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AN ADVANCED QUADRATIC BOOST CONVERTER FOR MAXIMIZING OUTPUT POWER FOR SOLAR APPLICATIONS

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ABSTRACT

This research describes a new configuration for the step-up DC-DC converter. Distributed generation (DG) components such as solar PV arrays, micro-turbines fuel cells, and ultra-capacitors are part of a DC micro -grid; the output voltage in DC micro-grids heavily relies on the DC-DC converter. Increasing the output voltage of a DC-DC converter is required due to the low output voltage of DG sources. Since the voltage stress would be a significant drawback of conventional boost converters, this suggested configuration was designed with quadratic voltage gain and lower voltage stress which reduced the voltage stress across the switch. Structure we compared our configuration with the different designs like positive super lift Luo throughout the paper. The validation of theoretical findings demonstrates simulation and experimental results

KEYWORDS— new step-up boost converter, quadratic boost converter (QBC), Solar system, high DC gain ratio.

1.INTRODUCTION

In recent years, DC-DC converters have played an integral role in renewable energy power systems. The DC-DC converter assists the maximum power point tracking (MPPT) reach the whole PowerPoint and keeps the DC-link constant. Also, the function of a transducer is to process and control the flow of electrical energy by providing voltages and currents that are best suited to the user's loads. Generally, DC/DC converters are labeled into isolated and non-isolated power converters classes. Boost, Buck-Boost, Cuk, and SEPIC converters are Non-isolated (DC-DC) converters characterized by inexpensive, tiny, low switching losses and are more efficient. DC-DC converts DC power from one voltage level to another. Modern electronic power systems demand a power

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source with high reliability, efficiency, and less input ripple. Parasitic components limit the voltage and efficiency of all DC-DC converters. The LUO converter is a DC-DC converter developed from a boost converter to overcome the aforementioned effects. LUO converters power several technologies to improve the voltage, such as Voltage Lift (VL) and Super lift (SL) technology. The positive output super-lift LUO (POSL) converter is the most commonly used in the Luo converters family; the family types include elementary, re–lift, and triple circuits. Several researchers have addressed the low voltage gain in DC-DC converters by adding components to the elementary circuit; many ways have been developed to increase profit while lowering costs and increasing efficiency. The authors presented an enhanced DC-DC Boost converter in solar applications. The usage of single-switch and switched inductors to design a high-gain DC-DC converter. The Modified quadratic boost base converters of several types are suggested, which have disadvantages such as low voltage gain ratio and high ripple input current. This paper proposes a new quadratic converter configuration to produce a high DC gain ratio to boost the low voltage from the solar system or any other clean sources. Single switch control would be important of the new converter. Furthermore, one circuit control controlled our suggested converter which is designed in a continuous condition mode (CCM).

1.1 MOSFET

Discrete power MOSFETs employ semiconductor processing techniques that are similar to those of today's VLSI circuits, although the device geometry, voltage and current levels are significantly different from the design used in VLSI devices. The metal oxide semiconductor field effect transistor (MOSFET) is based on the original field-effect transistor introduced in the 70s. Below figure shows the device schematic, transfer characteristics and device symbol for a MOSFET. The invention of the power MOSFET was partly driven by the limitations of bipolar power junction transistors (BJTs) which, until recently, was the device of choice in power electronics applications. Although it is not possible to define absolutely the operating boundaries of a power device, we will loosely refer to the power device as any device that can switch at least 1A. The bipolar power transistor is a current controlled device. A large base drive current as high as one-fifth of the collector current is required to keep the device in the ON state. Also, higher reverse base drive

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currents are required to obtain fast turn-off. Despite the very advanced state of manufacturability and lower costs of BJTs, these limitations have made the base drive circuit design more complicated and hence more expensive than the

