International Journal of Scientific Research & Engineering Trends
Volume 12, Issue 6, Nov-Dec-2026, ISSN (Online): 2395-566X

Analysis of Fuzzy Logic Based MPPT Technique for Solar PV System Using MATLAB/SIMULINK

Nisha Kumari[1], Taranjeet Kaur[2]
[1]M.Tech Scholar: Deptt. Of Electrical Engineering Institute Of Engineering And Technology Bhaddal, Ropar Nk321229@Gmail.Com
[2]Associate Professor: Deptt. Of Electrical Engineering Institute Of Engineering And Technology Bhaddal, Ropar Taran1309@Gmail.Com

Abstract – The performance of a solar photovoltaic (PV) system is strongly influenced by changes in solar irradiance, which shift the operating point of the PV array. This study analyzes a fuzzy logic based Maximum Power Point Tracking (MPPT) technique implemented in MATLAB/Simulink. A single approximately 250 W PV module is interfaced with a DC–DC boost converter and a fuzzy logic controller using the error and change in error as control inputs. The controller uses five linguistic variables—Negative Big, Negative Small, Zero, Positive Small and Positive Big—and a 25-rule knowledge base to regulate the converter duty cycle. The system is evaluated at 800, 600, 400 and 200 W/m² while the temperature is maintained at 25°C. The thesis results show that the fuzzy MPPT reaches stable powers of 200, 150, 100 and 50 W respectively, matching the stated target maximum powers. In contrast, the corresponding responses without fuzzy MPPT oscillate over 194–206, 145.5–154.5, 97–103 and 48.5–51.5 W. These results indicate that the fuzzy controller provides stable maximum-power operation across the tested irradiance conditions.

Keywords—Solar PV, Maximum Power Point Tracking, Fuzzy Logic Controller, DC–DC Boost Converter, MATLAB/Simulink, Irradiance.

I. INTRODUCTION

Solar photovoltaic generation is an important renewable-energy technology because it converts sunlight directly into electrical energy. The electrical characteristics of PV modules are nonlinear and vary with environmental conditions, particularly irradiance and temperature. For a given operating condition, a maximum power point (MPP) exists on the PV power–voltage characteristic. Because this point changes as the operating conditions change, an MPPT controller is required to extract the available PV power effectively.

Conventional MPPT methods such as Perturband Observe (P&O) and Incremental Conductance are widely used because of their relatively simple implementation. However, the supplied thesis identifies oscillation around the MPP and reduced response under rapidly changing conditions as important limitations of conventional approaches. Fuzzy Logic Control (FLC) offers an alternative for nonlinear PV control because it does not require an exact mathematical model and can make control decisions using linguistic rules.

The objective of the present work is to analyze a fuzzy logic based MPPT controller for a PV system in MATLAB/Simulink and compare itsoutput-power response with the corresponding system without fuzzy MPPT at four irradiance levels. The work focuses on the power response, stability around the operating point and the ability of the controller to reach the stated maximum-power values.

II. LITERATURE REVIEW

Ankit Gupta et al. (2014) The maximum power point tracking (MPPT) technique in the photovoltaic (PV) system is used to achieve maximum power through the solar PV system. Therefore, the interest is generated to design a more effective and efficient MPPT to achieve maximum power transfer to the load. In this context, two MPPT techniques, i.e. artificial neural network (ANN) and fuzzy logic control (FLC) are implemented and their performance is analysed. Both the MPPT techniques are investigated in terms of efficiency and response and they are developed in MATLAB/Simulink environment. Their performance is investigated under variable irradiation conditions and found satisfactory for both the techniques.

T. P. Mish-al et al. (2022) The maximum power of a PV module varies due to changing temperature, solar radiation, and load. To maximize efficiency, PV systems use a maximum power point tracker (MPPT) to constantly extract the highest power that can be produced by a solar panel and then deliver it to the load. The MPPT finds and maintains operations at the maximum power point using a tracking algorithm during variations in weather conditions. to design and implement a maximum power point tracker that uses a fuzzy logic control algorithm. Because of the nonlinear behaviour of PV module current-voltage characteristics and the nonlinearity of DC-DC converters due to switching, conventional controllers are unable to provide the best response, especially when dealing with wide parameter

© 2026 IJSRET

variations and line transients. Fuzzy logic naturally provides a superior controller for this type of nonlinear application. An integrated model of the PV module with the Boost Converter is simulated in MATLAB to obtain the expertise required for the formulation and development of the fuzzy logic controller.

