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A Review on Neural Network-Assisted Boost Converter for Enhanced Voltage Gain in Solar PV Systems

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Abstract: Solar photovoltaic (PV) systems are increasingly adopted as sustainable energy sources; however, their inherently low output voltage and sensitivity to environmental variations limit their effectiveness in high-voltage applications. Conventional boost converters often fail to provide sufficient voltage gain efficiently, while isolated converter topologies increase cost, size, and complexity. This paper proposes an Artificial Neural Network (ANN)-controlled interleaved boost converter integrated with a Maximum Power Point Tracking (MPPT) algorithm to enhance voltage gain and overall system efficiency. A Radial Basis Function Neural Network (RBFNN) is employed to dynamically track the maximum power point under fluctuating irradiance and temperature conditions. The interleaved converter topology minimizes current ripple, distributes thermal stress, and reduces switching losses, resulting in improved reliability and performance. MATLAB/Simulink simulations demonstrate superior voltage amplification, reduced harmonic distortion, and improved dynamic response compared to conventional control methods. The proposed system offers a cost-effective and adaptive solution suitable for high-voltage renewable energy applications such as electric vehicles, grid-connected PV systems, and energy storage integration. This research highlights the potential of intelligent control techniques in advancing high-performance solar energy conversion systems.
Keywords: Solar Photovolatic (PV) System, Interleaved Boost Converter, Maximum Power Point Tracking (MPPT), Artificial Neural Network (ANN), High Voltage Gain.

I. INTRODUCTION

The increasing global demand for energy, coupled with environmental concerns and the depletion of fossil fuels, has accelerated the transition toward renewable energy sources. Among the available alternatives, solar photovoltaic (PV) systems have emerged as one of the most promising solutions due to their abundance, sustainability, and environmental friendliness. Solar PV technology converts sunlight directly into electrical energy, making it suitable for residential, industrial, and grid-connected applications. Despite these advantages, PV systems suffer from inherent limitations, including low output voltage levels and dependency on environmental conditions such as solar irradiance, temperature, and shading. These factors significantly affect power generation and system stability, particularly in high-voltage applications such as electric vehicles, grid integration, and renewable energy storage systems.

To overcome the low output voltage of PV arrays, DC–DC boost converters are commonly employed to step up the voltage to required levels. However, conventional boost converters face challenges such as high switching losses, increased current ripple, limited voltage gain, and reduced efficiency when operating under dynamic environmental conditions. Additionally, high duty cycle operation required for large voltage gain increases component stress and reduces reliability. Researchers have proposed high-gain converter topologies incorporating coupled inductors, switched capacitors, and voltage multiplier cells to improve voltage amplification and efficiency [1], [5]. Interleaved boost converter configurations have gained significant attention because they distribute current among multiple phases, reduce input current ripple, and improve thermal performance and efficiency [1], [7].

Isolated converters using high-frequency transformers can achieve high voltage gain by adjusting the turns ratio, but they increase system cost, complexity, and size. Therefore, non-isolated high-gain converters are preferred for compact and cost-effective PV applications [2]. Advanced topologies integrating coupled inductors and voltage multiplier units have demonstrated improved voltage gain while reducing voltage stress on switching devices [8]. Additionally, ultra-high gain architectures combining switched-inductor and capacitor networks have shown promising results for high-power applications, though they may introduce design complexity and control challenges [7].

Another critical challenge in PV systems is maximizing energy extraction under varying environmental conditions. The power–voltage (P–V) characteristics of PV modules are nonlinear and vary with irradiance and temperature, making Maximum Power Point Tracking (MPPT) essential for optimal performance.

Traditional MPPT techniques such as Perturb and Observe (P&O) and Incremental Conductance (IncCond) are widely used due to their simplicity, but they suffer from slow tracking speed, oscillations near the maximum power point, and reduced efficiency under rapidly changing conditions [3]. Intelligent control techniques, including Artificial Neural Networks (ANN), fuzzy logic, and hybrid algorithms, have been introduced to address these limitations [5].

ANN-based MPPT methods offer significant advantages, including fast convergence, adaptability, and the ability to handle nonlinear system behavior. Neural networks can learn from data and predict optimal operating points, improving tracking efficiency under partial shading and dynamic atmospheric conditions [3], [4]. Experimental studies have demonstrated that ANN-based MPPT systems can achieve higher tracking efficiency and faster response compared to conventional techniques [4]. Recent advancements in deep learning approaches further enhance MPPT performance by improving prediction accuracy and dynamic adaptation [9].

