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A Fast Convergent Homotopy Perturbation Method for Solving Selective Harmonics Elimination PWM Problem in Multi Level Inverter

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ABSTRACT Pulse width modulation (PWM) control for power converters have been vastly investigated and used in many industrial application. For medium voltage and high power applications, low switching frequency PWM techniques are preferred over high switching frequency-based PWM techniques. The preprogrammed low switching frequency-based PWM technique known as selective harmonics elimination (SHE) gives the better quality waveform at a lower switching frequency. The main difficulty in applying SHE PWM is in solving of non-linear transcendental equations for obtaining switching angles. Several methods have been proposed for computation of switching angles that include numerical techniques, optimization techniques, and algebraic techniques. However, the computation of switching angles is still a challenging task in the application of SHE PWM. In this paper, a novel fast convergent homotopy perturbation method (HPM) is proposed to compute switching angles for a multilevel inverter at a faster rate. The solutions obtained by the proposed technique is as accurate as obtained by the algebraic methods with no dependency on the initial guess. The proposed technique can compute the higher number of switching angles with multiple solutions in some modulation index range. A prototype is developed and the computed switching angles have been verified using field-programmable gate arrays (FPGA) controller to validate the results for practical applications.

INDEX TERMS Multilevel inverter, modulation index, selective harmonics elimination, pulse width modulation, homotopy perturbation method, FPGA.

I. INTRODUCTION

Pulse width Modulation (PWM) techniques have been extensively investigated and used for the efficient operation of power electronics converter in the past. It produces desired fundamental component at the output with minimum undesired harmonics components [1]. However, the main focus was on high switching frequency-based PWM techniques, such as carrier-based modulation (SPWM) and space vector-based modulation (SVPWM). In SPWM, a high-frequency carrier is continuously compared with a fundamental component (desired component), and at the intersection points, the pulses are generated. In space vector PWM, the distinct switching states are first identified, and then these vectors are applied to obtain the desired output. The main advantage of high switching frequency (in kHz) techniques includes having the desired output components along with shifting of harmonics component at switching frequency as sideband and thus higher switching frequency will result in the minimum filtering [1]–[3] requirement. In the past, two-level voltage source inverters (VSI's) have been mainly used, and various PWM techniques have been implemented for two-level VSI's. However, higher power processing requirement creates the opportunity to develop new converter topologies to meet the increasing power demands with limited semiconductor device voltage and current ratings.

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