# *A Generalized Space Vector Modulation (SVM) Algorithm for Three-phase Converters to Calculate Proper Phase Voltages*

Space vector modulation (SVM) has been employed for decades for three-phase converters to find the appropriate switching combinations and their duty ratios. In multi-level converters, however, considering the possible number of phase voltage vectors to apply as $N^3$, where $N$ is the number of the possible different levels in the phase voltage (see Fig. 1 for example, 125 possible phase voltage vectors in a 5-level converter), the complexity of the modulation increases drastically when $N$ increases, and doing SVM becomes an onerous task, if not impossible.

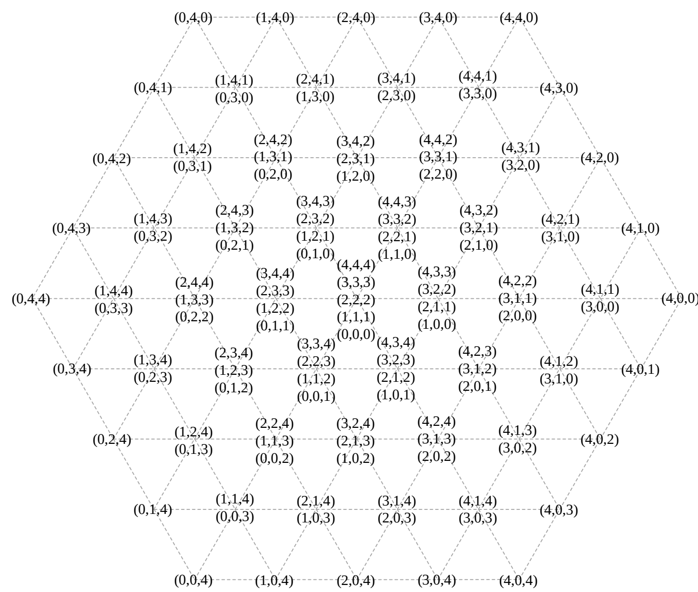


*Fig. 1. 125 possible phase voltage vectors in a 5-level converter*

This paper addresses the problem by proposing a new SVM capable of determining phase voltage vectors for every three-phase converter. Modulation is done in ab-bc-ca and a-b-c rotating frames to calculate line vectors and phase vectors respectively, while no additional transformation is needed. As the algorithm is applicable to all three-phase converters, no look-up table is used and the algorithm itself calculates the phase vectors. Apart from that, minimum switching loss is guaranteed, zero-sequence signal is appropriately injected, and common mode (CM) voltage reduction and balancing capacitor voltage, as done in this paper, harmonic suppression, conferring fault tolerance, etc., can easily be added to the modulation algorithm based on the user's needs. At the modulation index of M = 0.69 (M = 0.8 in the case zero sequence is not injected), phase a voltage level and its average value from the SVM simulation results are presented in Fig. 2 to verify the proper operation of the algorithm. Indeed, the complexity of the modulation is not increased for higher converter levels, as the algorithm takes advantage of repetitive patterns when the number of possible phase voltage levels ($N$) increases.

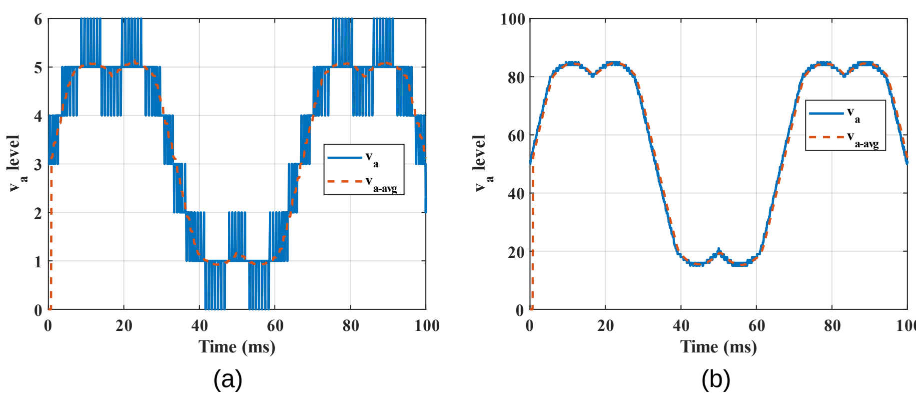


*Fig. 2. Phase a voltage level and its averaged value:*
*(a) 7-level converter; (b) 101-level converter*