Electric Power Systems Research 80 (2010) 444–455

Contents lists available at ScienceDirect

Electric Power Systems Research

journal homepage: www.elsevier.com/locate/epsr

Back-to-back three-level converter controlled by a novel space-vector hysteresis current control for wind conversion systems

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ARTICLE INFO

Article history:
Received 3 July 2008
Received in revised form 23 February 2009
Accepted 9 October 2009
Available online 23 December 2009

Keywords:
Space-vector hysteresis current control
Back-to-back three-level converter
Doubly fed induction machine
Wind power
Active and reactive powers control
Neutral point voltage control

ABSTRACT

In this paper, a novel space-vector hysteresis current control (SVHCC) is proposed for a back-to-back three-level converter which is used as an electronic interface in a wind conversion system. The proposed SVHCC controls the active and reactive powers delivered to the grid by the doubly fed induction machine (DFIM) through the control of its rotor currents. In addition, it controls the neutral point voltage by using the redundant inverter switching states. The three rotor current errors are gathered into a single space-vector quantity. The magnitude of the error vector is limited within boundary areas of a square shape. The control scheme is based firstly on the detection of the area and sector in which the vector tip of the current error can be located. Then, an appropriate voltage vector among the 27 voltage vectors of the three-level voltage source inverter (VSI) is applied to push the error vector towards the hysteresis boundaries. Simple look-up tables are required for the area and sector detection, and also for vector selection. The performance of the proposed control technique has been verified by simulations.

1. Introduction

In recent years, multilevel converters are being increasingly preferred for high power applications [1,2] such as wind power conversion, especially with the development of high power wind generators (more than 1 MW).

The great interest to these converters is due to their advantages that provide: they improve the waveform of voltage outputs, reduce the harmonic content compared to the standard two levels ones, increase the power rating and decrease the stress across the switches [3–6].

In order to control these converter currents, many control strategies were proposed. At present, carrier-based modulation (CBM) and space-vector modulation (SVM) have been considered as the most popular modulation strategies for multilevel inverters [7,8] due to their operation at fixed frequency. However, the CBM method controls each phase current separately by using a linear controller and a comparison between a triangular carrier and a phase reference signal. Hence, a complex analog circuit is required. In contrast to the CBM, The SVM strategy controls the three-phase currents together through the use of a single space-vector reference entity. The SVM scheme is based on the application of a zero vector and three nearest voltage vectors. Thus, multiple timers are needed for calculating the duty cycles. Moreover, the SVM technique uses linear regulators for closed loop current control.

The control technique based on three independent hysteresis comparators has been considered as a simplest current control strategy due to its implementation simplicity and also beside the fast dynamic response, it does not require any knowledge of load parameters [9–11]. However, it suffers from a high frequency operation, a phase current interaction [12] and a neutral point voltage unbalance of the multilevel VSI.

Recently, the works presented in [2,13,14] have focused on the hysteresis type current controllers for multilevel drives. However, these are proposed only for single-phase multilevel inverters.

In this paper, the SVHCC is presented for controlling the three-phase three-level VSI used as a rotor side converter in a wind conversion system. The proposed control technique controls the active and reactive powers delivered to the grid by the DFIM through the control of its rotor currents.

In contrast to the conventional hysteresis where the three independent current errors are employed, the proposed control scheme gathers them into a single space-vector quantity. In this case the magnitude of the error vector is limited within boundary areas of a square shape. The control method is based on the detection of the area and sector in which the reference current vector can be located. Then, an appropriate voltage vector of the three-level VSI vectors will be applied to move the measured current vector towards the reference one. In addition, the neutral point voltage balancing can be easily achieved by using the redundant inverter

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doi:10.1016/j.epsr.2009.10.009