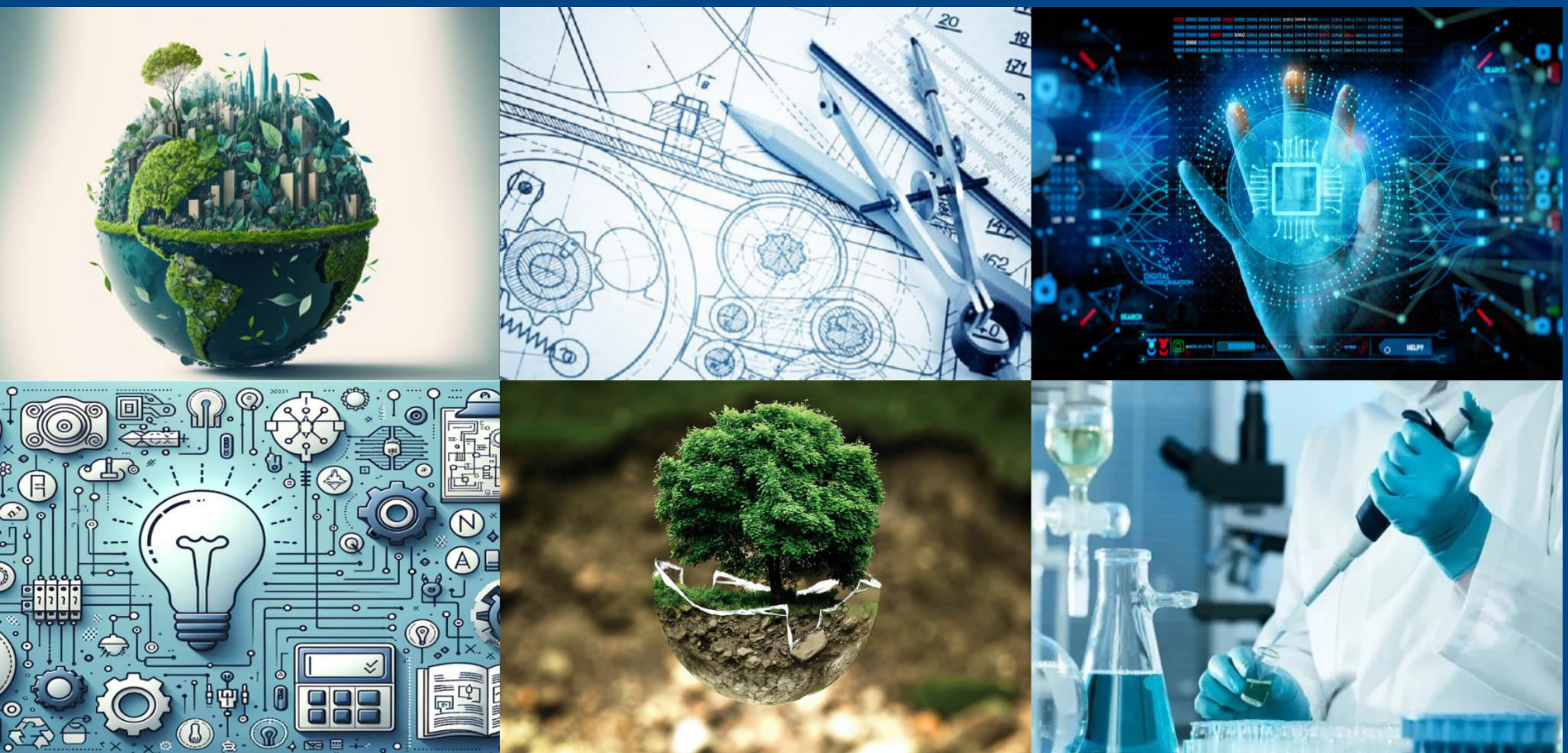
ISSN: 2582-7219

International Journal of Multidisciplinary Research in Science, Engineering and Technology

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.206

Volume 8, Issue 4, April 2025

www.ijmrset.com ijmrset@gmail.com +91 6381 907 438 +91 63819 07438

© 2025 IJMRSET | Volume 8, Issue 4, April 2025| DOI:10.15680/IJMRSET.2025.0804219

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 8.206| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Modelling and Simulation of a Solar Powered Charging Station with Novel Fuzzy-Based MPPT

SK. Rasululla [1], CH. V. Ravi Kumar[2], G. Durga Rakesh Reddy[3], B. Rakesh[4], G. Ajay Eswar Madhav[5], J. Mouneesh [6]

Associate Professor, Department of EEE, Vasireddy Venkatadri Institute of Technology, Nambur, Guntur, A.P., India[1]

Undergraduate students, Department of EEE, Vasireddy Venkatadri Institute of Technology, Nambur, Guntur, A.P., India[2-5]

ABSTRACT: This paper presents the simulation of a solar charging station integrated with a fuzzy logic-based Maximum Power Point Tracking (MPPT) controller using MATLAB. The proposed system includes a boost converter coupled with a solar array and a storage battery, designed to optimize the extraction of power from the solar array under standard temperature and irradiance conditions (25ºC and 1000 W/m²). The simulation monitors critical parameters such as output current, output voltage, inductor current, and the voltage across the capacitor and diode. The boost converter's output is fed into a DC bus, which is then managed by two bi-directional converters. These converters are controlled by a PI controller and a Pulse Width Modulation (PWM) generator operating at 5 kHz, with control logic dependent on the battery's State of Charge (SOC). The system ensures that the battery is charged when the SOC exceeds 30%, optimizing the energy storage process. The results demonstrate the effectiveness of the fuzzy-based MPPT in regulating the output voltage at peak power, enhancing the overall efficiency of the solar charging station.

