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A SINGLE-PHASE BOOST DC LINK INTEGRATED CASCADED MULTILEVEL INVERTER FOR PV APPLICATIONS

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ABSTRACT

This paper proposes a single-phase boost DC link integrated cascaded multilevel inverter (CMLI) designed for photovoltaic (PV) applications. The system combines a boost converter and a cascaded inverter to step up and convert DC power generated from PV modules into a high-quality AC output. The integrated architecture improves efficiency, reduces component count, and achieves better control over voltage levels. Simulation results validate the system's performance, showing reduced total harmonic distortion (THD) and improved voltage gain compared to conventional CMLI systems.

1. INTRODUCTION

As global demand for clean energy grows, photovoltaic (PV) systems have become a leading renewable energy source for both grid-connected and standalone applications. conventional cascaded multilevel inverters (CMIs) often require multiple isolated DC sources, increasing complexity and limiting their feasibility for single-source PV systems [1].

To overcome these challenges, researchers have proposed integrating a DC-DC boost converter into the multilevel inverter configuration.. The single-phase Boost DC Link Integrated Cascaded Multilevel Inverter (B-DCL-CMI) addresses these limitations by combining voltage boosting and multilevel conversion into a single system, ensuring enhanced voltage gain and improved waveform quality for PV applications [2]. The proposed system provides a unified power electronic interface suitable for residential PV installations, offering advantages in terms of reduced component count, high efficiency, and modular expandability

2. LITERATURE REVIEW

The performance of multilevel inverters in renewable energy systems, especially in PV applications, has been a subject of extensive research over the past two decades. Traditional two-level inverters suffer from high total harmonic distortion (THD), higher voltage stress, and limited scalability. To address these issues, cascaded H-bridge (CHB) multilevel inverters were developed, offering improved output waveform quality with reduced filter requirements [3]. However, the dependence on multiple DC sources in CHB topologies poses design and cost challenges, particularly in small-scale PV installations [4]. Recent advancements have led to hybrid topologies that integrate a single DC source with a boost converter and multilevel inverter. These systems not only improve voltage gain but also reduce the number of switches and passive components required [5]. In [6], a boost converter was employed with a five-level inverter to eliminate the need for transformer-based isolation, improving efficiency and reducing overall system footprint. Other studies have implemented novel control strategies, such as phase-shifted PWM and space vector modulation (SVM), to further reduce THD and enhance output waveform quality [7].

Research in [8] introduced a single-source, seven-level inverter using a switched capacitor structure, highlighting the trend toward topologies that reduce the component count while maintaining high output quality. Additionally, in [9], a transformerless grid-tied inverter with integrated MPPT (maximum power point tracking) capability was proposed, allowing for optimal PV utilization and reduced energy losses.

3. METHODOLOGY

The methodology of the proposed single-phase boost DC link integrated cascaded multilevel inverter (B-DCL-CMI) involves the design, simulation, and performance analysis of a power conversion system tailored for photovoltaic (PV) applications.

The system is divided into two main stages: a DC-DC boost converter and a cascaded H-bridge multilevel inverter (CHB-MLI). Initially, the unregulated low-voltage DC output from the PV panel is fed into a boost converter, which steps up the voltage to a suitable level. MATLAB/Simulink is employed to simulate the model under varying solar irradiance and load conditions. The system is also evaluated for metrics such as total harmonic distortion (THD), voltage gain, switching stress, and dynamic performance during solar fluctuations.

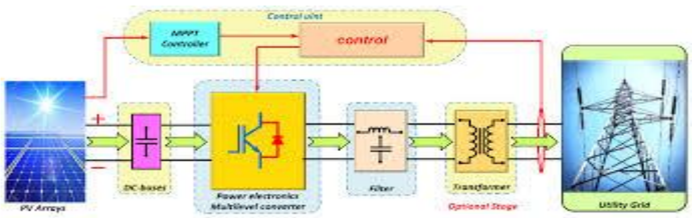

Figure. 1 Block diagram of single-phase boost DC link integrated cascaded multilevel inverter

4. PROPOSED SYSTEM

The proposed paper integrates a single PV source with a DC-DC boost converter and a cascaded multilevel inverter. The PV panel generates low-voltage DC power, which is insufficient for most single-phase grid or appliance loads. To overcome this, a boost converter increases the DC link voltage to the desired level while maintaining efficient power transfer through maximum power point tracking (MPPT). The inverter employs sinusoidal pulse-width modulation (SPWM) or multicarrier PWM techniques to control switching and ensure minimal harmonic content in the output waveform. This system is ideal for rooftop solar applications where space, cost, and power quality are critical.

