ABSTRACT

Multilevel inverters have been receiving greater attention for past few decades in numerous applications like high-power medium voltage (MV) drives, power quality improvement techniques etc. Particularly for the control of multilevel inverters in MV drives at megawatt range, high switching frequency modulation strategies cannot be used because side bands around the carrier frequency appear as low order harmonics, producing high distortion in the output voltage and current waveforms. In addition to that, it leads to high thermal losses which results in poor converter efficiency.

Instead, Selective Harmonic Elimination (SHE) technique has been one of the traditionally preferred modulation schemes at fundamental frequency which produces less switching losses and provides better harmonic profile but the equations formed by SHE technique is highly non linear and transcendental in nature. Hence, there may exist single, multiple or even no solutions at a particular Modulation index. However, in some drive applications, it is required to operate the inverter during whole range of Modulation index ($M_i$). Hence, solving SHE equations during whole range of $M_i$ has been an active research topic for researchers since several decades.

Seven to eleven level cascade H-bridge inverters have been increasingly used by MV drive manufacturers in the present market. Hence, three-phase cascade H-bridge 11-level inverter has been chosen for case study. The main objective of this work is to present a
comparative harmonic analysis of deterministic and stochastic techniques in solving SHE equations and to present an effective, rugged, most efficient algorithm with less computational burden to solve SHE equations during complete range of modulation index from 0 to 1 with an aim of minimizing lower order harmonics such as 5th, 7th, 11th and 13th to comply with IEEE 519-1992 harmonic guidelines.

Proposed way of approach is in four steps, in first step SHE equations are solved by deterministic method like Newton-Raphson (NR) method with any random initial guess. In second step, the limitations observed in NR method are attempted to overcome by using stochastic optimization technique like Continuous-Genetic Algorithm(C-GA). In third step, most of the drawbacks which are observed in previous approaches are attempted to overcome by using another stochastic optimization like Modified Species based Particle Swarm Optimization algorithm (MPSO).

In fourth step, the effectiveness of the proposed MPSO algorithm is validated by considering a low-power prototype of three-phase CHB 11-level inverter and FPGA based Xilinx's SPARTAN-3A DSP controller has been used to generate gating signals to sixty MOSFETs. The results obtained are nearly equal to simulation results during whole range of $M_f$ from 0 to 1 and the %THDs obtained over major range of $M_f$ also satisfies IEEE 519-1992 harmonic guidelines.