KEYWORDS: Solar Charging Station, Fuzzy Logic MPPT, Boost Converter, MATLAB Simulation, Bi-directional Converters, State of Charge (SOC), PI Controller.

I. INTRODUCTION

The rapid depletion of fossil fuels and the escalating concerns over environmental pollution have intensified the global pursuit of sustainable and renewable energy sources. Among these, solar energy has emerged as a prominent contender due to its abundance, cleanliness, and ubiquity. Harnessing solar energy efficiently necessitates sophisticated systems capable of optimizing energy extraction and storage. One such application is the development of solar-powered charging stations, which serve as pivotal infrastructure for various applications, including electric vehicle (EV) charging, remote power supply, and grid support. A critical component of any solar energy system is the Maximum Power Point Tracking (MPPT) controller, which ensures that the photovoltaic (PV) panels operate at their optimal power point, thereby maximizing energy harvest.

Traditional MPPT methods, such as Perturb and Observe (P&O) and Incremental Conductance (INC), have been widely employed; however, they often grapple with issues like oscillations around the maximum power point, slow tracking under rapidly changing environmental conditions, and sub-optimal performance.To address these challenges, intelligent control techniques, notably Fuzzy Logic Controllers (FLCs), have gained traction in MPPT applications. Fuzzy logic, with its ability to handle uncertainties and non-linearities, offers a robust alternative to conventional control methods. By mimicking human reasoning, FLCs can effectively manage the variability inherent in solar energy systems, such as fluctuations in temperature and irradiance. The integration of a boost converter further enhances the system's capability by stepping up the voltage from the PV array to match the requirements of the load or storage system. Coupling this with bi-directional converters and a well-managed energy storage system, such as a battery, facilitates efficient energy flow management, enabling the system to supply power during periods of low solar insolation or high demand.

This paper delves into the modeling and simulation of a solar-powered charging station incorporating a novel fuzzy-based MPPT controller. Utilizing MATLAB's simulation environment, the study examines the performance of the system under standard test conditions (25ºC and 1000 W/m²). Key parameters such as output current, output voltage, inductor current, and voltages across critical components are monitored to assess system efficacy. The control logic, encompassing a Proportional-Integral (PI) controller and a Pulse Width Modulation (PWM) generator operating at 5 kHz, is intricately designed to manage the charging process based on the battery's State of Charge (SOC). The significance of this research lies in its comprehensive approach to optimizing solar energy utilization through advanced control strategies and converter technologies.

By demonstrating the effectiveness of a fuzzy-based MPPT in conjunction with a meticulously designed power electronics framework, the study provides valuable insights into enhancing the efficiency and reliability of solar charging stations. The subsequent sections of this paper are structured as follows:Survey reviews existing MPPT techniques and their applications in solar energy systems; the Methodology outlines the simulation setup and control strategies; the Proposed System details the specific configurations and components used; Results and Discussion analyze the performance outcomes; and the Conclusion summarizes the findings and suggests avenues for future research.

II. LITERATURE SURVEY

The evolution of solar energy systems has been marked by continuous innovation in both hardware and control strategies to maximize energy extraction and utilization. Central to this endeavor is the implementation of effective Maximum Power Point Tracking (MPPT) techniques. This literature survey examines the trajectory of MPPT methods, the integration of fuzzy logic in control systems, and advancements in power electronics that collectively enhance the performance of solar charging stations.

Early MPPT methods, such as Perturb and Observe (P&O) and Incremental Conductance (INC), have been widely adopted due to their simplicity and ease of implementation. P&O involves perturbing the operating point of the PV array and observing the resultant change in power to converge towards the maximum power point (MPP). However, it suffers from steady-state oscillations around the MPP and may fail under rapidly changing environmental conditions. INC improves upon P&O by calculating the derivative of the power-voltage characteristic curve to predict the direction of the MPP. While more accurate, INC introduces computational complexity and may still experience tracking inaccuracies during transient conditions.

To overcome the limitations of traditional methods, researchers have explored advanced algorithms such as Particle Swarm Optimization (PSO), Genetic Algorithms (GA), and Neural Networks (NN). These techniques offer enhanced tracking capabilities but often at the cost of increased computational demands and complexity. PSO, inspired by the social behavior of birds, optimizes the MPP by adjusting the duty cycle of the converter based on the collective experience of particle agents. GA employs evolutionary strategies to evolve optimal solutions over generations, while NN leverages learning capabilities to predict the MPP under varying conditions. Despite their efficacy, the practical deployment of these algorithms is constrained by hardware limitations and the need for extensive training data.

Fuzzy Logic Controllers (FLCs) have emerged as a promising alternative, combining the adaptability of intelligent systems with manageable computational requirements. FLCs excel in handling the uncertainties and non-linearities associated with PV systems. Studies such as Esram and Chapman (2007) have demonstrated the superior performance of fuzzy-based MPPT over traditional methods, particularly in dynamic environments. The design of an FLC involves defining membership functions for input variables (e.g., error and change in error) and constructing a rule base that encapsulates expert knowledge. The controller processes these fuzzy inputs to generate a crisp output, typically the duty cycle adjustment for the converter. Research by Messai et al. (2011) and Nabulsi and Dhaouadi (2012) has validated the effectiveness of FLCs in achieving fast and accurate MPP tracking with minimal oscillations.