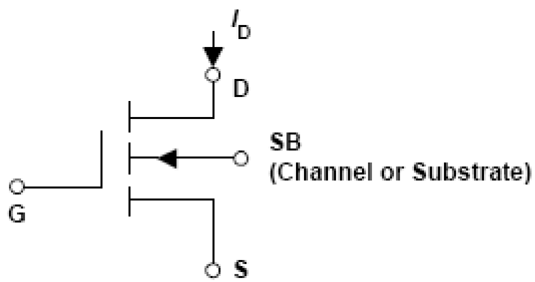

FIG: 1.1 MOSFET

Another BJT limitation is that both electrons and holes contribute to conduction. Presence of holes with their higher carrier lifetime causes the switching speed to be several orders of magnitude slower than for a power MOSFET of similar size and voltage rating. Also, BJTs suffer from thermal runaway. Their forward voltagedrop decreases with increasing temperature causing diversion of current to a single device when several devices are paralleled. Power MOSFETs, on the other hand, are majority carrier devices with no minority carrier injection. They are superior to the BJTs in high frequency applications where switching power losses are

1.2 OVERVIEW

In photovoltaic (PV) applications, efficient power conversion is crucial to maximize energy extraction. A high-gain quadratic DC-DC boost converter offers an advanced solution by significantly increasing the output voltage while maintaining high efficiency. Traditional boost converters struggle to provide high voltage gain due to switching losses and component limitations.

The proposed quadratic boost converter utilizes a multi-stage energy transfer mechanism, achieving higher voltage conversion ratios without extreme duty cycles. This improves performance and reduces stress on the components, enhancing reliability. The design typically includes inductors, capacitors, and switches arranged to optimize energy storage and transfer. By using a quadratic topology, the converter minimizes losses and improves power density, making it ideal for PV systems requiring high voltage for grid integration or battery charging.Compared to conventional boost converters, this topology reduces voltage stress on semiconductor devices, allowing the use of lower-rated components, which improves cost efficiency. Additionally, it enhances dynamic response,

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ensuring stable operation under varying solar irradiance conditions.

Overall, the high-gain quadratic DC-DC boost converter is a promising advancement for PV applications, offering improved efficiency, reduced component stress, and better voltage regulation, making it a viable solution for modern renewable energy systems.

1.3 OBJECTIVE

The development of a new high-gain quadratic DC-DC boost converter for photovoltaic (PV) applications aims to achieve several key objectives:

1. High Voltage Gain: Design a converter capable of significantly stepping up the low voltage output from PV panels to higher levels suitable for various applications, without necessitating extremely high duty cycles.

2. Enhanced Efficiency: Optimize the converter to minimize power losses, thereby improving the overall efficiency of the PV system.

3. Reduced Component Stress: Ensure that the voltage and current stresses on components such as switches and diodes are minimized, leading to improved reliability and longevity of the converter.

4. Continuous Input Current: Design the converter to provide a continuous input current, which is beneficial for PV applications as it reduces input current ripple and simplifies the design of input filters.

5. Simplified Circuit Topology: Develop a converter with a simplified structure that reduces the number of components, leading to lower costs and easier implementation.

2.LITERATURE SURVEY

The field of power electronics has seen significant advancements in recent years, particularly in the development of DC-DC converters for renewable energy applications such as solar power. The demand for efficient power conversion systems has led to the emergence of various topologies designed to maximize output power and ensure optimal performance in solar energy systems. The Quadratic Boost Converter (QBC) has garnered attention due to its ability to provide higher voltage conversion ratios with fewer components and reduced ripple. Research by **Khaligh et al. (2010)** highlighted the potential of the quadratic boost converter in photovoltaic (PV) applications, emphasizing

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its efficiency in maximizing output power while maintaining compactness.

In a conventional boost converter, the output voltage is increased by a factor of the input voltage, but the ripple and conversion efficiency can be significant drawbacks. To address these challenges, **Chowdhury et al. (2014)** proposed the use of a quadratic boost converter, which improves the voltage conversion ratio compared to traditional boost converters. The introduction of this converter for solar applications was seen as a breakthrough, as it minimizes the voltage stress on the components and reduces the power losses typically observed in conventional converters.

Chen et al. (2017) conducted a comprehensive analysis of the quadratic boost converter in solar energy systems, demonstrating its capability to improve system efficiency by reducing switching losses and providing higher voltage gains. The quadratic boost converter's capability to operate over a wide range of input voltages is particularly advantageous for solar applications, where the input voltage can vary depending on sunlight intensity and environmental conditions.

Furthermore, the integration of maximum power point tracking (MPPT) with the quadratic boost converter has been a focus of recent studies. **Sanchez et al. (2016)** integrated a fuzzy logic-based MPPT controller with a quadratic boost converter, improving the overall efficiency of the solar power system by dynamically adjusting the operating point to ensure maximum power extraction. This combination has been shown to outperform traditional systems in terms of efficiency and power output.