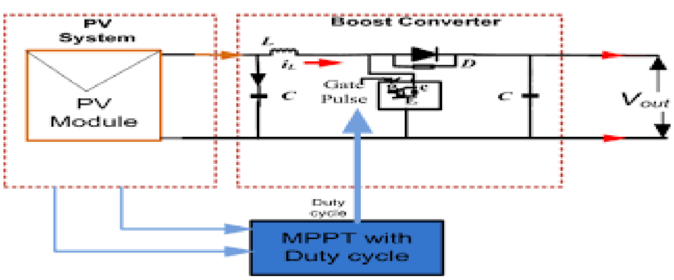

Figure. 2 Block diagram of single-phase boost DC link integrated with PV module using MPPT algorithm

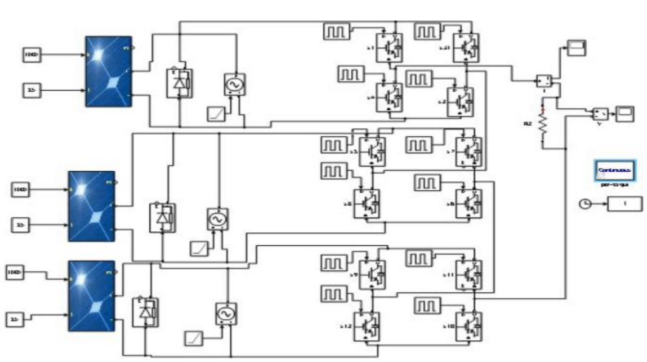

Figure 3 Simulation of proposed Hybrid cascade multilevel inverter in MATLAB/Simulink environment

5. RESULTS

Simulation results validate the effectiveness of the B-DCL-CMI for photovoltaic applications. Under standard test conditions (1000 W/m² irradiance), the PV panel generated approximately 75 V DC, which was successfully boosted to over 200 V by the DC-DC boost converter. The cascaded multilevel inverter generated a five-level AC output waveform closely resembling a sine wave, significantly reducing total harmonic distortion (THD). Dynamic performance tests demonstrated that the system responded well to sudden irradiance changes, with minimal voltage ripple and quick stabilization. The inverter maintained consistent output across varying loads, proving its capability for real-time residential or standalone PV power delivery.

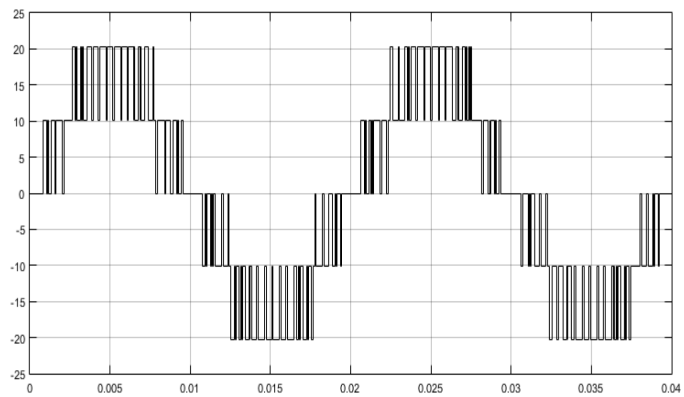

Figure 4 Details of output voltage and output cascade multilevel inverter

6. CONCLUSION

The proposed single-phase boost DC link integrated cascaded multilevel inverter offers an efficient, scalable, and cost-effective solution for photovoltaic energy conversion. By integrating a boost converter with a CHB multilevel inverter, the system addresses the limitations of low DC output from PV panels and reduces the need for multiple DC sources. Simulation results highlight the system's ability to produce high-quality AC output with low THD and high voltage gain, making it suitable for grid-tied or standalone solar systems. The modular design and reduced component count make the topology favorable for residential and commercial PV installations. Future enhancements could include experimental prototyping, advanced MPPT algorithms, and real-time control integration for adaptive grid response.

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