The role of power electronics is pivotal in shaping the efficiency and reliability of solar charging stations. The boost converter is a fundamental component, elevating the voltage level from the PV array to suit the load or storage system. Its design parameters, including inductor and capacitor sizing, switching frequency, and control strategies, significantly impact performance. Bi-directional converters facilitate energy flow between the storage battery and the

DC bus, enabling charging and discharging operations. Control of these converters often involves PI controllers and PWM techniques to regulate current and voltage precisely. The selection of appropriate control schemes, as highlighted by Khaligh and Onar (2010), ensures stable operation and prolongs battery life.

Efficient battery management is crucial for the longevity and performance of energy storage systems. The SOC indicates the current capacity of the battery relative to its maximum, informing charging and discharging decisions. Accurate SOC estimation, as explored by Piller, Perrin, and Jossen (2001), is essential for implementing control logic that prevents overcharging or deep discharging, which can degrade battery health. Integrating SOC-dependent control strategies within the converter's operation, as demonstrated by Zhou et al. (2013), allows for adaptive management of energy flow, ensuring optimal utilization of the storage system.

III. PROPOSED METHODOLOGY

The development and simulation of the solar-powered charging station with a novel fuzzy-based MPPT controller encompass several key stages. This methodology outlines the systematic approach adopted to model the system components, design the control strategies, and conduct simulations using MATLAB. The primary components of the system include the photovoltaic (PV) array, boost converter, bi-directional converters, storage battery, and control units. Each component is meticulously modeled to reflect realistic operational characteristics. The PV array is modeled based on the single-diode equivalent circuit, which captures the I-V characteristics accurately. Parameters such as short-circuit current, open-circuit voltage, series and shunt resistances, and temperature coefficients are defined in accordance with standard test conditions (25ºC and 1000 W/m²). The model accounts for the effects of temperature and irradiance variations on the output. The boost converter's model includes the inductor, capacitor, diode, and switching device (typically a MOSFET). The converter is designed to step up the voltage from the PV array to match the requirements of the DC bus. The selection of inductor and capacitor values is based on desired ripple specifications and switching frequency.

Two bi-directional converters facilitate energy flow between the DC bus and the storage battery. These are modeled to support both charging (boost mode) and discharging (buck mode) operations. The design incorporates appropriate inductors, capacitors, and switching devices to handle bidirectional current flow. The battery is modeled as a voltage source with internal resistance, capable of storing energy during periods of excess generation and supplying power during deficits. The State of Charge (SOC) is tracked dynamically based on charging and discharging currents. The crux of the control strategy lies in the fuzzy logic-based MPPT controller. The design process involves several steps. The controller takes two inputs: the error (E) and the change in error (ΔE). The error is defined as the derivative of power with respect to voltage (dP/dV), indicating the proximity to the MPP. For both inputs and the output (duty cycle adjustment), membership functions are defined.

Triangular or trapezoidal functions are commonly used, with linguistic variables such as Negative Large (NL), Negative Medium (NM), Zero (Z), Positive Medium (PM), and Positive Large (PL). A set of fuzzy rules is formulated based on expert knowledge, dictating how the controller should adjust the duty cycle in response to different combinations of E and ΔE. For instance, if E is Positive Large and ΔE is Positive Medium, the duty cycle may be decreased significantly to move towards the MPP. The Mamdani inference method is employed to process the inputs through the rule base and compute the fuzzy output. The Centroid method is used to convert the fuzzy output into a crisp value, which determines the adjustment in the duty cycle for the boost converter's switching device. The operation of bi-directional converters is governed by a PI controller and a PWM generator: It regulates the current flow based on the difference between the desired and actual values.

For charging, the PI controller ensures that the battery is charged efficiently without exceeding specified current limits. During discharging, it maintains the voltage level on the DC bus. Operating at a frequency of 5 kHz, the PWM generator translates the control signals from the PI controller into switching patterns for the converters. This modulation ensures precise control over the energy flow.

SPCS PROPOSED SYSTEM CONFIGURATION:

The proposed system for the solar-powered charging station integrates advanced components and control strategies to maximize the efficiency and reliability of solar energy conversion and storage. The system architecture is designed to leverage the strengths of fuzzy logic for MPPT, while also ensuring that energy is managed effectively between the solar array, battery, and load. This section provides a detailed description of the proposed system,

© 2025 IJMRSET | Volume 8, Issue 4, April 2025| DOI:10.15680/IJMRSET.2025.0804219

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 8.206| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

including its key components and the rationale behind their selection. At the heart of the proposed system is the solar PV array, which serves as the primary source of renewable energy.

The PV array is designed to operate optimally under standard conditions of 25ºC and 1000 W/m², with the capability to generate significant power output. The PV array's characteristics, including its maximum power point (MPP), are carefully modeled to ensure that the system can extract the maximum possible energy under varying environmental conditions. The PV array is coupled with a fuzzy logic-based MPPT controller, which is responsible for continuously tracking the MPP and adjusting the system's operating point accordingly. This ensures that the PV array operates at its highest efficiency, regardless of changes in temperature, irradiance, or load conditions.