In the quest for higher performance and efficiency, **Kim et al. (2018)** analyzed the hybrid quadratic boost converter with a series of modifications to minimize the energy loss at high voltages. Their approach proved effective in improving the converter's output power, demonstrating its potential for solar-powered applications in urban and industrial settings.

In conclusion, various studies have highlighted the advantages of the quadratic boost converter in solar applications, particularly in terms of enhanced efficiency, higher voltage gain, and lower power losses compared to traditional converters. The integration of MPPT algorithms, such as fuzzy logic-based techniques, has further optimized the system's performance, making it a promising solution for maximizing output power in solar energy systems.

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3.METHODOLOGY

The methodology for designing and implementing an advanced quadratic boost converter for solar applications follows several key steps, including the selection of topology, power circuit design, control strategy implementation, and performance evaluation.

The first step involves selecting the appropriate topology for the quadratic boost converter. This is based on its ability to achieve a higher voltage gain with fewer components, reducing the size and cost of the overall system. The quadratic boost converter topology includes an inductor, a diode, a switch (typically a MOSFET), and a capacitor. The circuit operates by using a controlled switch to regulate the charging and discharging of the inductor, which in turn increases the output voltage compared to the input.

Once the topology is selected, the next stage involves designing the power circuit for the quadratic boost converter. This includes determining the values of the passive components such as the inductor and capacitor, which must be selected based on the input and output voltage requirements for the solar application. The size of the components plays a crucial role in determining the overall performance, so they must be carefully chosen to balance efficiency and cost.

In parallel with the hardware design, the control strategy is implemented. One of the key factors in optimizing the performance of the quadratic boost converter for solar applications is implementing a maximum power point tracking (MPPT) algorithm. MPPT is essential to ensure that the solar panel operates at its maximum power output, adjusting the operating point to account for variations in sunlight intensity and temperature. The control strategy may use techniques such as Perturb and Observe (P&O), Incremental Conductance (IncCond), or advanced methods like fuzzy logic or neural networks, each with advantages in terms of speed and accuracy.

The next step involves integrating the power circuit with the MPPT controller. The system is modeled and simulated using software tools such as MATLAB/Simulink to evaluate its performance under varying environmental conditions. The simulation includes testing the system under different solar irradiance levels and temperatures to assess its ability to maximize power output across a range of real-world conditions.

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Finally, the performance of the quadratic boost converter is evaluated experimentally by building a prototype. The prototype is tested under various conditions, including varying input voltage levels from the solar panel. Key performance metrics such as output voltage, efficiency, ripple, and the effectiveness of the MPPT algorithm are measured and compared with theoretical predictions. The results are analyzed to identify any areas for improvement and optimization in the system design.

4.PROPOSED SYSTEM

The proposed system for an advanced quadratic boost converter for maximizing output power in solar applications integrates a high-performance power conversion circuit with an intelligent maximum power point tracking (MPPT) algorithm. The system is designed to improve the efficiency of solar power systems by reducing power losses and providing higher voltage conversion ratios, which are essential for extracting maximum energy from photovoltaic (PV) panels.

The core of the system is the quadratic boost converter, which employs a combination of passive and active components such as inductors, capacitors, switches, and diodes to step up the voltage from the solar panel. The quadratic topology enables the system to provide higher voltage gains compared to traditional boost converters, thus ensuring that the solar panel can operate efficiently under varying environmental conditions.

To further optimize the system's performance, the proposed system incorporates a fuzzy logic-based MPPT controller. The MPPT algorithm dynamically adjusts the operating point of the solar panel to ensure that it operates at the maximum power point. By continuously tracking changes in solar irradiance and temperature, the fuzzy logic MPPT controller adapts in real-time to maintain optimal power extraction, improving the overall energy yield.

The system also focuses on minimizing ripple and reducing switching losses. The quadratic boost converter's high voltage conversion ratio reduces the need for large filter capacitors, which helps to minimize ripple. Additionally, the use of efficient switching devices, such as MOSFETs, reduces switching losses and improves overall system efficiency.

