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RESEARCH ARTICLE

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Low-order harmonics control in staircase waveform useful in high-power application by a novel technique

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Summary

Few switching transition in high-power and medium-voltage application of power converters is desirable. The optimal pulse-width modulation (OPWM) at fundamental switching frequency offers a better quality waveform at lower switching losses. It is a preprogrammed modulation technique where certain amounts of lower order harmonics are controlled and fundamental voltage is maintained. Here, a set of nonlinear transcendental equations is obtained, which exhibits multiple, unique, or no solution in different range of modulation index (MI). This paper proposes an advanced and fast method to obtain switching instants for OPWM equations. Moreover, it can solve a large number of such equations as computation of Jacobian matrix in the subsequent iteration is estimated from the previous values. Moreover, the proposed method also removes the singularity problem especially for large OPWM equations. The computational, simulation, and hardware results are provided to validate the concept for various cases.

KEYWORDS

FPGA, high-power application, medium voltage, optimum pulse-width modulation, renewable energy, staircase waveform

1 | INTRODUCTION

Multilevel voltage source/current source converters have been widely studied and researched for a variety of applications, which include induction machine drives, renewable energy integration in the grid, active rectifiers, pumps, fans, rolling mills, marine propulsion, high-voltage, direct current (HVDC) transmission, and railway traction.[1-7] Various research groups mainly focused on its topology, modulation, and control algorithm. The important topologies include neutral point clamped (NPC), cascaded H-bridge (CHB), and flying capacitor (FC) and various hybrid topologies such as active neutral point clamped (ANPC) and H-bridge neutral point clamped (HNPC). The performance characteristics of multilevel converters are highly dependent on the choice of modulation techniques adopted for their operation. The broad classification of important modulation techniques is high-switching frequency pulse-width modulation (PWM) techniques and low-switching frequency PWM techniques.[8] The high-switching frequency PWM techniques include

List of symbols and abbreviations: Alpha, Switching angle; CHD, cascaded H-bridge; FPGA, Field programmable gate arrays; IGBT, Insulated gate bipolar transistor; LUT, Look up table; MI, modulation index; MLI, Multi level inverter; OPWM, optimum pulse width modulation; SHE, Selective Harmonics Elimination; THD, Total Harmonics Elimination

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