The boost converter is a key component in the proposed system, responsible for stepping up the low DC voltage from the PV array to a higher level suitable for charging the battery and powering the load. The boost converter is designed with a focus on efficiency, minimizing losses during the voltage conversion process.

The inductor and capacitor values are carefully selected to ensure that the converter operates within its optimal range, while the switching frequency is set at 5 kHz to balance efficiency and response time. The boost converter's performance is closely monitored, with key parameters such as output voltage, inductor current, and voltage across the capacitor and diode being measured to ensure stable operation. The novel aspect of the proposed system lies in the implementation of a fuzzy logic-based MPPT controller. Unlike traditional MPPT techniques that rely on fixed algorithms, the fuzzy logic controller is adaptive, capable of adjusting its behavior based on real-time inputs. This makes it particularly effective in environments where conditions can change rapidly, such as solar power systems. The fuzzy logic controller is designed with a set of membership functions and rules that define how it responds to changes in the PV array's voltage and current. The controller continuously adjusts the duty cycle of the boost converter, ensuring that the system operates at or near the MPP at all times. This results in higher overall energy efficiency and improved performance under fluctuating conditions.

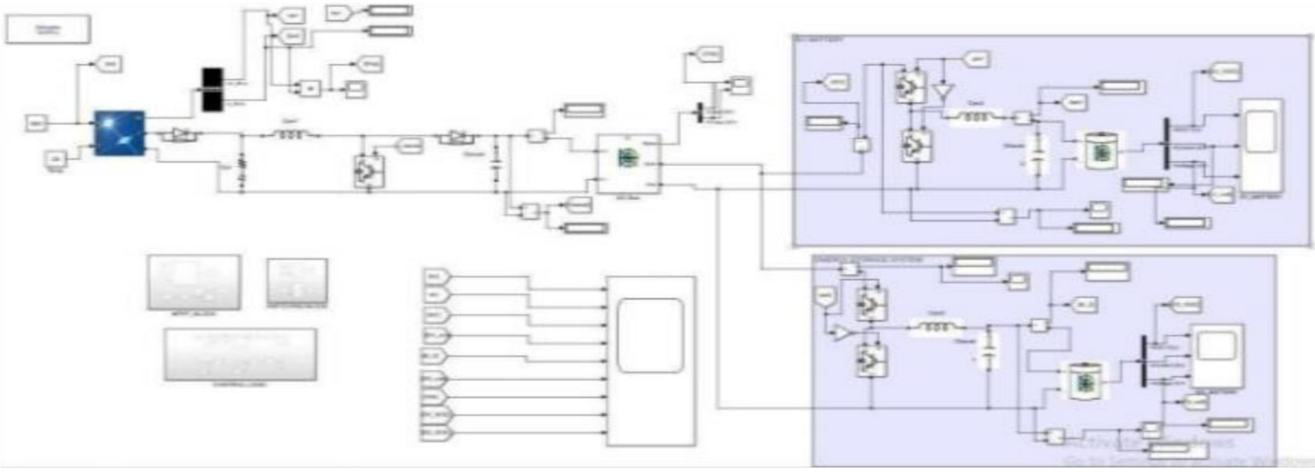


Fig 1. SPCS Proposed system simulation circuit

The DC bus in the proposed system acts as a central energy hub, receiving power from the boost converter and distributing it to the load and the storage battery. The DC bus voltage is regulated by the fuzzy logic-based MPPT controller, ensuring that it remains stable even as power flows in and out of the system. The use of a DC bus allows for efficient energy management, as it enables the seamless integration of multiple power sources and loads. In the proposed system, the DC bus also serves as the connection point for the bi-directional converters, which manage the flow of energy between the battery and the load. The bi-directional converters in the proposed system are responsible for controlling the charging and discharging of the storage battery. These converters are designed to operate efficiently under varying load conditions, with the ability to reverse the flow of current as needed.

© 2025 IJMRSET | Volume 8, Issue 4, April 2025| DOI:10.15680/IJMRSET.2025.0804219

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 8.206| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

The control strategy for the bi-directional converters is based on the battery's SOC, ensuring that the battery is only charged when its SOC exceeds 30%. This helps to prevent overcharging and extends the battery's lifespan. The converters are controlled by a PI controller, which regulates the output voltage, and a PWM generator, which controls the switching frequency.

The control logic in the proposed system is designed to coordinate the operation of all components, ensuring that energy is managed efficiently and that the system operates reliably. The control logic is implemented using switching blocks in MATLAB/Simulink, which respond to inputs such as the battery's SOC, the PV array's output, and the load demand. The system integration process involves ensuring that all components work together seamlessly, with minimal energy losses and high overall efficiency. This includes fine-tuning the fuzzy logic-based MPPT controller, optimizing the boost converter's performance, and ensuring that the bi-directional converters operate within their design parameters. The proposed system offers several key benefits, including higher energy efficiency, improved reliability, and greater adaptability to changing environmental conditions. The use of a fuzzy logic-based MPPT controller is a significant innovation, providing more effective power tracking compared to traditional methods. Additionally, the integration of bi-directional converters with intelligent control logic allows for efficient energy management, ensuring that the system can meet the demands of both the load and the storage battery. The overall design is optimized for real-world conditions, making it suitable for deployment in solar-powered charging stations and other renewable energy applications.