This research proposes an ANN-controlled interleaved boost converter for solar PV systems to achieve high voltage gain, improved efficiency, and enhanced dynamic performance. A Radial Basis Function Neural Network (RBFNN) is implemented to optimize MPPT under fluctuating environmental conditions. The interleaved topology reduces ripple, switching stress, and harmonic distortion while improving system reliability. The proposed system is modeled and simulated in MATLAB/Simulink to evaluate performance in terms of voltage gain, efficiency, and harmonic reduction. The integration of intelligent control with advanced converter topology provides a cost-effective and robust solution for high-voltage renewable energy applications, including electric vehicles, smart grids, and hybrid energy systems.

II. EASE OF USE

A. Problem Identification

The growing global demand for energy and the depletion of conventional fossil fuels have accelerated the adoption of renewable energy sources, particularly solar photovoltaic (PV) systems. Although solar energy is abundant and environmentally friendly, PV panels inherently produce low output voltage and their performance varies significantly with changes in solar irradiance, temperature, and shading conditions. This variability leads to unstable power generation and limits the direct use of PV systems in high-voltage applications such as electric vehicles, grid-connected systems, and industrial loads.

Conventional DC–DC boost converters are widely used to increase PV output voltage; however, they face limitations including high switching losses, reduced efficiency at high duty cycles, excessive current ripple, and increased component stress. While isolated converters can provide high voltage gain, they increase system cost, size, and complexity, making them unsuitable for compact renewable energy applications. Additionally, traditional Maximum Power Point Tracking (MPPT) methods such as Perturb & Observe and Incremental Conductance exhibit slow response and oscillations under rapidly changing environmental conditions.

Therefore, an efficient, high-gain, and intelligent control-based solution is required to improve voltage gain, enhance energy extraction, and ensure stable operation of solar PV systems.

B. Literature Review

Chen, S.-J et. al. (2024), This paper presents an interleaved high-gain DC–DC topology that combines winding-cross-coupled inductors (WCCIs) with voltage-multiplier cells to attain large step-up ratios without resorting to bulky transformers. The interleaved structure reduces input current ripple and thermal stress by dividing the PV source current among phases; the WCCI mitigates leakage effects and improves energy transfer efficiency. Simulation and experimental results show improved voltage gain across a range of duty cycles and operating conditions, with lower component voltage stress compared to some prior high-gain topologies. The authors emphasize the design's suitability for PV systems where non-isolated, compact, high-gain solutions are desired, noting tradeoffs in complexity and component count.

Majid Hosseinpour et. al. (2025), This recent study proposes an interleaved boost architecture integrated with a voltage-multiplier rectifier to achieve superior voltage amplification while remaining non-isolated. The authors analyze two distinct duty-cycle operating regions, demonstrating flexible operation from low to high duty cycles. Interleaving reduces ripple and spreads switching losses across phases, while the multiplier raises effective output without transformer turns ratio. Simulation and lab validation confirm improved efficiency and stable regulation under varying input (PV) conditions and loads, showing applicability to EV charging and energy storage interfaces. The converter attains high conversion ratios with manageable switch stress, though careful component sizing and control are required to balance conduction and switching losses.

Ahmad Dawahdeh et. al. (2024), This paper integrates a neural network with classical Perturb & Observe (P&O) MPPT to enhance tracking during rapid irradiance changes. The ANN is trained to predict optimal duty-cycle adjustments and to correct P&O's direction errors, reducing oscillation and improving convergence speed.

Results (simulated and hardware) show higher tracking efficiency and faster recovery from transient shading compared to base P&O and standalone ANN schemes. The hybrid approach exploits the simplicity of P&O and the adaptability of ANN — lowering steady-state oscillations and tracking time while maintaining implementation feasibility on embedded platforms. The authors report tradeoffs in the need for training data and occasional retraining to accommodate long-term PV aging/seasonal shifts.

Ahmed Fathy Abouzeid et. al. (2024), The study experimentally validates an ANN-based MPPT algorithm on a small-scale PV setup. The ANN is trained with measured PV I–V/P–V profiles and implemented on low-cost hardware. Experimental outcomes indicate an MPPT efficiency of ~98.16% and a fast tracking time (~1.3 s) under step irradiance changes, outperforming traditional P&O and Incremental Conductance methods in both speed and steady-state power extraction. The results emphasize ANN's practical viability for cost-sensitive PV applications, highlighting its resilience to rapid environmental changes. The authors discuss implementation considerations — microcontroller capacity, memory for weights, and the need for representative training sets to ensure robustness across seasonal and module-to-module variations.

