CHAPTER 9

CONCLUSION

Continuous and discontinuous PWM strategies have been developed and laid out in an analytical way. The performances of these strategies, their limitations, and advantages were studied in three different power converters viz. (a) Three Phase VSI, (b) Three Phase CSI, (c) Four legged inverter. Using the PWM strategy developed for four legged converters, the control scheme was designed for the control of a four-legged inverter and four legged active power filter.

9.1 PWM Strategies in VSI

In the first section various continuous and discontinuous PWM strategies on three phase VSI were studied. An analytical methodology for the determination of the expressions for the modulation signals required in carrier-based generalized discontinuous PWM modulation schemes in three-phase inverters was developed. The method for evolving modulation strategies using the theory of existence function is applicable for situations where the reference three-phase voltages are either balanced or unbalanced. This development is made possible with the extension of the classical space vector technique and the appropriate definition of the distribution or partition ratio of the times the zero (null) switching modes are used in the synthesis of a reference voltage. Some confirmatory experiments results have been provided to illustrate the various generalized carrier-based modulation signals possible. The methodology set forth is extendable to the determination of discontinuous modulation schemes of other converters such as four-leg, current source inverters multi-level, AC-AC converters, and other topologies.

9.2 PWM Strategies from VSI applied to CSI

A simplified and detailed method for VSI to CSI mapping is explicated. The approach for development of logic circuit is explained with utmost simplicity. Various modulating schemes of VSI mapped to CSI are studied. It can be shown that the benefits of the discontinuous schemes can be drawn in CSI to generate high quality waveforms and reduce the switching losses. This also means that the switching frequency for the devices can be increased. In general for lower modulating signals space vector modulation still remains the best choice whereas for higher modulating signals, DPWM and GDPWM for delta gives much better waveforms for output currents. But these PWM schemes are a function of load power factor.

Thus depending on the load power factor and the system requirement. By using the α, γ which decide the time spend in the null state by a given reference voltage vector in three phase VSI as control parameters, an adaptive carrier-based PWM scheme derived from VSI modulating schemes can be utilized to improve the converter performance.

9.3 PWM Strategies for Four Legged Converters

There are sixteen sequences to be preprogrammed in case of the 3-D SVM modulation for the four-leg converters. There is an intensive search needed for sequencing the switching combinations for dedicated applications. The carrier-based discontinuous modulation methodology developed overcomes this disadvantage. The possibility of generating an infinite number of discontinuous modulation signals is explained in a lucid way. The method shows the limitations and advantages of the possible exploratory parameters [γ, κ] to meet application measures such as harmonic content, switching loss requirements.

Using the definitions of the space vector methodology, which includes the zero sequence voltages, the carrier-based discontinuous modulation scheme for the four-leg converter has been developed. The space vector comprising of active and null states is split into two halves (a) positive sequence voltages constituting positive zero sequence voltages and (b) negative sequence voltages constituting negative zero sequence voltages. The remaining set of four modes with zero qd voltages constitutes the null states. Using the positive and negative sequence sets and their combinations, the timings for the adjacent switching modes required to synthesize a reference voltage in all the six sectors are calculated.

From these expressions the modulation functions for the top switching devices are determined. From the study of the switching combinations, phases a, b, c are clamped to the dc rail only when γ and κ take values of unity or zero and $\gamma = \kappa$. Hence, the value of γ [1,0] is selected to ensure that t_d is always positive. When $\kappa = 1- \gamma$, the d – phase device alone is clamped to the dc rail. There are four possible expressions for the modulation signals for each device; from these four conditions only a few can be used for synthesis of the reference voltage due the condition on positivity of the switching times. It is apparent that the switching mode combination that yields the minimum instantaneous time t_d gives the highest linearity range when converter operates in the over-modulation region.

For the case in which the three load voltages are balanced, the period for which the devices are clamped in each load phase are seen to be the same (120 degrees per cycle); however; for the situation in which the load phase voltages are unbalanced, there is a total of 360 degrees clamping for the three-phase but are unevenly distributed in the load phases.

9.4 Four Legged Inverter Control scheme

The developed modulation scheme becomes the platform for the implementation of an output-input linearizing with decoupling controller for the four-leg inverter feeding unbalanced or/and nonlinear loads. With the aid of synchronous reference frame transformation, the defining equations of the converter-load system are made linear but coupled between the q and d axes. These equations are decoupled using a decoupling scheme and a method for the design of simple IP controllers with features of Butterworth polynomials for the load voltage regulations was used. Simulation results for the dynamic and steady-state regulation of the load voltages for an unbalanced three-phase impedance load and a balanced three-phase impedance load with a nonlinear rectifier validated the control strategy and modulation scheme proposed.

9.5 Four Legged Active power filter control scheme

Using the implementation of an output-input linearizing with decoupling controller for the four-leg inverter feeding unbalanced or/and nonlinear loads. With the aid of stationary reference frame PI controllers and, the defining equations of the converter-load system equations, a good control is achieved for all the dynamic conditions. These equations are decoupled using a decoupling scheme and a method for the design of simple IP controllers with features of Butterworth polynomials for the source current regulations. Simulation results for the dynamic and steady-state regulation of the load voltages for an unbalanced three-phase impedance load and a balanced three-phase impedance load with a nonlinear rectifier validated the control strategy and modulation scheme proposed.