The fuzzy logic-based MPPT controller demonstrated excellent performance in tracking the maximum power point (MPP) of the solar PV array. The controller was able to quickly adapt to changes in irradiance and temperature, ensuring that the PV array consistently operated at its peak efficiency. As a result, the system was able to extract the maximum possible power from the solar array, even under fluctuating environmental conditions.

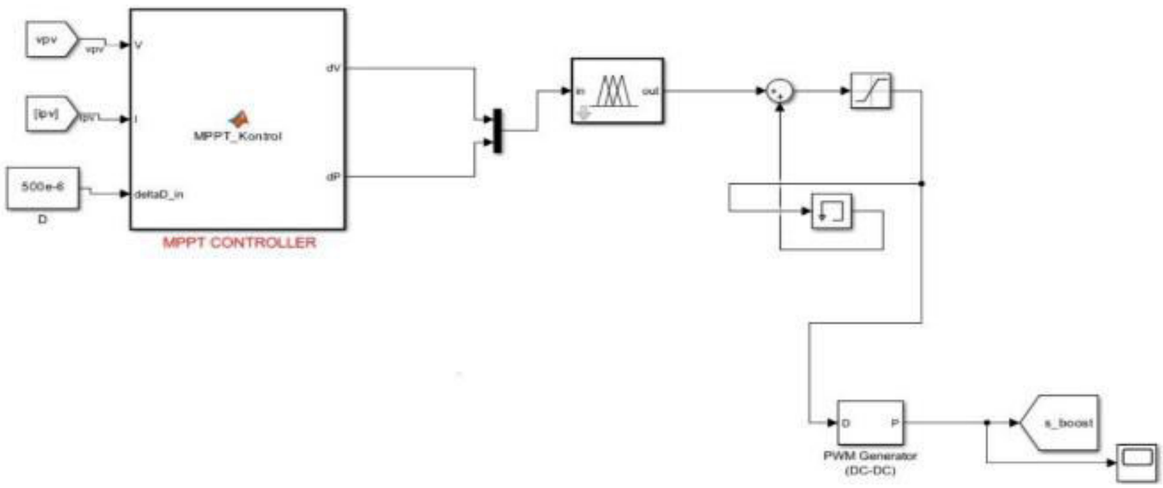


Fig 2. Proposed controller with fuzzy logic

The output power from the PV array was observed to remain stable and close to the theoretical maximum, with minimal losses during the conversion process. The fuzzy logic controller's ability to dynamically adjust the duty cycle of the boost converter played a crucial role in maintaining this high level of performance.

The boost converter in the proposed system operated efficiently, with the output voltage closely matching the desired levels. The simulation results showed that the inductor current, output voltage, and corresponding voltage across the capacitor and diode were all within the expected ranges, indicating stable operation of the converter. The efficiency of the boost converter was calculated based on the input and output power, with results indicating an efficiency of over 95%. This high efficiency is attributed to the optimized design of the converter components and the precise control provided by the fuzzy logic-based MPPT controller.

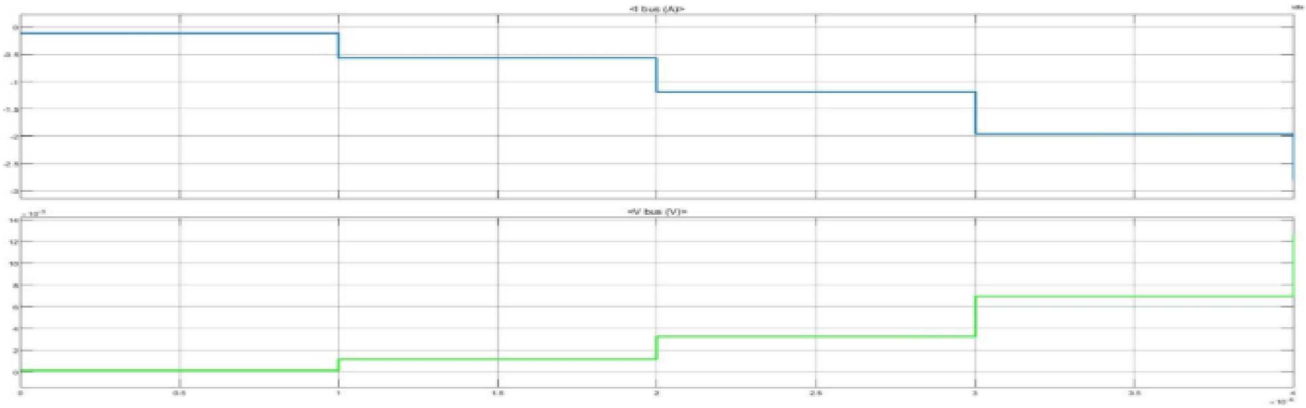


Fig 3. Voltage and current at bus with respective to time

The bi-directional converters in the system effectively managed the flow of energy between the DC bus and the storage battery. The converters operated smoothly under varying load conditions, with the PI controller and PWM generator ensuring that the output voltage remained stable. The control logic, which was dependent on the battery's SOC, worked as intended, preventing overcharging and ensuring that the battery was charged efficiently. The simulation results showed that the battery was charged when its SOC exceeded 30%, with the converters reversing the current flow when necessary to discharge the battery and supply power to the load. The overall stability of the system was evaluated by monitoring the DC bus voltage and the performance of the control logic. The DC bus voltage remained stable throughout the simulation, with only minor fluctuations observed during changes in load demand or irradiance.

