under different sunlight conditions to examine its operational performance and adaptability. Testing was carried out across a wide range of solar irradiance levels, starting from low intensity conditions of around 200 W/m² and extending to peak levels close to 1000 W/m². The system was designed to adjust automatically to these variations and maintain efficient energy generation.During experimentation, the output voltage showed a clear relationship with changes in sunlight intensity. Under low irradiance conditions, the system generated voltage values in the range of approximately 4.5 V to 7.0 V. As the irradiance increased, the voltage output rose steadily, reaching values between 21.0 V and 25.0 V under strong sunlight. This behavior confirms the system's ability to respond effectively to environmental changes and maintain optimal performance. The system demonstrated stable operation throughout the testing phase. The implemented control mechanism continuously adjusted the panel's operating point to extract maximum available power. When compared with traditional fixed-load solar systems, the proposed setup achieved a noticeable improvement in energy efficiency, with performance gains estimated between 18% and 22%. These results indicate that the smart solar panel system is well suited for real-world applications where sunlight conditions are unpredictable, offering reliable operation and improved energy conversion efficiency.



CONCLUSION

The Smart Solar Panel System demonstrates an effective and reliable method for improving solar energy generation under varying sunlight conditions. By using intelligent control techniques to continuously adapt to changes in irradiance, the system is able to operate efficiently without requiring manual adjustment. The results confirm that automatic optimization significantly enhances power output compared to conventional approaches, highlighting the value of smart solar technologies in renewable energy systems. This solution is well suited for real-world environments with fluctuating weather conditions and offers strong potential for future enhancement through energy storage integration and remote monitoring capabilities, contributing to sustainable and efficient clean energy utilization.

REFERENCE

1. R.Praveen Hariharan, K. Selvakumar, and M. Udhayakumar, Solar Power Monitoring System Using IoT and Solar Tracking System, B.E. project report, Dept. Elect. Electron. Eng., Kumaraguru College of Technology, Coimbatore, India, May 2021.
2. P.Muthukumar, S.Manikandan, R.Muniraj, T.Jarin, and A.Sebi, “Energy efficient dual axis solar tracking system using IOT,” Measurement: Sensors, vol. 28, Art. no. 100825, 2023, https://doi.org/10.1016/j.measen.2023.100825.
3. Q.N.Qisti, N.Abdullah, and K.A.Ahmad, “Enhanced solar tracking system using Internet of Things technology,” Platform: A Journal of Engineering, vol. 7, no. 4, pp. 1–10, Dec. 2023, https://doi.org/10.11113/platform.v7n4.405.
4. M.Kassim, and F.Lazim,“Adaptive photovoltaic solar module based on Internet of things and web-based monitoring system,” International,Journal of Electrical and Computer Engineering, vol. 12(1), 2022.
5. J.Saranya, and V.Divya, “A Feature Extraction of Photovoltaic SolarPanel monitoring system based onInternet of Things (IoT),” EAI,Endorsed Transactions on Internet of Things, vol. 10, 2024.
6. Beyaz, and V.Gül,“Determination of low-cost arduino based light,intensity sensors effectiveness for agricultural applications,” Brazilian Archives of Biology and Technology, vol. 65, e22220172, 2022.
7. Al-Naima, F.,& Hamad,A.(2019).A Low-cost Solar Farm Monitoring System Based on Cloud Database. MEST Journal, 7(2), 1–8.https://doi.org/10.12709/mest.07.07.02.01
8. Achbi, M. S., Rouabah, B., Benarabi, B., Mahboub, M. A., and Kechida, S. (2024). IoT-Based Monitoring of a Dual-Axis Solar Tracking System,2025.
9. Gonalves P., Orestes M. Photovoltaic solar energy: Conceptual framework. Renew. Sustain. Energy, 2017, 74, 590–601.
10. J.C.Franklin, M.Chandrasekar, and D.A.Mattius, “Development of cost effective data acquisition system to evaluate the performance of solar photovoltaic thermal systems,” Journal of Solar Energy Engineering, vol. 143, no. 1, Feb. 2021, https://doi.org/10.1115/1.4047453
11. M.T.A. Khan, S.M.S. Tanzil, R. Rahman, S.M.S. Alam. ‘’Design and Construction of an Automatic Solar Tracking System.’’ 6th International Conference on Electrical and Computer Engineering ICECE 2010, 18 – 20 December, Dhaka, Bangladesh.
12. A.K. Saxena and V. Dutta, “A versatile microprocessor based controller for solar tracking,” in Proc. IEEE, 1990.
13. El.Hammoumi, S.Motahhir, A.El Ghzizal, and A. Derouich, "Internet of Things-Based Solar Tracker System," Green Energy and Technology.
14. Y.Zhu, J.Liu, X.Yang, Design and performance analysis of a solar tracking system with a novel single-axis tracking structure to maximize energy collection, Appl. Energy 264 (2020), 114647.
15. M.V.Hardas, S.Ingole, S. Sheikh, and S. Kale, “Solar panel monitoring system using IOT,” International Journal for Research in Applied Science and Engineering Technology, vol. 10, no. 5, pp. 935–938, May 2022, https://doi.org/10.22214/ijraset.2022.42133.
16. R.Malvi, K.Mankar, K.Bhoyar, S.Godamale, S.Pawar, and A.D.Nanure, “A paper on solar power monitoring system using IOT,” International Journal of Research Publication and Reviews, vol. 3, no. 6, pp. 265–267, 2022.
17. M.Keerthana, J.Sandeep, M.V.Kumar, and S.R.Kumar, “IoT based solar power monitoring system,” International Research Journal of Modernization in Engineering Technology and Science, vol. 4, no. 6, pp. 5447–5450, 2022
18. M.Keerthana, J.Sandeep, M.V.Kumar, and S.R.Kumar, “IoT based solar power monitoring system,” International Research Journal of Modernization in Engineering Technology and Science, vol. 4, no. 6, pp. 5447–5450, 2022
19. N.S.Palkar, A.Janwe, A.Chopde, A.Yadav, P.Bhad, and V.Borkar, “Solar power monitoring system using IoT,” International Journal of Advance Research and Innovative Ideas in Education (IJARIIE), vol. 7, no. 3, pp. 924–929, 2021.
20. M.Gopal, T.C.Prakash, N.V.Ramakrishna, and B.P.Yadav, “IoT based solar power monitoring system,” IOP Conference Series: Materials Science and Engineering, vol. 981, no. 3, Dec. 2020.
21. G.K.Ali and A.Luaibi,“Microcontroller based automatic sun tracking solar panel,” in 2020 Fourth International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), Oct. 2020.
22. M.H.Shah and N.H.Abosaq, “IoT based efficient solar panel monitoring,” 3C Tecnología_Glosas de innovaciónaplicadas a la pyme, vol. 9, no. 4, pp. 87–93, Dec. 2020.
23. L.Chitra et al., “IoT-based solar energy measurement and monitoring model,” International Journal of Photoenergy, vol. 2022, pp. 1–8, Oct. 2022.
24. S.H.Cheragee, N.Hassan, S.Ahammed, and A.Z.M.T.Islam, “A study of IoT based real-time solar power remote monitoring system,” The International Journal of Ambient Systems and Applications, vol. 9, no. 2, pp. 27–36, Jun. 2021.