Transistor-Clamped H-Bridge Based Cascaded Multilevel Inverter with New Method of Capacitor Voltage Balancing

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***Abstract*—This paper presents a three-phase cascaded multilevel inverter that uses five-level transistor-clamped H-bridge power cells. Multicarrier phase-shifted pulse-width modulation method is used to achieve balanced power distribution among the power cells. A new method to balance the midpoint capacitor voltage in each cell is developed and tested. The analysis of the output voltage harmonics and the total power losses covering the conduction and the switching power losses are carried out and compared with the cascaded neutral-point-clamped and the conventional cascaded H-bridge inverters. For verifications, the proposed inverter is experimentally tested on an induction motor. From the results, the proposed inverter provides higher output quality with relatively lower power loss as compared to the other conventional inverters with the same output quality.**

***Index Terms*—Cascaded H-bridge, cascaded neutral-point-clamped inverter, five-level inverter, multilevel inverter, multicarrier phase-shifted pulse-width modulation, transistor-clamped converter.**

I. Introduction

DEMAND for high voltage, high power converters capable of producing high quality waveforms whilst utilizing low voltage devices and reduced switching frequencies has led to the multilevel inverter development with regards to semiconductor power switch voltage limits. Multilevel inverter research is on-going to further improve its capabilities, to optimize control techniques, and to minimize both component count and manufacturing cost. Owing to voltage limits, to enable high power conversion, power switches are typically cascaded in series and configured into multilevel structures. The synthesized multilevel outputs are superior in quality which results in reduced filter requirements and overall system size. Switching losses are also reduced, with lower switching frequency operation and maintained high power quality.

The multilevel inverter has been implemented in various applications ranging from medium to high power levels, such as motor drives [1]-[3], power conditioning devices [4], [5] also conventional or renewable energy generation and distribution [6]-[8]. There are three major multilevel voltage source inverters (VSI) topologies, namely neutral-point-clamped (NPC) or the diode-clamped inverter [9], cascaded multilevel [10], and flying capacitor (capacitor-clamped) [11]. There are also topologies that have been introduced and have successfully found various industrial applications [12]-[14]. Modulation strategies applied to multilevel inverters are selective harmonics elimination (SHE) [15]-[17] carrier-based pulse-width modulation (PWM) [18]-[22], space vector modulation (SVM) [23]-[26] and staircase or fundamental frequency modulation [27], [28].

This paper focuses on the cascaded multilevel inverter topology. Generally, among the three topologies, the cascaded multilevel inverter has the potential to be the most reliable and achieve the best fault tolerance owing to its modularity; a feature that enables the inverter to continue operating at lower power levels after cell failure [29]-[31]. Modularity also permits the cascaded multilevel inverter to be stacked easily for high power and high voltage applications. The cascaded multilevel inverter typically comprises several identical single phase H-bridge cells cascaded in series at its output side. This configuration is commonly referred to as a cascaded H-bridge (CHB), which can be classified as symmetrical if the dc bus voltages are equal in all the series power cells, or as asymmetrical if otherwise. In an asymmetrical CHB, dc voltages are varied to produce more output levels [2], [32]. Consequently, inverter design becomes more complicated as each power cell has to be sized accordingly to the different power levels, including isolated dc sources. This makes symmetrical CHB modularity advantageous over asymmetrical with regards to maintenance and cost.

For the symmetrical cascaded inverter, voltage level increase is possible without varying dc voltage with the same number of power cells, as proposed by this paper. Recently,

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