Lyu Guanghua et. al. (2025), This comprehensive review classifies MPPT techniques into traditional (P&O, IncCond), advanced (fuzzy, sliding-mode), and intelligent/deep-learning based methods. It compares metrics such as tracking speed, complexity, hardware requirement, partial shading capability, and real-time adaptability. The paper highlights that while classical algorithms are simple and easy to implement, they suffer under partial shading and fast dynamics. Intelligent techniques (ANN, fuzzy, DNN/LSTM) show superior steady-state performance and robustness but require training data, higher computational resources, and careful hyperparameter tuning. Hybrid methods (ANN+P&O, fuzzy+IncCond) often offer practical tradeoffs, improving dynamic response without prohibitive complexity. The review calls for standardized benchmarks and more experimental validations.

A.S. Valarmathy et. al. (2024), This review surveys high-gain interleaved boost-derived converters, cataloguing gain-extension techniques: coupled inductors, switched capacitors/multiplier cells, cross-coupling, multi-stage/interleaving, and switched-inductor networks. It discusses how interleaving reduces input ripple and allows smaller inductors, while cascaded/multiplier approaches increase voltage but at cost of more components and higher stress on switches/capacitors. The survey highlights design tradeoffs: efficiency vs. complexity, voltage stress management, EMI, and converter control. Practical recommendations include combining interleaving with soft-switching and selective multiplier stages for improved efficiency in PV applications. The paper also identifies benchmarking gaps in long-term reliability studies and partial shading effects.

Ammar Algamluoli et. al. (2023), This paper introduces a modified triple-boosting architecture interleaved with switched-inductor/capacitor modules that produces ultra-high voltage gain without isolation. The design specifically addresses high-gain demands for PV to grid/battery interfaces. The authors demonstrate that combining multi-boost stages with interleaving doubles/triples the effective gain with acceptable efficiency levels and manageable component stresses when duty cycles are optimized. Simulations show that the architecture can achieve conversion ratios unattainable by simple boost converters, but practical concerns — increased component count, inrush currents, and control complexity — are noted. The authors conclude the topology is promising for medium-power applications where size/weight constraints outweigh cost.

Yuqing Yang et. al. (2024), This study proposes a coupled-inductor plus voltage-multiplier unit topology targeted at matching battery and DC bus voltages in hybrid vehicle energy systems. The coupled inductor enables energy exchange that raises voltage while the multiplier reduces switch voltage stress. The topology improves efficiency by using energy-exchange capacitors and reduces peak stress from leakage inductance. Experimental results show improved gain and lower switch stress compared to classic coupled-inductor converters. The research underscores applicability to PV-battery hybrid systems, suggesting that similar strategies can be adapted to PV-only high-gain converters; however, control complexity and component tolerances (coupling coefficient) must be carefully managed for real-world deployment.

Bappa Roy et. al. (2024), This paper evaluates DNN/LSTM models trained on historical PV datasets to predict the MPP under varying irradiance/temperature and partial shading. Results demonstrate improved tracking under highly dynamic conditions, with LSTM's temporal modeling yielding faster, more accurate adaptation than feedforward ANN in scenarios with temporal irradiance patterns (passing clouds). The study emphasizes data quality, the need for realistic training sets, and computational cost — recommending edge-compatible network architectures or model compression/pruning for embedded implementation. While deep models outperform classic algorithms in simulation and offline validation, the paper calls for more hardware-in-loop and long-term field tests to validate robustness and energy gains in real PV installations.

Edara Sreelatha et. al. (2024), This work presents a bidirectional interleaved boost converter aimed at interfacing a 24 V PV source and a 12 V battery to a 400 V DC link. The converter uses phase-shifted interleaving to reduce ripple and enable bidirectional power flow for charging/discharging scenarios. Simulated and hardware results show good voltage regulation, reduced ripple, and acceptable efficiency at medium power levels.

The authors validated control with conventional PI and demonstrated that interleaving significantly reduces inductor size requirements. The study emphasizes that careful thermal management, soft-start and current limiting are essential for safe battery handling; it advocates ANN/hybrid controllers as next steps to further improve dynamic MPPT and battery management.