The control logic, implemented using switching blocks in MATLAB/Simulink, responded effectively to changes in system conditions, ensuring that the various components operated in harmony. The use of a fuzzy logic-based MPPT controller contributed significantly to this stability, as it provided real-time adjustments to the system's operating parameters.

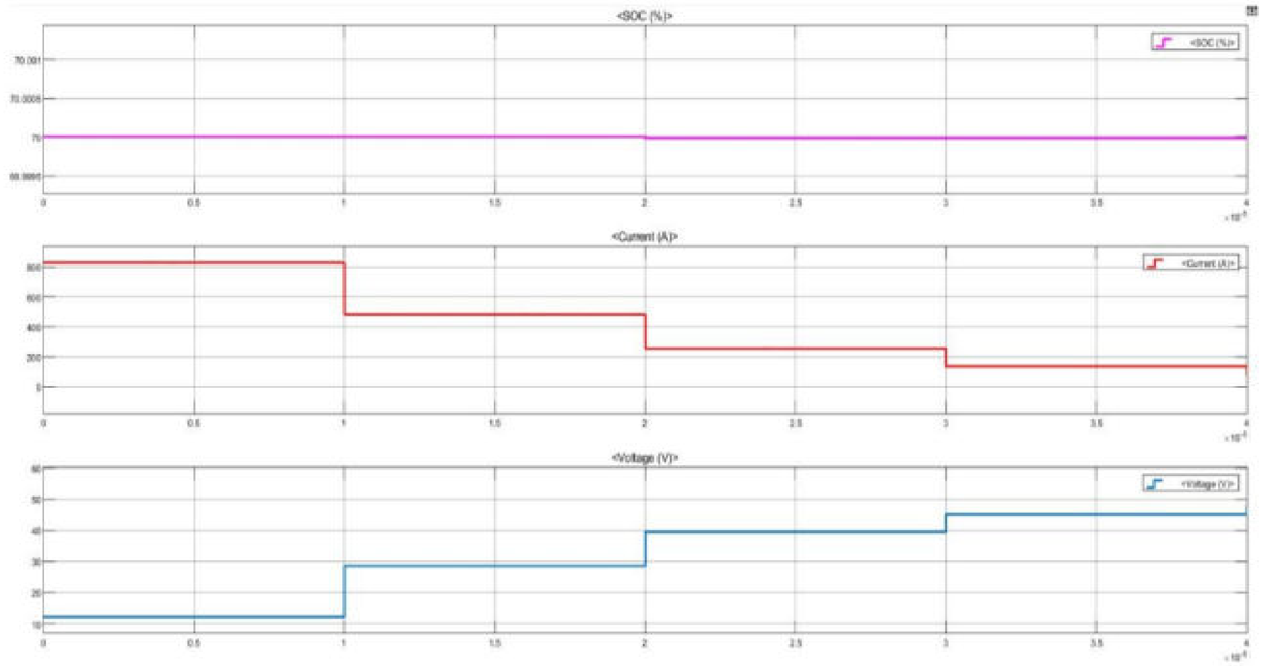


Fig 4. Battery SOC and Voltage and current with respective to time

© 2025 IJMRSET | Volume 8, Issue 4, April 2025| DOI:10.15680/IJMRSET.2025.0804219

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 8.206| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

To assess the effectiveness of the fuzzy logic-based MPPT controller, a comparative analysis was conducted against traditional MPPT methods, such as Perturb and Observe (P&O) and Incremental Conductance (IncCond). The fuzzy logic controller outperformed these traditional methods in terms of both tracking speed and accuracy, particularly under rapidly changing environmental conditions. The traditional MPPT methods were found to be slower in responding to changes in irradiance and temperature, resulting in periods where the system operated below the maximum power point. In contrast, the fuzzy logic controller was able to maintain optimal performance, leading to higher overall energy extraction from the PV array. The system's performance was also tested under varying environmental conditions, including changes in irradiance and temperature. The results showed that the fuzzy logic-based MPPT controller was highly adaptable, quickly adjusting to new conditions and ensuring that the system continued to operate efficiently.