T. P. Mish-al et al. (2022) The maximum power of a PV module varies due to changing temperature, solar radiation, and load. To maximize efficiency, PV systems use a maximum power point tracker (MPPT) to constantly extract the highest power that can be produced by a solar panel and then deliver it to the load. The MPPT finds and maintains operations at the maximum power point using a tracking algorithm during variations in weather conditions. to design and implement a maximum power point tracker that uses a fuzzy logic control algorithm. Because of the nonlinear behaviour of PV module current-voltage characteristics and the nonlinearity of DC-DC converters due to switching, conventional controllers are unable to provide the best response, especially when dealing with wide parameter variations and line transients. Fuzzy logic naturally provides a superior controller for this type of nonlinear application. An integrated model of the PV module with the Boost Converter is simulated in MATLAB to obtain the expertise required for the formulation and development of the fuzzy logic controller.

Kifayat Ullah et al. (2023) The ability of the Maximum Power Point Tracking (MPPT) technology to prevent losses by stabilizing power fluctuations during severe weather conditions is critical in improving photovoltaic power generation systems. Overall system stability is improved by carefully tracing the maximum power point (MPP). This research focuses on improving MPPT performance in solar systems by employing the "Fuzzy Logic" control method. The simulation, which is run in MATLAB/Simulink, includes a detailed model of the entire system. The primary circuit is designed with a DC-DC Boost architecture and a single MOSFET transistor. The Fuzzy Logic Controller (FLC) unit in MATLAB/Simulink generates an output variable led by two input variables via the Fuzzy Logic Controller unit. The Fuzzy Logic Controller (FLC) unit generates an output variable led by two input variables in MATLAB/Simulink. The simulation model, called "Fuzzy Disturbance," combines Perturb & Observe with Fuzzy Logic and runs for 3 s. The results show an essential increase in system efficiency to 97%. The simulation results show that the suggested approach tracks MPP, reduces output power fluctuations, and improves system efficiency.

Akash Garg (2015) Energy is essential component for improving the living condition of the civilization. One of the major concerns in the power sector is that day to day increasing power demand has forced to use the fossil fuels in extreme causing the increasing serious environmental problems thus it is essential to use renewable energies which are characterized by their negligible pollution level and environment friendly. Solar photovoltaic is a phenomenon where the solar irradiance is converted directly into electricity through solar cell. The photovoltaic energy as an alternative energy source has been widely used as it is pollution free, abundant and broadly available. An important consideration in the use of PV system is to operate the system near maximum power point so as to increase the output efficiency of PV panel. Maximum power point tacking (MPPT) techniques are used in PV applications to extract the maximum power that PV panel can produce, which depends upon different atmospheric conditions i.e solar insolation and temperature. DC-DC converter is inserted between PV array and load for obtaining the desired voltage level at load side. In this paper, a new maximum power point tracker using fuzzy set theory is proposed to improve energy conversion efficiency. Fuzzy algorithm based on linguistic rules describing the operator's control strategy is applied to control boost converter for maximum power point tracking linguistic variables implemented in the fuzzy logic controller have been selected appropriately to modulate the DC-DC converter. Fuzzy logic controller provides advanced features such as fast response, good performance in terms of oscillations. The fuzzy logic controller is designed and analyzed in MATLAB/SIMULINK.

Sasi and Mahmud Ahmed (2017). This thesis presents a comparison between two methods to optimize the energy extraction in a photovoltaic (PV) power system. The maximum power of a PV module varies due to changing temperature, solar radiation, and load. To maximize efficiency, PV systems use a maximum power point tracker (MPPT) to constantly extract the highest power that can be produced by a solar panel and then deliver it to the load. The general structure of an MPPT system contains a DC-DC converter (an electronic device that converts a source of direct current DC from one voltage

level to another) and a controller. The MPPT finds and maintains operations at the maximum power point using a tracking algorithm during variations in weather conditions. Many different algorithms of MPPT have been proposed and discussed in the literature, but most of these methods have disadvantages in terms of efficiency, accuracy, and flexibility. Because of the nonlinear behavior of PV module current-voltage characteristics and the nonlinearity of DC-DC converters due to switching, conventional controllers are unable to provide the best response, especially when dealing with wide parameter variations and line transients.