These studies emphasize the need for high-gain DC–DC converters to overcome the low output voltage of photovoltaic (PV) systems. Interleaved boost converters combined with coupled inductors, switched capacitors, and voltage multiplier cells have demonstrated improved voltage gain, reduced ripple, and enhanced efficiency [1], [7], [8]. Non-isolated converter topologies are preferred due to their compactness and cost-effectiveness compared to transformer-based designs [2]. Research also highlights the importance of Maximum Power Point Tracking (MPPT) for optimizing PV output under varying environmental conditions. Conventional techniques such as Perturb & Observe and Incremental Conductance are simple but suffer from slow response and oscillations [3]. Intelligent control methods, including Artificial Neural Networks (ANN) and deep learning approaches, offer improved tracking accuracy, adaptability, and efficiency [4], [9]. Hybrid MPPT techniques further enhance performance, but implementation complexity and real-time validation remain key challenges [5].

C. Research Gap

Despite significant advancements, several challenges remain in achieving efficient high-voltage gain for solar PV applications. Many high-gain converter designs increase circuit complexity, component stress, and electromagnetic interference, affecting long-term reliability. Although interleaved converters reduce ripple and improve efficiency, their integration with intelligent control for dynamic optimization is still limited. Traditional MPPT methods struggle under rapidly changing irradiance, while ANN-based techniques often require large training datasets and high computational resources. Furthermore, most studies focus either on converter topology improvement or intelligent MPPT control independently, rather than integrating both for optimal performance. Experimental validation of ANN-controlled high-gain converters under real-time operating conditions is also limited. Therefore, there is a need for a cost-effective, non-isolated interleaved boost converter integrated with an adaptive ANN-based MPPT system to achieve high voltage gain, improved efficiency, and reliable operation in dynamic environmental conditions.

III. ANN-BASED HIGH VOLTAGE GAIN INTERLEAVED BOOST CONVERTER FOR PV SYSTEMS

A. Criteria for Selecting this Study

The selection of this study is motivated by the growing demand for efficient renewable energy systems capable of supporting high-voltage applications. Solar photovoltaic (PV) systems are widely recognized as sustainable energy sources; however, their low output voltage and performance variability under changing environmental conditions limit their effectiveness. Existing converter technologies either fail to provide sufficient voltage gain or increase system complexity and cost. Furthermore, traditional MPPT methods struggle to maintain optimal performance under fluctuating irradiance and temperature conditions. Integrating intelligent control techniques such as Artificial Neural Networks (ANN) with advanced converter topologies presents a promising solution to these challenges. This study focuses on combining an interleaved boost converter with ANN-based MPPT to enhance voltage gain, efficiency, and system reliability, making it relevant for modern renewable energy applications.

- Increasing demand for high-efficiency renewable energy systems
- Limitations of conventional boost converters in high-voltage applications
- Need for improved MPPT performance under dynamic environmental conditions
- Advantages of ANN in adaptive and intelligent control
- Requirement for cost-effective, compact, and high-gain converter solutions
- Relevance to EVs, smart grids, and renewable energy integration

B. Method of Analysis

The proposed system is analyzed using a simulation-based methodology to evaluate performance under varying operating conditions. A solar PV array model is developed and integrated with a two-phase interleaved boost converter designed to achieve high voltage gain while reducing ripple and switching losses. A Radial Basis Function Neural Network (RBFNN) is implemented for Maximum Power Point Tracking (MPPT), enabling adaptive control under fluctuating irradiance and temperature conditions. MATLAB/Simulink is used to model and simulate the system, allowing detailed performance evaluation. Key performance parameters such as voltage gain, conversion efficiency, harmonic distortion, and dynamic response are analyzed and compared with conventional boost converter systems and traditional MPPT techniques.

The results are validated using different environmental scenarios to assess robustness and reliability.
- Modeling PV array under varying irradiance and temperature
- Designing interleaved boost converter topology
- Implementing RBFNN-based MPPT controller
- Simulating system in MATLAB/Simulink
- Evaluating voltage gain, efficiency, and THD
- Comparing results with conventional methods
- Validating performance under dynamic conditions

C. Highlighting trends, advancements, and challenges

Emerging Trends
- Increasing adoption of solar PV systems for sustainable energy generation.
- Shift toward high-gain DC–DC converters for EVs and grid integration.
- Growing use of interleaved converter topologies to improve efficiency.
- Integration of AI-based MPPT techniques for intelligent energy optimization.
- Expansion of smart grid and hybrid renewable energy systems.

