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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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Keywords: Seven-level Uniform Step Cascaded H-bridge Asymmetrical Inverter; Third Harmonic Injection PWM; Sinusoidal PWM; High Power Induction Motor.

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

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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.

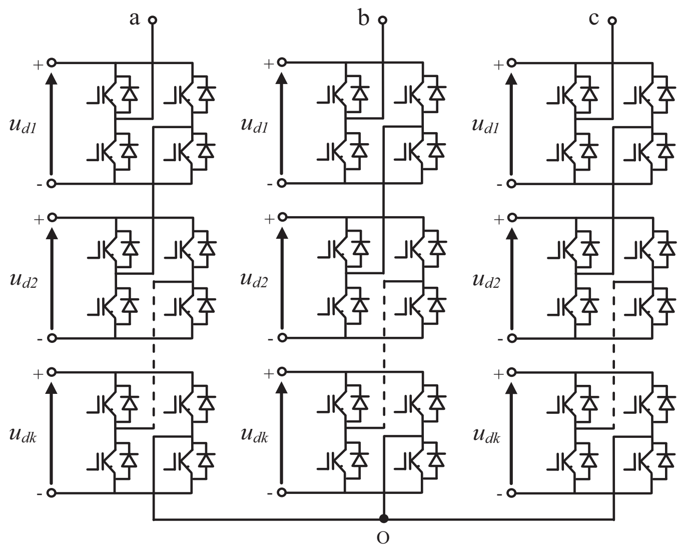

Fig.1. Three-phase structure of a multilevel converter with *k* H-bridge inverters series connected per phase

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_{s1}, u_{s2}...u_{sN} 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 Δu between all voltage levels are equal. In this case the step is equal to the smallest dc-voltage, u_{d1} [14]. This can be expressed by