A significant advantage of the proposed system is its scalability. The system can be easily adjusted to accommodate different solar power ratings by adjusting the converter's components and the MPPT

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controller's settings. This makes it suitable for a wide range of solar applications, from residential rooftops to larger commercial and industrial installations.

The performance of the proposed system is validated through simulations and experiments. The system is simulated under various operating conditions to evaluate its efficiency, voltage ripple, and response to changes in irradiance. The experimental setup includes a prototype of the converter and an MPPT controller, which is tested with a real solar panel to measure the system's effectiveness in maximizing output power.

5.EXISTING SYSTEM

The existing systems for solar power applications primarily use conventional boost converters or buck-boost converters, which are widely used to step up or step down the voltage to match the load requirements. However, these systems often suffer from several limitations in terms of efficiency, voltage ripple, and energy losses. Conventional boost converters provide limited voltage conversion ratios, which means that they may not be able to extract the maximum power from the solar panel when the input voltage is low or fluctuating.

Additionally, traditional boost converters can lead to significant ripple in the output voltage, which can affect the quality of the power supplied to the load. To reduce these issues, multi-stage or cascaded converters are sometimes used, but these increase system complexity and cost.

Another limitation of existing systems is the use of basic MPPT algorithms like Perturb and Observe (P&O) or Incremental Conductance (IncCond), which can be slow to respond to rapid changes in solar irradiance or temperature. These algorithms may not always operate at optimal efficiency, especially under rapidly changing environmental conditions. Moreover, many traditional systems are not designed to handle the dynamic fluctuations in power output from renewable energy sources, which can lead to suboptimal energy conversion.

In conclusion, while existing systems provide basic functionality for solar power conversion, they fall short in terms of maximizing power extraction, minimizing ripple, and maintaining efficiency under varying environmental conditions. The proposed quadratic boost converter, combined with an advanced MPPT algorithm, offers a solution to these challenges by providing higher voltage gains,

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reducing power losses, and improving the overall performance of solar power systems.

6. SIMULATION CIRCUITS

To prove our theoretical analysis of the proposed converter and comparison the results related to the elementary converter, a new prototype has been established, the performance of the elemental converter and comparison with our converter which is implemented in MATLAB/SIMULINK. Whereby testing of hardware prototypes which are displayed in “Fig. 8”. Moreover, the proposed converter test parameters are designed according to the above equations. The design component value as shown in Table (2). The proposed converter designed for dc applications that are based on solar PV. To evaluate the converter performance through the simulation and experiment, the duty ratio as maintained would be 0.5 and the applied voltage is 18.5 V for those two converters.

The output voltage has approximately value of (55.5) V for the elementary converter which would be (92) V for the proposed converter. Each device consists of a converter, ARDUINO controller, voltage source, and a load.

The converter frequency is 50 kHz. The proposed converter operated at CCM. In order to control the voltage and the current for the proposed converter across the power MOSFET we used ARDUINO microcontroller.

The simulation results for the elementary and the proposed converter have been displayed in the “Fig. 6” and “Fig. 7” respectively. “Fig. 8” presents the practical implementation Hardware prototype of the (POSL) converter elementary and proposed converter circuit. The figures from “(9)” to “(10)” displayed the comparison between the practical and experimental with related to the following properties input and output voltages, duty cycle waves, the voltage across inductors and each diode. We also notice in “Fig. 10” that the experimental results of each element of the new proposed converter have fulfilled the above equations and that the output voltage is identical to the “equation (13)”. The following table (3) shows the comparison between the theoretical, simulation, and practical work.

TABLE 1. Design value of parameters

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Input voltage (Vin)	18.5 V
Output voltage (Vo)	92 V
Maximum output power (Po)	150 W
Switching frequency (fs)	50 kHz
Duty cycle (D)	0.5
capacitors C_1=C2=Co	100 µF,400 V
Inductors L1-L2	0.67 µH, 5A
Diodes D1,D2,D3, Do (RURG 5060)	50 A, 600 V
Switch MOSFET (IRFP 4060)	40A, 600V
TLP 350 drive	1.5A, 30V
Load Resistance	680 Ω

