Cascaded H-bridge Asymmetrical Seven-level Inverter Using THIPWM for High Power Induction Motor

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Abstract

Multilevel inverters are well used in high power electronic applications because of their ability to generate a very good quality of waveforms, reducing switching frequency, and their low voltage stress across the power devices. This paper presents the Third Harmonic Injection Pulse Width Modulation (THIPWM) strategy of a Seven-level Uniform Step Cascaded H-bridge Asymmetrical Inverter (7-level USCHBAI). The THIPWM approach is compared to the well-known Sinusoidal PWM (SPWM) strategy. Simulation results demonstrate the better performances and technical advantages of the THIPWM controller in feeding a High Power Induction Motor (HPIM).

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1. Introduction

Inverters are widely used in modern power grids; a great focus is therefore made in different research fields in order to develop their performance. Three-level inverters are now conventional apparatus but other topologies have been
attempted this last decade for different kinds of applications. Among them, Neutral Point Clamped (NPC) inverters, flying capacitors inverters also called imbricated cells, and series connected cells inverters called cascaded H-bridge inverters [1-3].

This paper is a study about a three-phase multilevel converter based on series connected single phase inverters (partial cells) in each phase. A multilevel converter with k partial inverters connected in serial is presented by Fig.1. In this configuration, each cell of rank \( j = 1 \ldots k \) is supplied by a dc-voltage source \( u_{dj} \). It has been shown that feeding partial cells with unequal dc-voltages (asymmetric feeding) increases the number of levels of the generated output voltage without any supplemental complexity to the existing topology [4, 5]. These inverters are referred to as “Cascaded H-bridge Asymmetrical Multilevel Inverters” or CHBAMI.

![Fig.1. Three-phase structure of a multilevel converter with k H-bridge inverters series connected per phase](image)

Some applications such as active power filtering need inverters with high performances [6]. These performances are obtained if there are still any harmonics at the output voltages and currents. Different Pulse-Width Modulation (PWM) control-techniques have been proposed in order to reduce the residual harmonics at the output and to increase the performances of the inverters [7, 8]. The most popular one is probably the Sinusoidal PWM technique (SPWM) which shifts the harmonics to high frequencies by using high-frequency carriers [9, 10].

To minimize the Total Harmonic Distortion (THD), and to increase the maximum amplitude fundamental of the output voltage of the CHBAMI, we have applied the Third Harmonic Injection PWM strategy (THIPWM) [11-13]. In this study we compare the SPWM strategy and THIPWM strategy applied to the control of a Seven-level Uniform Step Cascaded H-bridge Asymmetrical Inverter (7-level USCHBAI). As well we compare the performances related to the association 7-level USCHBAI-HPIM for both strategies. Simulation results demonstrate the better performances and technical advantages of the THIPWM controller in feeding a high power induction motor.

2. Uniform Step Cascaded H-bridge Asymmetrical Multilevel Inverter (USCHBAMI)

Multilevel inverters generate at the ac-terminal several voltage levels as close as possible to the input signal. Fig. 2 for example illustrates the \( N \) voltage levels \( u_{l1}, u_{l2}, \ldots, u_{lN} \) composing a typical sinusoidal output voltage waveform. The output voltage step is defined by the difference between two consecutive voltages. A multilevel converter has a uniform or regular voltage step, if the steps \( \Delta u \) between all voltage levels are equal. In this case the step is equal to the smallest dc-voltage, \( u_{dl} \) [14]. This can be expressed by
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