JPE 13-5-6

http://dx.doi.org/10.6113/JPE.2013.13.5.787

New Three-Phase Multilevel Inverter with Shared Power Switches

Hew Wooi Ping*, Nasrudin Abd. Rahim*, and Jafferi Jamaludin†

†*UM Power Energy Dedicated Advanced Center (UMPEDAC), University of Malaya, Kuala Lumpur, Malaysia

Abstract

Despite the advantages offered by multilevel inverters, one of the main drawbacks that prevents their widespread use is their circuit complexity as the number of power switches employed is usually high. This paper presents a new multilevel inverter topology with a considerable reduction in the number of power switches used through the switch-sharing approach. The fact that the proposed inverter applies two bidirectional power switches for sharing among the three phases does not prevent it from producing seven levels in the line-to-line output voltage waveforms. A modified scheme of space vector modulation via the application of virtual voltage vectors is developed to generate the PWM signals of the power switches. The performance of the proposed inverter is investigated through MATLAB/SIMULINK simulations and is practically tested using a laboratory prototype with a DSP-based modulator. The results demonstrate the satisfactory performance of the inverter and verify the effectiveness of the modulation method.

Key words: Bidirectional switches, Digital Signal Processor (DSP), Multilevel inverter, Space vector modulation, Virtual vector

I. Introduction

In renewable energy generation systems such as photovoltaic (PV) systems, the inverter has become the most important component as it converts the DC power from the PV modules into AC power to be fed to the grid. The inverter also plays a significant role in electric motor drive systems especially in variable speed drives (VSD) where a considerable level of energy saving can be accomplished. These drives ensure that electric machines consume only the required amount of energy for the conducted tasks, hence reducing power loss and improving overall efficiency.

A common topology for the inverters applied in such systems is the conventional full-bridge configuration. In PV systems for instance, although the inverter can meet the specifications needed via a very high switching operation, it also increases the switching loss, acoustic noise and level of interference to other equipment [1]. In motor drive systems, the current distortion which results from non-sinusoidal voltage reduces the motor efficiency and introduces undesirable vibrating torque. In addition, the high dv/dt stress exposes the motor insulation to the risk of breakdown [2]. A promising solution to these problems has been proposed with the introduction of the multilevel inverter.

Multilevel inverters offer improved quality in terms of output waveforms with a lower total harmonic distortion and a better harmonic spectrum, which then leads to a reduction in the filter's size. In addition, decreases in the level of electromagnetic interference, in the switching loss and in the dv/dt stress can also be achieved [3]-[5]. A number of circuit topologies have been proposed and many modulation and control techniques have been developed to accommodate their potential widespread utilization in industrial applications.

There are three well-known multilevel topologies which have been continuously investigated namely the diode-clamped inverter, the capacitor-clamped inverter and the cascaded H-bridge inverter [6]. The most common modulation strategies applied to these topologies include the selective harmonic elimination [7], the carrier-based pulse width modulation [8] and the space vector pulse width modulation [9]. In a search for more innovative designs, recent studies have introduced modifications to the existing topologies [10]-[12]. Other studies have introduced combinations of various low and high switching frequencies to develop hybrid control methods [13], [14].

Manuscript received May 7, 2013; revised Jul. 16, 2013
Recommended for publication by Associate Editor Lixiang Wei.
†Corresponding Author: jafferi@um.edu.my
Tel: +60-03-2246 3246, Fax: +60-03-2246 3257, University of Malaya
*UM Power Energy Dedicated Advanced Center (UMPEDAC), University of Malaya, Malaysia