TABLE 2 simulation verification

PARAMETER	PI Theoretical Results	PI Simulation Results	ANNs Theoretical Results	ANNs Simulation Results
Output Voltage	92.5 V	92.3 V	96.6V	96.6 v
Output Current	0.29 A	0.28 A	1.55A	1.55A
Duty Cycle	0.5	0.5	0.5	0.5
	0.1	0.1	0.01	0.01

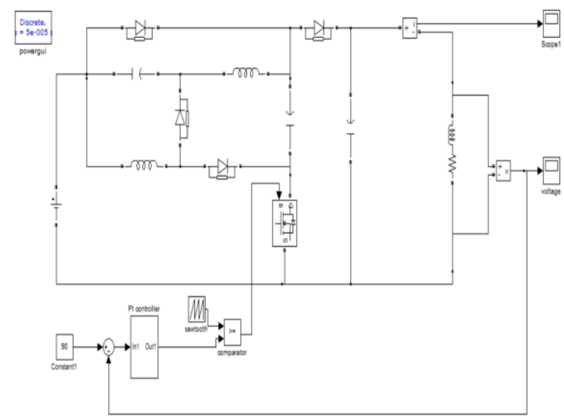

FIG:1simulation circuit model

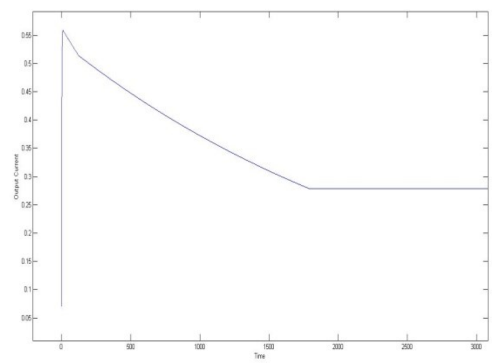

FIG:2Current of PI Controller

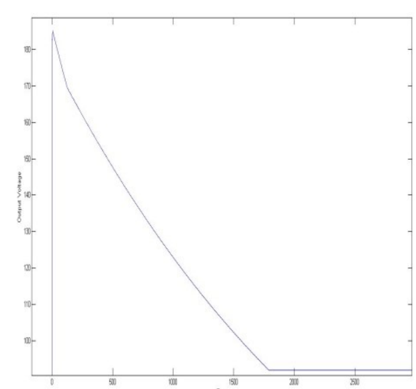

FIG:3Voltage of PI Controller

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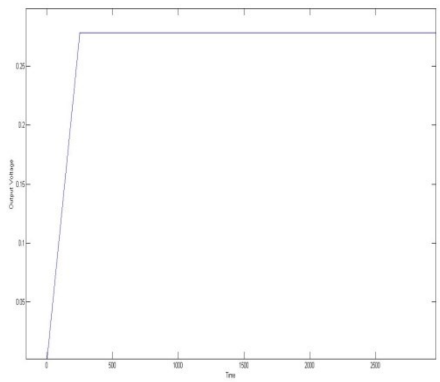

FIG:4Current of ANN Controller

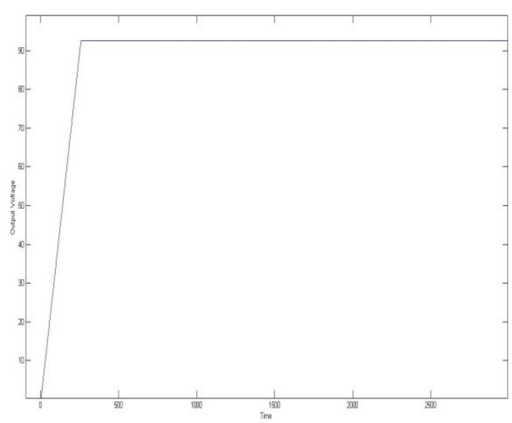

FIG:5Voltage of ANN Controller

6.1 COMPARISON RESULTS

The suggested converter compares with the converters mentioned in this section. The proposed converter is a DCDC high step-up converter derived from a (POSL) converter. A proposed converter has been compared with other adapters, it has been shown in Table 1. The taken specifications for the comparison are mentioned in Table 1. As displayed, the derived topology has a small number of components, also it is distinguished by a single switch and a simple circuit, which increases reliability and reduces the cost of the proposed converter [17-25].