© 2026 IJSRET

Vasantharja Subaramanian et al. (2021) Due to the easiness of setup and great energy efficiency, direct current (DC) microgrids (MGs) have become more common. Solar photovoltaic (PV) and fuel cell (FC) systems drive the DC MG. Under varying irradiance and temperature, this work proposes a fuzzy logic controller (FLC) based maximum power point tracking (MPPT) approach deployed to PV panel and FC generated boost converter. PV panels must be operated at their maximum power point (MPP) to enhance efficiency and shorten the system's payback period. There are different kinds of MPPT approaches for using PV panels at that moment. Still, the FLC-based MPPT approach was chosen in this study because it responds instantaneously to environmental changes and is unaffected by circuit parameter changes. Similarly, this research proposes a better design strategy for FLC systems. It will improve the system reliability and stability of the response of the system. An FLC evaluates PV and FC via DC–DC boost converters to obtain this enhanced response time and accuracy.

Sundeep Siddula et al. (2020) An MPPT technique containing of two methods: incremental conductance (INC) and Fuzzy Logic (FL) control is presented in this paper. Under variable solar irradiance this algorithm is able to track maximum power point (MPP). Due to the upcoming shortage in fossil fuels, renewable energy becomes the key source in which solar energy stands as the most promising. The generation rate of the solar panel is low and can be improved with the help of MPPT techniques. In order to validate that the introduced system is better in both effectiveness and the usefulness than the conventional methods, simulation analysis has been done and comparative studies of other methods are conducted. The results show that the introduced method can track MPP under different solar irradiance and will possibly reduce fluctuation in MPP area.

Unal Yilmaz et al. (2017) This paper puts forward to Fuzzy Logic MPPT (Maximum Power Point Tracking) method applied photovoltaic panel sourced boost converter, under variable temperature (25–60 °C) and irradiance (700–1000 W/m2) after that the PI control was applied buck converter to behave as a charge controller. The voltage and current of PV panels are nonlinear and they depend on environmental conditions such as temperature and irradiance. Variable environmental conditions cause to change voltage, current and also cause to change maximum available power of PV panels. To increase efficiency and decrease payback period of the system, it needs to operate PV panels at maximum power point (MPP). Under any environment conditions there is unique MPP. To operate PV panels at that point (MPP) there are many MPPT method in literature, FLC MPPT method was preferred in this study because, its rapid response to changing environmental conditions and not affecting by change of circuit parameters. The accuracy of FLC MPPT method used in this system to find MPP changes, from 94.8% to 99.4%. To charge a battery there are two traditional methods which are constant current (CC), and constant voltage (CV) methods. For fast charging with low loss constant current and voltage source is a need. One of the methods providing constant is PI control which used in this study. PI control is not only well developed and a simple technique but also it provides satisfactory results. The goal of this study is operating PV panel at maximum power point under variable environment conditions to increase efficiency and reduce cost and also provide appropriate current and voltage for charging battery to charge quickly, reduce losses and also increase life cycle of battery. This system was established and analyzed in MATLAB/Simulink.

Swarup Kumar Saha et al. (2018). Sunlight based Photovoltaic (PV) is a vital sustainable power hotspot for mankind. The productivity of the PV framework is subject to the different ecological elements like irradiance, temperature, tidy, daylight's ghastly thickness. By utilizing

Maximum Power Point Tracking (MPPT) strategies, we can build the effectiveness of sun oriented photovoltaic framework. Numerous strategies have been proposed to build the energy of PV module in the diverse condition factors. In the present work Genetic algorithm based Fuzzy Logic MPPT has been utilized and reproduction comes about are contrasted with Perturb and Observe (P&O) MPPT utilizing MATLAB. A Solar Photovoltaic Generation System incorporated a sun powered module, a Fuzzy Logic Controller (FLC), a Boost converter (venture up converter) and a resistive load. Fuzzy Logic Controller use for controlling the switch plot for boost Converter. Viability and achievability of the FLC based MPPT system is appeared by the recreation result.

CB Prasad et al. (2017). The maximum power point tracking based on fuzzy logic controller of photovoltaic power generation is proposed based on perturbation and observation MPPT method. The real time adjustment of fuzzy logic controller gives a stable and smooth operation of solar power generation with maximum output. The proposed method of fuzzy controller is simulated using MATLAB/Simulink and results are presented.

I. System Model And Methodology

1. Pv Array And Simulation Conditions

The simulated system uses one PV module with an approximate nominal power of 250 W. The reference conditions are 1000 W/m² and 25°C. The module parameters reported in the thesis are Voc = 37.3 V, Isc = 8.66 A, Vmp = 30.7 V and

Imp = 8.15 A. The PV output power is evaluated from the measured PV voltage and current.

