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A Review on H6 Transformerless PV Grid-Tied Inverters

Madhuri Kshirsagar[1]

[1]Professor, M. E. (Electrical Power System)

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Abstract: Photovoltaic (PV) grid-tied inverters are essential for integrating solar energy into modern power grids. Transformerless topologies have become increasingly significant due to their superior efficiency, reduced cost, and compact size compared to traditional transformer-based inverters. Among these, the H6 topology has gained prominence for its ability to suppress common-mode (CM) leakage currents and maintain high efficiency. This paper reviews the principles, advantages, limitations, and applications of the H6 topology, with a comparative analysis against other transformerless inverter designs such as H5, HERIC, and NPC. Particular emphasis is placed on leakage current suppression, control strategies, and future research directions involving wide-bandgap devices and AI-based optimization. Reported efficiencies exceed 97%, making H6 inverters suitable for residential and commercial PV applications. This review highlights ongoing challenges in EMI, thermal management, and grid compliance, and provides insights into future developments in PV inverter technology.

Keywords: *PV Inverter, H6 Topology, Transformerless, Grid-Tied, Leakage Current, Efficiency.*

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I. INTRODUCTION

The growing demand for renewable energy, especially solar photovoltaics (PV), necessitates efficient power conversion technologies. Grid-tied inverters are responsible for converting DC from PV panels into AC compatible with the utility grid. Traditional transformer-based inverters provided galvanic isolation but at the expense of bulk, cost, and efficiency losses. Transformerless inverters address these challenges, with the H6 topology emerging as one of the most effective designs for minimizing common-mode leakage currents.

II. LITERATURE REVIEW ON TRANSFORMERLESS INVERTERS

Several transformerless inverter topologies have been proposed, including H5, HERIC, Neutral Point Clamped (NPC), and T-type inverters. H5 introduced reduced leakage current through modified switching sequences. HERIC further improved efficiency but at the cost of complexity. NPC and T-type inverters provide multilevel voltage operation, reducing harmonic distortion. However, the H6 topology balances efficiency, leakage current suppression, and cost. Comparative studies indicate that H6 achieves >97% efficiency with significantly reduced leakage currents compared to earlier designs.

III. H6 TOPOLOGY: STRUCTURE AND OPERATION

The H6 inverter consists of six switches (MOSFETs or IGBTs). Its operation can be classified into three states: positive half-cycle, negative half-cycle, and zero-voltage state. By controlling switching sequences, the inverter maintains nearly constant CM voltage, reducing leakage currents.

IV. COMPARATIVE ANALYSIS WITH OTHER TOPOLOGIES

[Insert Table: Comparison of H5, H6, HERIC, NPC in terms of efficiency, leakage current, THD, and cost]

V. CONTROL STRATEGIES

PWM methods (unipolar, bipolar, hybrid), Maximum Power Point Tracking (MPPT), and grid synchronization techniques are vital for H6 performance. Advanced control algorithms using DSPs and microcontrollers ensure optimized operation.

VI. APPLICATIONS

H6 inverters are widely used in residential and small commercial PV installations, where efficiency and compactness are crucial. They are also suitable for smart grid integration and distributed generation systems.

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VII. CHALLENGES AND RESEARCH GAPS

Despite its advantages, the H6 topology faces challenges such as complex digital control requirements, electromagnetic interference (EMI), and thermal management in compact designs. Grid compliance standards (e.g., IEEE 1547, IEC 61727) also demand advanced functionalities such as reactive power support.

VIII. FUTURE TRENDS

Future research includes AI and machine learning for adaptive control, wide-bandgap devices (SiC, GaN) for higher efficiency, and integration of H6 inverters with hybrid energy storage and smart grids.

IX. CONCLUSION

The H6 topology is a promising solution for transformerless PV grid-tied inverters, offering high efficiency, low leakage current, and compact design. Its continued development, supported by advanced semiconductors and AI-based control, will ensure its role in next-generation sustainable energy systems.

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