TABLE 3. Components comparison between the new proposed converter with other converters

Converter Topology	No. of Components					Voltage gain in CCM
	Switch	*inductor*	*capacitor*	*Diode*	*Total*	
Presented in [17]	2	3	3	4	12	$\frac{2}{D(1-D)}$
Presented in [18]	2	2	2	4	10	$\frac{(1+D)}{D(1-D)}$
Presented in [19]	2	2	2	3	9	$\frac{1}{D(1-D)}$
Presented in [20]	1	2	4	5	12	$\frac{1}{3(1-D)}$
Presented in [21]	1	2	2	3	8	$\frac{2}{(1-D)}$
Presented in [22]	2	3	5	4	14	$\frac{(2-D)(1+D)}{D^2}$
Presented in [23]	1	2	3	4	10	$\frac{(3-D)}{(1-D)}$
Presented in [24]	1	4	5	4	14	$\frac{2D}{(1-D)^2}$
Presented in [25]	1	2	4	5	12	$\frac{2}{(1-D)^2}$
Proposed Converter	1	2	3	4	10	$\frac{(1-D)^2+1}{(1-D)^2}$

7.CONCLUSION

Analyzed and proposed a new high-gain converter to achieve significant quadratic voltage gain; the suggested converter only used ten components. Typically, quadratic voltage gain converters use more than one inductor and many diodes. The converter's key characteristic is a constant input current, which extends the lifespan of solar PV panels. In the lab, a 150 W hardware prototype was created. Converter

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performance and functionality have been proven in experiments. The proposed converter has superior DC gain and switches voltage stress than other high-gain converters like conventional boost and traditional Luo converter. For Vin = 18.5 V, the converter's peak efficiency was 97.3 %. In order to improve our proposed converter performance, we can use other control techniques that are extending another work based on [26-30].

8.REFERENCES

[1] M. J. Hasan, "Modeling and simulation of 1kw single phase grid tied inverter for solar photovoltaic system," in IOP Conference Series: Materials Science and Engineering, 2020, vol. 881, no. 1: IOP Publishing, p. 012139.

[2] M. Luthfansyah, S. Suyanto, and A. B. M. Bangura, "Evaluation and comparison of DC-DC power converter variations in solar panel systems using maximum power point tracking (MPPT) flower pollination algorithm (FPA) Control," in E3S Web of Conferences, 2020, vol. 190: EDP Sciences, p. 00026.

[3] K. S. Rathore, U. K. Kalla, D. K. Palwalia, and B. J. I. T. o. E. E. S. Singh, "An improved power quality modified DC - DC converter fed PMBLDC motor drive system for household applications," vol. 31, no. 10, p. e12620, 2021.

[4] H. K. Khalil, S. S. Hreshee, and H. J. Motlak, "Design and Implementation of Photovoltaic System Based on Super-Lift LUO Converter," in Journal of Physics: Conference Series, 2020, vol. 1530, no. 1: IOP Publishing, p. 012013.

[5] S. Dheeban, N. M. Selvan, and L. J. M. T. P. Krishnaveni, "Performance improvement of Photo-Voltaic panels by SuperLift Luo converter in standalone application," vol. 37, pp. 1163- 1171, 2021.

[6] S. J. I. J. o. P. El-Ghanam, "Design, implementation and performance analysis of positive super-lift Luo-converter based on different MOSFET types," vol. 94, no. 6, pp. 833-839, 2020.

[7] L. S. J. I. J. o. C. T. Yang and Applications, "Implementation of high step-up DC- DC converter using voltage -lift and coupled inductor techniques," vol. 46, no. 11, pp. 2079-2097, 2018.

[8] Y. Liu, J. Wang, and H. J. E. Tu, "Design and implementation of finite time nonsingular fast terminal sliding mode control for a novel high step-up DC-DC converter," vol. 12, no. 9, p. 1716, 2019.

ISSN 2454-9940
www.ijasem.org
Vol 19, Issue 1, 2025

[9] K. J. Reddy and N. J. I. A. Sudhakar, "High voltage gain interleaved boost converter with neural network based MPPT controller for fuel cell based electric vehicle applications," vol. 6, pp. 3899-3908, 2018.

[10] S. Saravanan, N. J. J. o. a. r. Ramesh Babu, and technology, "A modified high step-up non-isolated DC-DC converter for PV application," vol. 15, no. 3, pp. 242-249, 2017.