© 2026 IJSRET

Parameter	Value	Parameter	Value
PVmodule power	≈250 W	Vmp	30.7 V
Voc	37.3 V	Imp	8.15 A
Isc	8.66 A	Reference temperature	25°C
Series modules	1	Parallel strings	1

2. Boost Converter

A DC–DC boost converter is placed between the PV array and the load so that the operating point can be controlled through the converter duty cycle. The basic simulation parameters reported in the thesis are an inductance of 5 mH, an output capacitance of 1000 mF, a 10 Ω load resistance, a 10 kHz switching frequency and an initial duty cycle of 0.3.

3. Fuzzy Logic Mppt Controller

The fuzzy controller receives two inputs: the error E and the change in error ΔE. The thesis defines the error from the change in power with respect to the change in voltage, $E(k) = [P(k) - P(k-1)]/[V(k) - V(k-1)]$, and $\Delta E(k) = E(k) - E(k-1)$. The controller output is the change in duty cycle applied to the boost converter.

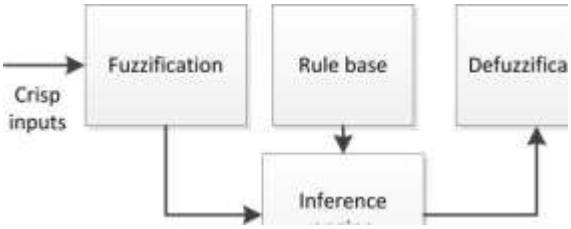


Fig. 1. Block Diagram of Fuzzy Logic Controller

Five linguistic variables are used for each input and output: NB, NS, ZE, PS and PB. The input ranges are −1 to +1 and the output range for the change in duty cycle is −0.01 to +0.01. A 25-rule fuzzy rule base determines the required duty-cycle correction.

E / ΔE	NB	NS	ZE	PS	PB
NB	NB	NB	NB	NS	ZE
NS	NB	NS	NS	ZE	PS
ZE	NB	NS	ZE	PS	PB
PS	NS	ZE	PS	PS	PB
PB	ZE	PS	PB	PB	PB

4. Simulation Procedure

Four irradiance conditions—800, 600, 400 and 200 W/m² are simulated at a constant temperature of 25°C. Two operating cases are considered under the same conditions: (i) PV system without fuzzy logic MPPT and (ii) PV system with the fuzzy logic MPPT controller. The PV output power is recorded as a function of simulation time for direct comparison.

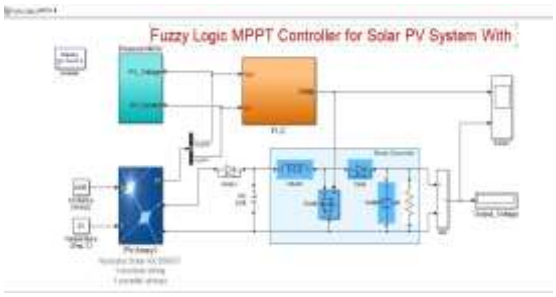


Fig. 2. Complete MATLAB/Simulink model of the PV system.

III. RESULTS

The numerical results in the supplied thesis summarize the maximum/steady-state power obtained at each irradiance level. With fuzzy logic MPPT, the response reaches the stated target maximum power and is described as stable at all four test conditions. Without fuzzy MPPT, the response oscillates around the target value. The ranges shown below are taken directly from the thesis result table.

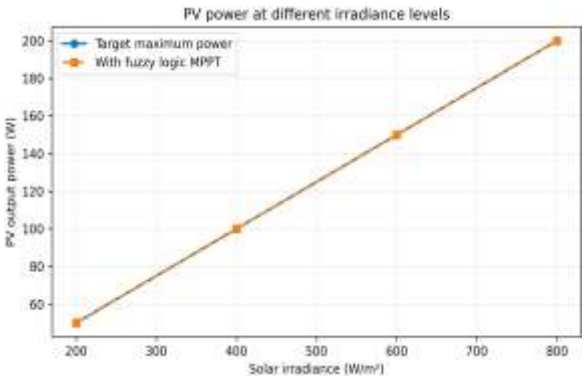


Fig. 3. Target and fuzzy-MPPT PV power at different irradiance levels.

