

Improved Output Voltage Quality using Space Vector Modulation for Multilevel Inverters

By Auzani Jidin

Editorial

Improved Output Voltage Quality using Space Vector Modulation for Multilevel Inverters

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Abstract

Space vector modulation (SVM) has received wide acceptance due to many benefits over other techniques such as higher output voltages, lower total harmonic distortion (THD), high-efficiency and flexible to be implemented in vector control systems. In digital implementation, the SVM equations can be optimally computed by eliminate the use of complex forms. In this paper, the simple SVM based on two-level inverter is employed for higher levels of inverters. This is to retain the simplicity of SVM computation for three-level and five-level cascaded H-bridge multilevel inverter (CHMI). Moreover, the proposed method utilizes two controller boards to perform high computational workloads and to eliminate glitch and error problems. Experiment results show that the THD of output voltage in five-level CHMI gives the smallest value among the results obtained from other levels.

Keywords: voltage quality, voltage source inverter, space vector modulation, multilevel inverter

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Voltage source inverters (VSI) have evolved as the most popular power conversion for many AC drive applications. The evolvement of VSI is in line with the development of various pulse width modulations (PWM) algorithms supported by the advent of solid state switching device technologies, fast digital signal processors, field programmable gate arrays (FPGA) and microcontrollers. Since a few decades ago, several PWM algorithms were developed to improve some performances of VSI such as high-power efficiency [1-2], high-output voltage [3-4], and low-total harmonic distortion (THD) [5-6]. Obviously, the research on VSI has not yet come to state of saturation, as novel or simplified PWM methods continue to emerge for various topology inverter circuits and multilevel inverters [7-8]. Among various modulation strategies or PWM methods, the space vector modulation (SVM) technique has received wide acceptance due to several advantages such as higher output voltages, lower THD, high-efficiency and flexible to be implemented in vector control systems [9-10].

The precision on SVM control algorithm is very important to produce desired output voltages, especially for high-performance AC drive system. For example, the SVM technique is widely adopted in motor drive systems to obtain excellent torque or speed control performance. The high degree of accuracy SVM modulator is compulsory to produce proper and desired instantaneous magnitude and frequency of output AC voltages. The accuracy performance of the modulator can be determined by the reliable design of control algorithm and speed computation of processor or controller board. The reliable design of control algorithm depends on the way the SVM algorithm is formulated.

In digital implementation, the SVM equations can be optimally computed if the equations eliminate the use of complex forms, e.g. trigonometry functions, exponential terms, differential equations and etc. Simplification of control algorithm is necessary for ensuring reliable data to be stored and manipulated by the controller and hence allows the computation of SVM at higher sampling rate. In the proposed development of SVM, the simple SVM based

on two-level inverter is employed for higher levels of inverters. This is to retain the simplicity of SVM computation for three-level and five-level cascaded H-bridge multilevel inverter (CHMI). Moreover, the proposed method utilizes two controller boards, where each controller has lesser tasks or computations that allows it to perform the computation at higher rate; provided that the data is digitally transmitted from DS1104 controller board to FPGA using Gray code, which eliminates glitch and error problems.

The evaluation on THD of output voltage and the accuracy of fundamental output voltage V_1 resulted for every level of inverter is also carried out at modulation index, $M_i = 0.9$. The simulation results obtained from the evaluation are demonstrated in Figure 1.

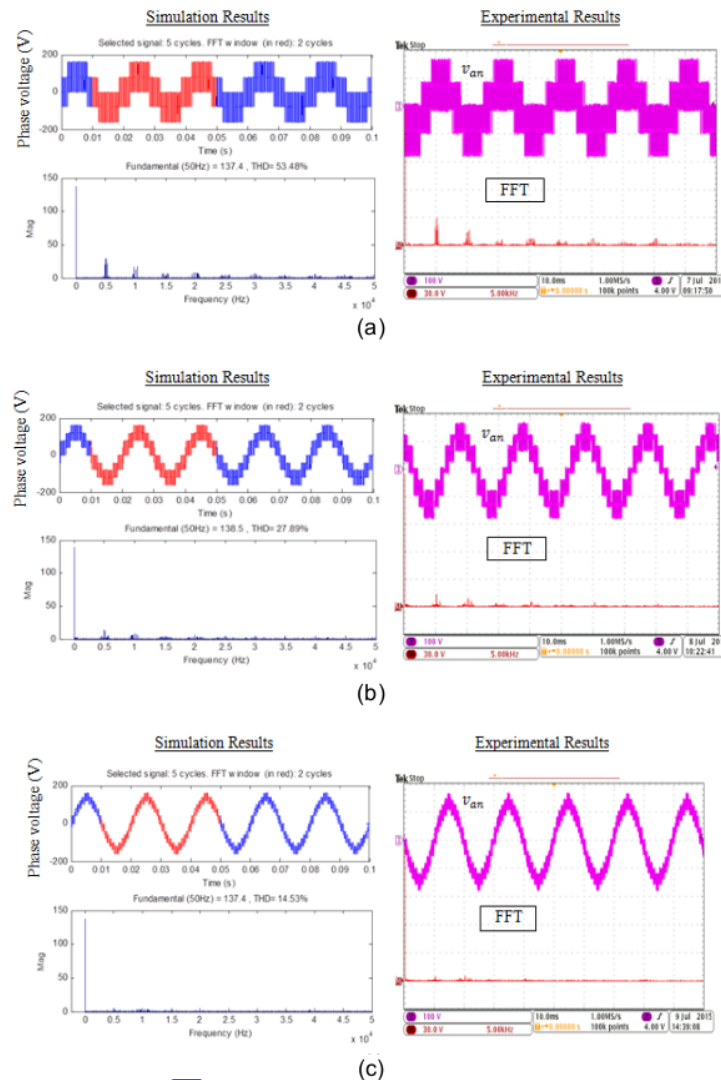


Figure 1. Simulation and experimental results of phase voltage and its frequency spectrum when modulation index $M_i = 0.9$ for (a) Two-Level, (b) Three-Level and (c) Five-Level Inverters

From this figure, it can be observed that the experimental results are in close agreements with the simulation results. Specifically, the patterns of wave shape and frequency spectrum of output voltages in the experimental results are similar to that obtained in the simulation results. The similarities between simulation and experimental results, allow the results of THD and fundamental output voltage obtained via simulation to be assumed similar with that of experimental results. The total harmonic distortion of output voltage (i.e. a -phase voltage, v_{an}) in five-level CHMI gives the smallest value among the results obtained from other levels. This is due to the wave shape of output voltage obtained in five-level inverter for $M_i = 0.9$ is closed to a pure sinusoidal wave shape, which is expected to have lesser harmonic components. From the simulation results, it can also be noticed that the results of fundamental output voltage V_1 obtained from any level of inverter at $M_i = 0.9$ is closed to the calculated value based on (1), where the error between the simulation and calculated values is insignificant and approximately less than 1 %.

$$M_i = \frac{V_1}{V_{1,six-step}} \quad (1)$$

Where the maximum fundamental output voltage produced by the six-step voltage $V_{1,six-step} = 2V_{dc}/\pi$.

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