CHAPTER 6

CONCLUSION AND FUTURE WORKS

6.1 CONCLUSION

This dissertation addresses the space vector pulse width modulation (SVPWM), especially Two-Dimensional Space Vector Modulation schemes, (2DSVPWM) Optimized Three-Dimensional Space Vector Pulse Width Modulation (3D-OSVPWM) schemes are proposed for multilevel inverters. The present study is focused on unequal dc voltages and minimizing the total harmonic distortion.

The main motivation of this work is to minimize the most significant harmonic components of the generated waveform and to find an alternative to traditional PWM methods, Sinusoidal PWM method (SPWM) and Space Vector Control (SVC) methods as they are not the better methods for the control of multilevel inverter with unequal DC voltages. The selective harmonic elimination method cannot be used as it is difficult to solve transcendental equations characterizing harmonics, the solutions are not available for the whole modulation index range, and it does not eliminate any number of specified harmonics to satisfy the application needs and also the real-time control of multilevel inverters with unequal DC voltages is impossible.

To overcome this problem, the space vector pulse width modulation algorithm is used to find out solutions to the harmonic equations and the
optimized three-dimensional space vector pulse width modulation is proposed which can deal with unequal voltages, unbalanced loads and harmonic generation. The two-dimensional space vector modulation can be applied to multilevel inverter with equal dc sources whereas; optimized three-dimensional space vector modulation can be applied to both equal and unequal dc sources.

The 3-D OSVPWM inherit all the merits of two-dimensional space vector modulation schemes, such as high DC link voltage utilization, low output distortion and harmonic contents, lower switching losses, and compatibility with digital controller. The proposed two-dimensional space vector modulation algorithm chooses two subhexagons randomly. From the two chosen subhexagons, the 2-D algorithm compares and selects the subhexagon that contains the nearest reference vector.

This comparison process helps in determining the appropriate subhexagon having the nearest reference vector as well as the sector to which the reference vector is pointing to is determined for calculating the switching states and the switching times. The proposed 3-D modulation algorithms are completely generalized and can be applied to any multilevel inverter topology. The 3-D OSVPWM technique presented, takes into account the actual unbalance of the multilevel inverter to carry out the necessary calculations, avoiding errors in the modulation process.

The proposed 3-D OSVPWM algorithm maintains $120^\circ$ phase for each phase to compute switching state vectors and the nearest switching sequence. This new algorithm is very useful to readily calculate the switching sequence and the on-state duration of the respective switching state vectors. The proposed technique directly allows optimizing the switching sequence minimizing the number of switching. The computational complexity is very low and independent on the number of levels of the inverter. This algorithm
does not use trigonometric functions or look-up tables. The 3-D OSVPWM method is applied to the multilevel inverters with unequal DC voltages.

The 3-D OSVPWM is extended for both equal and unequal DC voltages. The proposed 3-D OSVPWM modulation technique can be applied to wider modulation index range, and at the same time minimizes voltage THD. The simulation results are carried out on a fourteen-level cascaded inverter. The experimental implementation was successfully tested in laboratory by using a cascaded H-bridge inverter. Both test results validate the proposed modulation technique.

A three-phase, five-level cascaded H-bridge inverter is used as an experimental prototype. The 3-D OSVPWM developed can be easily applied to other multilevel inverter topologies with any number of levels. The SVPWM algorithms have been implemented in a Field programmable Gate Arrays (FPGA). The simulation and experimental results show that the proposed optimized three-dimensional space vector modulation method is very effective in multilevel inverters with equal DC voltages or unequal DC voltages. The proposed technique is suitable for high-voltage, high-power applications. This technique can be used as modulation algorithm in all applications needing a 3-D control vector such as active filters, where the conventional two dimensional space vector modulations cannot be used.

6.2 FUTURE WORKS

This thesis work focuses on space vector modulation for cascaded H-bridge multilevel inverters. The algorithm proposed can be extended to other multilevel inverter topologies. In this thesis, a study is carried out for applying unbalanced load to multilevel inverters. Therefore, significant research work is required for practically implementing the algorithm for unbalanced load conditions. Besides, further studies should be done on the
multilevel inverters connected to other loads such as non linear loads and electrical machines.

The future research can be carried out for various applications of the proposed algorithm to inverters with more than three-phases and in the higher-dimensional spaces of the inverters.

The case, when the reference vector lies in the over-modulation region, has not been studied. Therefore, the problem in SVPWM implementation due to nonlinearity of the over-modulation region should be solved in this case.

All the proposed methods in this thesis are for time-invariant systems. This assumes all the equal or unequal voltages will not change with time. However, the voltages for practical systems will change with time. Therefore, it is recommended to propose new real-time algorithms to eliminate harmonic contents for time-variant systems.