Figure 3 shows that the stable power reported with fuzzy MPPT follows the target maximum-power values at all four irradiance levels. The reduction in available power across the tested conditions corresponds to the reduction in solar irradiance used in the simulation.

© 2026 IJSRET

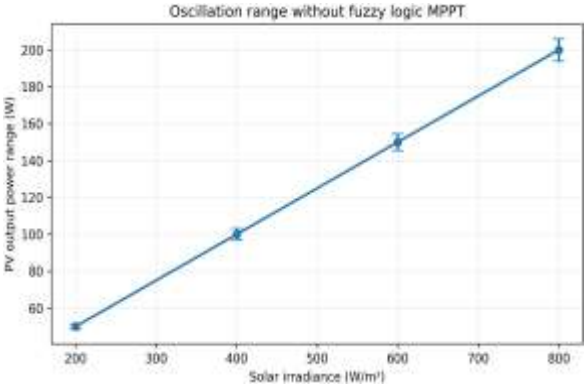


Fig. 4. Reported PV power oscillation range without fuzzy MPPT.

Figure 4 represents the lower and upper power values reported for the system without fuzzy MPPT. The width of the oscillation band is 12 W at 800 W/m², 9 W at 600 W/m², 6 W at 400 W/m² and 3 W at 200 W/m².

Irradiance	Target max power	With FLC-MPPT	Without FLC-MPPT	Oscillation span
200 W/m²	50.0 W	50.0 W (stable)	48.5–51.5 W	3.0 W
400 W/m²	100.0 W	100.0 W (stable)	97.0–103.0 W	6.0 W
600 W/m²	150.0 W	150.0 W (stable)	145.5–154.5 W	9.0 W
800 W/m²	200.0 W	200.0 W (stable)	194.0–206.0 W	12.0 W

The supplied thesis figures describe these responses as oscillating, whereas the fuzzy-MPPT responses are described as stable.

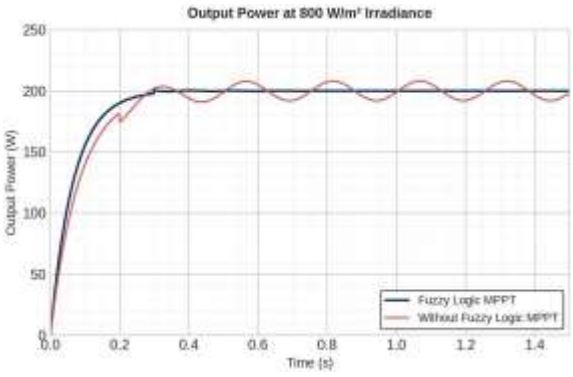


Figure 5. PV output power with and without fuzzy logic MPPT at 800 W/m² irradiance.

IV. DISCUSSION

The simulation comparison supports the intended role of the fuzzy controller: it adjusts the converter operating point so that the PV system settles at the target maximum-power value under each tested irradiance condition. The controller therefore provides a stable operating response without requiring a detailed mathematical PV model. The result is consistent

with the thesis objective of evaluating fuzzy logic MPPT under varying irradiance.

At 800 W/m², the target and fuzzy-MPPT power are both 200 W, while the no-MPPT response spans 194–206 W. At 600 W/m², the corresponding values are 150 W and 145.5–

W; at 400 W/m², 100 W and 97–103 W;

and at 200 W/m², 50 W and 48.5–51.5 W. Thus, the main observed distinction in the supplied results is stability of the power response rather than a higher steady-state target than the target MPP itself.

V. CONCLUSION AND FUTURE SCOPE

This paper presented an analysis of a fuzzy logic based MPPT technique for a solar PV system using MATLAB/Simulink. The modeled system consisted of a PV module, a DC–DC boost converter and a fuzzy logic controller based on error and change in error. Simulation was performed at 800, 600, 400 and 200 W/m² with temperature maintained at 25°C. The reported results show stable fuzzy-MPPT powers of 200, 150, 100 and 50 W, respectively, while the corresponding no-MPPT responses exhibit oscillation around these target values. Within the tested conditions, the fuzzy controller therefore demonstrates stable maximum-power tracking and adaptation to changes in irradiance.

Future work identified in the thesis includes real-

time hardware implementation using platforms such as Arduino, DSP or FPGA; evaluation under partial-shading conditions; investigation of ANN, ANFIS and PSO-assisted approaches; and extension to grid-connected and hybrid renewable-energy systems.