Recent Advancements
- Development of interleaved boost converters reducing ripple and thermal stress.
- Use of coupled inductors and voltage multiplier cells for higher voltage gain.
- ANN and deep learning techniques improving MPPT accuracy and response speed.
- Hybrid control strategies enhancing system stability and efficiency.
- MATLAB/Simulink-based modeling enabling precise performance evaluation.

Key Challenges
- High circuit complexity and component stress in high-gain converters.
- Requirement of large datasets and computational power for ANN training.
- Performance degradation under partial shading and extreme weather conditions.
- Electromagnetic interference and switching losses at high duty cycles.
- Limited real-time hardware validation for intelligent control-based PV systems.

D. Discussion

1) Existing Configuration

Conventional solar photovoltaic (PV) systems employ DC–DC boost converters to step up the low output voltage of PV arrays to usable levels for loads or grid integration. A typical configuration consists of a PV array, a DC–DC converter, a Maximum Power Point Tracking (MPPT) controller, and a load or inverter stage. Traditional boost converters are widely used due to their simple design and low cost; however, they require high duty cycles to achieve large voltage gains, which results in increased switching losses, voltage stress, and reduced efficiency [3]. To improve voltage gain, researchers have proposed high-gain topologies using coupled inductors, switched capacitors, and voltage multiplier cells [1], [8]. Interleaved boost converter configurations distribute current among phases, reducing input current ripple and thermal stress while improving efficiency and reliability [7]. Conventional MPPT techniques such as Perturb & Observe and Incremental Conductance are commonly used for power optimization but exhibit oscillations and slow response under rapidly changing irradiance conditions [3]. Although ANN-based MPPT methods improve tracking accuracy and adaptability, their integration with high-gain converters remains limited in existing configurations [4], [9].

2) Proposed Configuration work

Isolated converters with high frequency transformers or coupled inductors are proposed to accomplish voltage gain at high value by altering the turns proportion of the transformer.

Nonetheless, these isolated converters are pricey contrasted with non-isolated converters. So a non-isolated converter with high voltage gain is vital for PV systems which feed high rated loads.

A high voltage gain converter is demonstrated for the fuel cell based applications, which also may have the capability of improving the performance of any kind of nonlinear system including PV system.

Fig. 1. depicts a three phase high voltage gain interleaved boost converter (IBC) which feeds high rated resistive load. Artificial Neural Network (ANN) model is used for MPPT under robust atmospheric conditions.

This diagram represents a high-gain, three-phase interleaved boost converter used in a photovoltaic (PV) system. The key components and their roles are explained below:

- PV Array: The input source, converting sunlight into DC power.
- Inductors (L1, L2, L3): Each phase has an inductor that stores energy during the switching process.
- Switches (S1, S2, S3): Controlled switches (likely MOSFETs) that turn on and off to regulate the power flow through the inductors.
- Diodes (D1, D2, D3): Used for freewheeling, ensuring current flow during the off-state of the switches and protecting the circuit from reverse currents.
- Capacitors (C1, C01, C02): Store charge and reduce voltage ripple, helping to stabilize the output voltage.
- Resistive Load (RL): Represents the load connected to the system where the output power is delivered.
- Artificial Neural Network (ANN) Model for MPPT: Maximizes the power output from the PV array by adjusting the operating point based on Maximum Power Point Tracking (MPPT).
- Controller: Uses the reference voltage (Vref) and the PV array voltage (VPV) to generate switching pulses that control S1, S2, and S3. It ensures the optimal duty cycle for efficient energy conversion.

This interleaved design reduces stress on individual components, minimizes ripple, and increases overall efficiency for high-gain applications.

3) *Proposed Work*

Proposed Work Outline for ANN-Based High Voltage Gain Interleaved Boost Converter for PV Systems:

System Overview and Objective:

- Develop an ANN-based MPPT controller integrated with an interleaved boost converter for optimizing energy output from photovoltaic (PV) systems.
- Simulate the system using MATLAB/Simulink to evaluate its performance in achieving high voltage gain with minimized harmonic distortion.

Radial Basis Function Neural Network (RBFNN) Implementation:

- Employ a Radial Basis Function Neural Network (RBFNN) model to accurately track and predict the Maximum Power Point (MPP) under fluctuating solar conditions.
- Adapt the network to dynamic environmental parameters such as irradiance and temperature.

Design of the Interleaved Boost Converter:

- Develop a two-phase interleaved boost converter to achieve a high voltage gain with reduced ripple and lower switching losses.
- Evaluate the circuit design to improve efficiency and reduce Total Harmonic Distortion (THD).