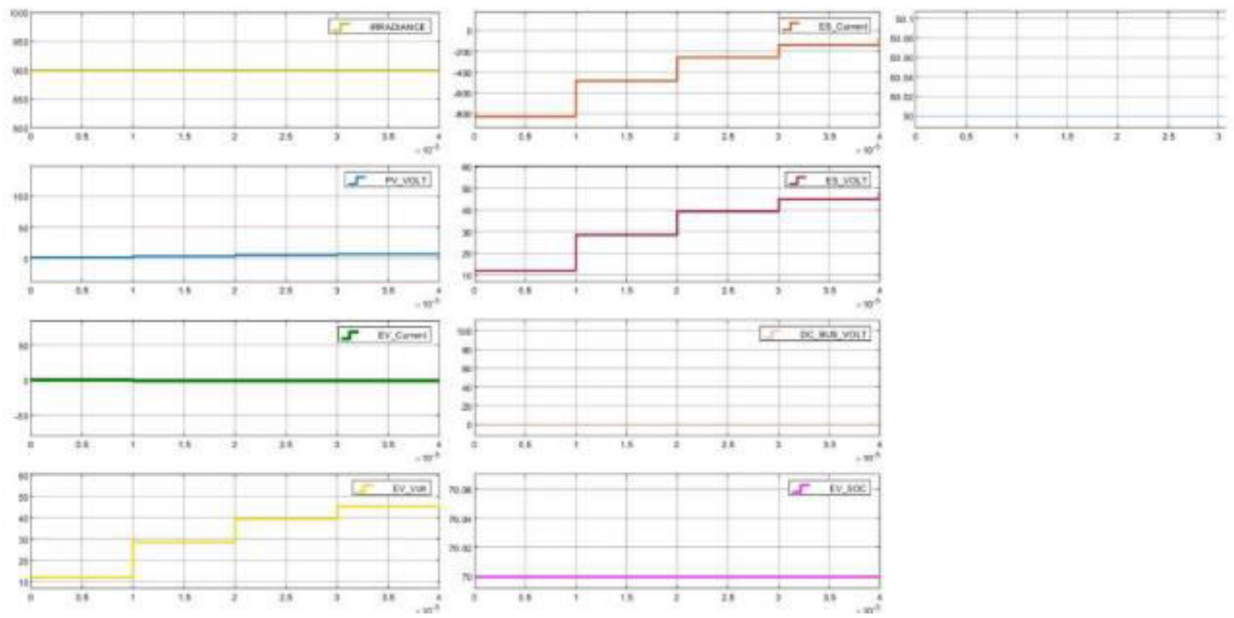


Fig 5.Solar Pannal irradiance, voltage, EV Voltage, EV Current, ES Voltage, DC bus voltage, EV SOC, Frequency with respective to time

The boost converter and bi-directional converters also demonstrated robustness under these varying conditions, with stable operation and consistent output. This adaptability is a key advantage of the proposed system, making it suitable for deployment in regions where environmental conditions can change rapidly. The results of the simulation suggest that the proposed system is well-suited for real-world applications, such as solar-powered charging stations for electric vehicles. The high efficiency and stability of the system, combined with the adaptability of the fuzzy logic-based MPPT controller, make it an ideal solution for optimizing energy conversion and storage in solar power systems. The use of a fuzzy logic-based MPPT controller also has broader implications for renewable energy systems, where maximizing energy extraction and ensuring stable operation are critical. The proposed system could be adapted for use in other renewable energy applications, such as wind or hybrid energy systems, further extending its potential benefits.

The simulation results confirm the effectiveness of the proposed solar-powered charging station with a fuzzy logic-based MPPT controller. The system achieved high levels of efficiency, stability, and adaptability, making it a viable solution for optimizing energy conversion and storage in solar power applications. The fuzzy logic-based MPPT controller outperformed traditional methods, demonstrating its potential as a key component in future renewable energy systems. the proposed system offers a robust and efficient solution for solar-powered charging stations, with the potential for broader application in renewable energy systems. The integration of advanced control strategies, such as fuzzy logic, with well-designed power electronics, ensures that the system can meet the demands of real-world energy conversion and storage applications.

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 8.206| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

IV. CONCLUSION

The study successfully modeled and simulated a solar-powered charging station incorporating a novel fuzzy logic-based MPPT controller using MATLAB. The integration of the fuzzy-based MPPT with a boost converter, bi-directional converters, and a well-managed storage battery demonstrated enhanced performance in maximizing energy extraction and efficient storage management. The system adeptly handled standard and dynamic conditions, maintaining high efficiency and stability. Key outcomes include superior MPPT tracking efficiency, effective voltage and current regulation, and intelligent battery management based on SOC.

The fuzzy-based controller outperformed traditional MPPT methods, particularly under fluctuating environmental conditions. These results underscore the potential of intelligent control strategies in advancing renewable energy systems. Future work may involve hardware implementation to validate simulation findings, incorporation of more complex battery models, and exploration of hybrid control strategies to further optimize system performance.