REFERENCES

1. Ankit Gupta and Pawan Kumar, “Performance analysis of neural network and fuzzy logic based MPPT techniques for solar PV systems,” 2014 6th IEEE Power India International Conference (PIICON).

© 2026 IJSRET

2. T. P. Mish, Kumar K. Nanda, Kumar Reddy and V. Mahesh, "Modeling of fuzzy logic based MPPT for PV array in Simulink/MATLAB," AIP Conference Proceedings, vol. 2452, 040007, 2022.
3. Kiffayat Ullah and Mohammad Ishaq, "Fuzzy-based maximum power point tracking (MPPT) control system for photovoltaic power generation system," Results in Engineering, vol. 20, 101466, December 2023.
4. Akash Garg, "Comparison of P&O and Fuzzy Logic Controller in MPPT for Photovoltaic (PV) Applications by Using MATLAB/Simulink."
5. Unal Yilmaz and Ali Kircay, "PV system fuzzy logic MPPT method and PI control as a charge controller," Renewable and Sustainable Energy Reviews, vol. 81, part 1, pp. 994–1001, January 2018.
6. Carlos Robles Algarin and John Taborda Giraldo, "Fuzzy Logic Based MPPT Controller for a PV System," Energies, vol. 10, no. 12, 2036, 2017.
7. Hegazy Rezk and Mokhtar Aly, "Design and Hardware Implementation of New Adaptive Fuzzy Logic-Based MPPT Control Method for Photovoltaic Applications," IEEE Access, vol. 7, pp. 106427–106438, 2019.
8. Mahmoud N. Ali and Karar Mahmoud, "An Efficient Fuzzy-Logic Based Variable-Step Incremental Conductance MPPT Method for Grid-Connected PV Systems," IEEE Access, vol. 9, pp. 26420–26430, 2021.
9. Diogo Remoaldo and Isabel Jesus, "Analysis of a Traditional and a Fuzzy Logic Enhanced Perturb and Observe Algorithm for the MPPT of a Photovoltaic System," Algorithms, vol. 14, no. 1, 24, 2021.
10. Muhammad Sheraz and M. A. Abido, "An Efficient Fuzzy Logic Based Maximum Power Point Tracking Controller for Photovoltaic Systems," ICREPQJ, 2013.
11. Carlos Robles Algarin and John Taborda Giraldo "Fuzzy Logic Based MPPT Controller for a PV System", Energies 2017, 10(12),2036; https://doi.org/10.3390/en10122036 Submission received: 19 October 2017. Published: 2 December 2017.
12. Hegazy Rezk and Mokhtar Aly "Design and Hardware Implementation of New Adaptive Fuzzy Logic-Based MPPT Control Method for Photovoltaic Applications", in IEEE Access, vol. 7, pp. 106427-106438, 2019, doi: 10.1109/ACCESS.2019.2932694.
13. Tao Hai and Jincheng Zhou "An efficient fuzzy-logic based MPPT controller for grid-connected PV systems by farmland fertility optimization algorithm", Optik Volume 267, October 2022, 169636.
14. Mahmoud N. Ali and Karar Mahmoud "An Efficient Fuzzy-Logic Based Variable-Step Incremental Conductance MPPT Method for Grid-Connected PV Systems", in IEEE Access, vol. 9, pp. 26420-26430, 2021.
15. Basem E. Elnaghi and Ahmed M.Ismaiel "Experimental validation of an adaptive Fuzzy Logic controller for MPPT of grid connected PV system", Sci Rep 15, 27173 (2025).
16. Claude Bertin Nzoundja Fapi and Hyacinthe Tchakount "Fuzzy logic-based maximum power point tracking control for photovoltaic systems: A review and experimental applications", Arch Computat Methods Eng 32, 24052428 (2025).
17. Sunkara Sunil Kumar & K. Balakrishna "A novel design and analysis of hybrid fuzzy logic MPPT controller for solar PV system under partial shading conditions", Scientific Reports volume 14, Article number: 10256 (2024).
18. Diogo Remoaldo & Isabel Jesus "Analysis of a Traditional and a Fuzzy Logic Enhanced Perturb and Observe Algorithm for the MPPT of a Photovoltaic System", Algorithms 2021.
19. Muhammad Sheraz and M.A. Abido "An Efficient Fuzzy Logic Based Maximum Power point Tracking Controller for Photovoltaic Systems", International Conference on Renewable Energies and Power Quality (ICREPQ'13) Bilbao (Spain), 20th to 22th March, 2013

© 2026 IJSRET