4) *Simulation and Analysis*

- Use MATLAB/Simulink to simulate the integrated system.
- Perform detailed analysis on the output voltage gain, efficiency, and harmonic reduction.
- Compare simulation results with traditional boost converter designs to assess performance improvements.

5) *Validation of Results*

- Validate simulation outcomes with real-world data to ensure the ANN-based model's accuracy in MPP tracking and efficiency improvements.
- Conduct comparison studies to showcase reduction in energy losses and better performance in high-voltage applications.

6) *Key Performance Metrics*

- Voltage Gain: Achieve higher voltage levels suitable for high-power applications like electric vehicles and grid-tied systems.
- Efficiency: Optimize energy conversion efficiency, minimizing power loss.
- Harmonic Reduction: Lower THD to ensure cleaner power output, enhancing the overall reliability of the system.

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7) Application and Future Scope

- Apply the developed system in renewable energy technologies, enhancing the feasibility of solar PV systems for high-voltage and low-input scenarios.
- Explore potential improvements in the ANN model for more complex energy systems.

E. Analysis of data

The reviewed literature indicates a clear trend toward improving voltage gain and efficiency in photovoltaic (PV) systems through advanced converter topologies and intelligent control techniques. Interleaved boost converters demonstrate superior performance by reducing input current ripple, distributing thermal stress, and enhancing overall efficiency. High-gain structures employing coupled inductors and voltage multiplier cells significantly improve voltage amplification while maintaining manageable component stress. Studies on ANN-based MPPT techniques show improved tracking accuracy, faster response, and better adaptability under fluctuating irradiance and temperature conditions compared to conventional methods. Hybrid and deep learning approaches further enhance dynamic performance but require higher computational resources. Additionally, reduced Total Harmonic Distortion (THD) and improved power quality are achieved using optimized converter designs. Overall, the data suggests that integrating intelligent control with advanced converter topology provides a reliable, efficient, and scalable solution for high-voltage renewable energy applications.

IV. CONCLUSION

This review highlights the growing importance of high-voltage gain power conversion techniques in improving the performance and applicability of solar photovoltaic (PV) systems. Conventional boost converters, although simple and cost-effective, are limited by low voltage gain, high switching losses, and reduced efficiency under dynamic operating conditions. Advanced converter topologies such as interleaved boost converters, coupled inductors, and voltage multiplier configurations have demonstrated significant improvements in voltage gain, ripple reduction, and thermal performance. Additionally, intelligent Maximum Power Point Tracking (MPPT) techniques, particularly those based on Artificial Neural Networks (ANN) and hybrid approaches, have shown superior adaptability, faster tracking, and improved energy extraction compared to traditional methods.

Despite these advancements, challenges remain in terms of circuit complexity, computational requirements, and real-time implementation. The integration of intelligent control with high-gain converter topologies presents a promising direction for achieving efficient, reliable, and cost-effective PV systems. Future research should focus on hardware validation, optimization of ANN models, and hybrid renewable energy integration to enhance system robustness and support next-generation smart grid and electric vehicle applications.

Table 2: MAIN PARAMETERS CONSIDERED FOR STUDY

Authors	Parameter	Description	Significance in Study
Chen et al. (2024)	Voltage Gain	Ratio of output voltage to PV input voltage	Determines converter suitability for high-voltage applications
Hosseinpour et al. (2025)	Converter Efficiency	Power conversion efficiency under varying loads	Indicates energy loss reduction and system performance
Dawahdeh et al. (2024)	MPPT Tracking Accuracy	Ability to track maximum power point	Ensures maximum energy extraction from PV panels
Abouzeid et al. (2024)	Tracking Speed	Response time to reach MPP	Improves performance during rapid irradiance changes
Lyu et al. (2025)	Algorithm Complexity	Computational requirements of MPPT methods	Affects real-time implementation feasibility
Valarmathy & Prabhakar (2024)	Current Ripple	Fluctuations in input/output current	Lower ripple improves efficiency and component life
Algamluoli et al. (2023)	Duty Cycle Range	Operating duty cycle for high gain	Impacts converter stability and switching stress
Yang et al. (2024)	Voltage Stress	Stress on switches and diodes	Lower stress improves reliability and durability
Roy et al. (2024)	Adaptability	Response to temperature & irradiance changes	Enhances performance under dynamic conditions
Sreelatha et al. (2024)	Total Harmonic Distortion (THD)	Harmonics in output waveform	Lower THD ensures better power quality

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