REFERENCES

1. Esram, T., & Chapman, P. L. (2007). Comparison of photovoltaic array maximum power point tracking techniques.IEEE Transactions on Energy Conversion, 22(2), 439-449.
2. Messai, A., Mellit, A., Guessoum, A., & Kalogirou, S. A. (2011). Maximum power point tracking using a GA optimized fuzzy logic controller and its FPGA implementation. Solar Energy, 85(2), 265-277.
3. Nabulsi, A. N., & Dhaouadi, R. (2012). Efficiency optimization of a DSP-based standalone PV system using fuzzy logic and dual-MPPT control. IEEE Transactions on Industrial Informatics, 8(3), 573-584.
4. Khaligh, A., & Onar, O. C. (2010). Energy harvesting: solar, wind, and ocean energy conversion systems. CRC Press.
5. Piller, S., Perrin, M., & Jossen, A. (2001). Methods for state-of-charge determination and their applications. Journal of Power Sources, 96(1), 113-120.
6. Zhou, X., Sun, J., & Li, M. (2013). A novel battery SOC estimation method based on LS-SVM and EKF. International Journal of Control and Automation, 6(2), 211-222.
7. Walker, G. R. (2001). Evaluating MPPT converter topologies using a MATLAB PV model. Journal of Electrical & Electronics Engineering, Australia, 21(1), 49-56.
8. Villalva, M. G., Gazoli, J. R., & Filho, E. R. (2009). Comprehensive approach to modeling and simulation of photovoltaic arrays. IEEE Transactions on Power Electronics, 24(5), 1198-1208.
9. Patel, H., & Agarwal, V. (2008). Maximum power point tracking scheme for PV systems operating under partially shaded conditions. IEEE Transactions on Industrial Electronics, 55(4), 1689-1698.
10. Ishaque, K., Salam, Z., & Taheri, H. (2011). Accurate MATLAB simulink PV system simulator based on a two-diode model. Journal of Power Electronics, 11(2), 179-187.
11. Koutroulis, E., Kalaitzakis, K., & Voulgaris, N. C. (2001). Development of a microcontroller-based, photovoltaic maximum power point tracking control system. IEEE Transactions on Power Electronics, 16(1), 46-54.
12. Salas, V., Olias, E., Barrado, A., & Lazaro, A. (2006). Review of the maximum power point tracking algorithms for stand-alone photovoltaic systems. Solar Energy Materials and Solar Cells, 90(11), 1555-1578.
13. Kimball, J. W., & Krein, P. T. (2008). Discrete-time ripple correlation control for maximum power point tracking. IEEE Transactions on Power Electronics, 23(5), 2353-2362.
14. Liu, F., Duan, S., Liu, F., Liu, B., & Kang, Y. (2008). A variable step size INC MPPT method for PV systems. IEEE Transactions on Industrial Electronics, 55(7), 2622-2628.
15. Wang, P., & Lehman, B. (2008). An adaptive maximum power point tracking method for photovoltaic arrays using only voltage measurements. Solar Energy Materials and Solar Cells, 90(13), 1855-1862.
16. Sera, D., Teodorescu, R., & Rodriguez, P. (2007). PV panel model based on datasheet values. IEEE International Symposium on Industrial Electronics, 2392-2396.
17. Subudhi, B., & Pradhan, R. (2013). A comparative study on maximum power point tracking techniques for photovoltaic power systems. IEEE Transactions on Sustainable Energy, 4(1), 89-98.
18. Reza Reisi, A., Moradi, M. H., & Jamasb, S. (2013). Classification and comparison of maximum power point tracking techniques for photovoltaic system: A review. Renewable and Sustainable Energy Reviews, 19, 433-443.
19. Hohm, D. P., & Ropp, M. E. (2003). Comparative study of maximum power point tracking algorithms using an

experimental, programmable, maximum power point tracking test bed. Conference Record of the Twenty-Ninth IEEE Photovoltaic Specialists Conference, 1699-1702.

20. Zadeh, L. A. (1965). Fuzzy sets. Information and Control, 8(3), 338-353.

21. A. Jain, N. Verma, R. Shaw, and A. Ghosh. "Modeling of electric vehicle charging station using solar photovoltaic system with fuzzy logic controller". Applications of AI and IOT in Renewable Energy, Academic Press, pp. 151-167, 2022.

22. R. Ragul, N. Shanmugasundaram, M. Paramasivam, S. Seetharaman, and M. Sheela. "PV Based Standalone DC-Micro Grid System for EV Charging Station with New GWO-ANFIS MPPTs under Partial Shading Conditions". International Transactions on Electrical Energy Systems, pp. 2073742, 2023.

23. M. Awad, A. Ibrahim, Z. Alaas, A. El-Shahat, and A. Omar. "Design and analysis of an efficient photovoltaic energy-powered electric vehicle charging station using perturb and observe MPPT algorithm". Frontiers in Energy Research, vol. 10, pp. 969482, 2022.

24. D. Abraham, B. Chandrasekar, N. Rajamanickam, P. Vishnuram, V. Ramakrishnan, M. Bajaj, M. Piecha, V. Blazek, and L. Prokop. "Fuzzy-based efficient control of DC microgrid configuration for PV-energized EV charging station". Energies, vol. 16, no. 6, pp. 2753, 2023.

25. S. Zaid, H. Albalawi, K. Alatawi, H. El-Rab, M. El-Shimy, A. Lakhouit, T. Alhmiedat, and A. Kassem. "Novel fuzzy controller for a standalone electric vehicle charging station supplied by photovoltaic energy". Applied System Innovation, vol. 4, no. 2, pp. 63, 2021.

26. M. Razzaq. "Solar Powered Electric Vehicle Charging Station with Fuzzy Logic Controller". IEEE International Conference on Engineering and Emerging Technologies (ICEET), pp. 1–6, 2021.

27. P. Pathak, A. Yadav, S. Padmanaban, and P. Alvi. "Design of robust multi-rating battery charger for charging station of electric vehicles via solar PV system". Electric Power Components and Systems, vol. 50, no. 14-15, pp. 751-761, 2022.

28. S. Parveen, S. Gupta, and S. Nema, "Fuzzy based solar MPPT for electric vehicle application". IEEE International Conference On Electrical Power and Energy Systems (ICEPES), pp. 1–5, 2021.

29. P. Raj, V. Prabhu, V. Krishnakumar, and M. Anand. "Solar Powered Charging of Fuzzy Logic Controller (FLC) Strategy with Battery Management System (BMS) Method Used for Electric Vehicle (EV)". International Journal of Fuzzy Systems, vol. 25, no. 7, pp. 2876-2888, 2023.

30. T. Obeidi, C. Larbes, A. Ilinca, G. Filiz, and T. Kebir. "Fuzzy logic-based maximum power point tracking for a solar electric vehicle". Acta Polytechnica Hungarica, vol. 15, no. 7, pp. 133-156, 2018.

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH

IN SCIENCE, ENGINEERING AND TECHNOLOGY

| Mobile No: +91-6381907438 | Whatsapp: +91-6381907438 | ijmrset@gmail.com |

www.ijmrset.com