CHAPTER 7
CONCLUSIONS AND FUTURE SCOPE

7.1 INTRODUCTION
A Shunt Active Filter is a controlled current or voltage power electronics converter that facilitates its performance in different modes like current harmonics compensation, reactive power compensation, power factor correction and load balancing in the distribution system. The compensation process uses different control approaches to extract the reference current but they all share a common objective i.e. imposing sinusoidal currents in the grid, eventually with unity power factor and load balancing. The prominence of the application of the AI tools has been felt in all the areas of the Power Systems and the need is emphasized. The main aim of the research work is to enhance the power quality using Active Filters. In this thesis, three phase three wire voltage source Shunt Active Filter has been implemented. It mainly deals with improvement of major power quality issues like harmonic elimination, reactive power compensation, power factor correction and load balancing due to nonlinear load. The thesis provides a complete framework for the analysis of power quality issues and replaces the conventional PI controller by intelligent computational techniques for more accuracy. A summary of conclusions of each chapter and suggestions for further work are presented in this chapter.

7.2 SUMMARY AND CONCLUSIONS
The main objective of the thesis was to investigate the power conditioning capabilities of the Shunt Active Filter and Hybrid Active Filter. Synchronous Reference Frame control strategy has been executed and investigated for harmonic cancellation, to reduce the THD of source current, reactive power compensation, load balancing and power factor improvement. To achieve these objectives DC capacitor voltage of the inverter has been controlled through various Artificial Intelligence Techniques keeping fixed reactive power compensation. The Active Filter is implemented with the hysteresis band current controller because of its simplicity of implementation. Also, besides fast response current loop, the method does not need any knowledge of load
parameters. The performance of the Shunt Active Filter is evaluated through MATLAB / SIMULINK environment using Simpower Systems toolbox.

The basics of harmonic studies and the associated issues are reviewed in Chapters 1. An exhaustive literature survey is summarized in chapter 2 to review the state of the art techniques that are pertinent to the methods proposed in this research.

Chapter 3 discusses the operating principle, mathematical modeling, and fundamental of control strategies used in this thesis. In this chapter the analysis of the performance of Shunt Active Filter with simple PI controller and effective AI algorithm under both steady state and dynamic load conditions has been investigated.

The controller and hence the filter configuration has been working under following system conditions:

(i) Three phase balanced source fed balanced linear/nonlinear load.
(ii) Three phase balanced source fed unbalanced linear/nonlinear load.
(iii) Three phase unbalanced source fed balanced linear/nonlinear load.
(iv) Three phase unbalanced source fed balanced linear/nonlinear load.

The implemented Shunt Active Filter proves to be an effective solution and manages to compensate the harmonics and reactive power of the electrical distribution network under different scenarios of source and linear/nonlinear load. Different controllers are able to uphold the DC capacitor voltage constant and equal to DC reference voltage. Even in unbalanced load and unbalanced source condition Shunt Active Filters is capable to maintain the balanced source current. It is investigated that steady state performance of balanced source unbalanced load using PI controller, and AI Techniques reduce the THD of source current at a level well below the defined standards specified by power quality standards.

Chapter 4 explains the design and implementation of a three phase shunt connected Hybrid Active Filter. The simulated model is composed of three phase shunt connected VSI with a shunt connected LC passive filter tuned at 250Hz. The amplification phenomenon of the shunt connected passive filter is suppressed by the applied hybrid filter topology. The 5th, 7th and 11th harmonics are greatly reduced and the line currents have become to comply with IEEE Std. 519-1992. Active power loss
computed by various controller like PI controller, Fuzzy controller and Neural controller with fixed reactive compensation leaves the source current perfectly sinusoidal, free from harmonics and in-phase with voltage of the main supply maintaining the unity power factor. The required rating and the losses of the stand-alone Shunt Active Filter has been reduced by the Shunt Hybrid Active Filter.

In the SRF control strategy, active power loss computed for maintaining the DC capacitor voltage, plays a major role in the power conditioning activity of Shunt Active Filter. As load condition changes, there is sudden increase/decrease in the capacitor voltage. The time taken by the capacitor to reach a steady state in the transient (changing) load condition is known as Transient Time. Thus a new proposed Energy based method for reducing the transient time of DC capacitor voltage under changing load condition is described in Chapter 5. A comparative analysis has been done to reduce the transient time by conventional PI controller method and proposed method using PI controller, Fuzzy controller and ANN method.

Chapter 6 presents the novel concept of Distributed Active Filters (DAFs). Distributed Active Filter System proves to be an effective solution of harmonic elimination by deploying multiple Shunt Active Filter Units (AFUs) in the system to cooperatively damp the harmonic resonance. Each AFU within the DAFS can share the filtering workload based on its own VA capacity. The current harmonic filtering performance of DAFs was simulated for different operating modes. A comparative study of THD of supply current in different topologies has been demonstrated using PI controller.

Using SRF control strategy aiming at fixed reactive compensation, reference current has been generated by computing the active power loss in DC capacitor voltage. PI controller/Fuzzy controller/ANN controllers have been used to estimate the peak amplitude of reference current by controlling the DC-voltage of the inverter. The conventional PI controller necessitates specific linear mathematical model of the system. Hence, it is difficult to optimize Active Filter performance under parametric variations viz non-linearity and load disturbances. This shortcoming is resolved by using fuzzy logic controller. It does not involve an accurate numerical calculation; it can work with imprecise inputs. Whereas Fuzzy logic require the operators experience and sometimes intuitive fuzzy design does not clearly outperform well-tuned
conventional controller. Since the objective of the thesis is to simulate a harmonic filter configuration which can compensate harmonics and reactive power with reduced active filter rating, Particle Swarm Optimization Techniques has implemented to optimize the PI gain parameter while evaluating the active power loss in Shunt Active Filter (chapter3). The next approach is the application of Artificial Neural Network controller. ANN controller has been trained with the aim of minimizing the source current harmonics and proves to be the best among the three controllers.

Based on the simulated results obtained in this dissertation we can conclude that that Shunt Active Filter is a potential tool for the growing power quality problems for damping the harmonic resonance, reactive power compensation and load balancing. This work identifies the area of research for power filtering by employing the AI techniques, reduction in the transient time by proposed Energy based method and the concept of DAFS. The easiness in evaluating the ambiguous or non-crisp concepts and the capability of these intelligent controllers to learn due to the technological advancement raised the importance of these soft computing techniques. Among the different AI techniques used ANN which can be substituted for any logical analysis has good performance for minimizing the harmonics. It has much better dynamic response than fuzzy controllers. PSO techniques is motivated by the evolutionary algorithm, provides an optimal solution depending upon the optimal objective function. It has verified its effectiveness in finding the optimal gain parameters for the PI controller and improvement in harmonic cancellation of source current. Thus these techniques emphasis power utility motivated on providing a better quality of supply power owing to augmented customer prospect in modern day challenging environment.

7.3 FUTURE SCOPE OF THE THESIS

The thesis presented here concern the development of the various techniques and their validation in different conditions for the enhancement of power quality using Active Filters. This research work can be extended to a multilevel inverter implemented for power conditioning. Three phase three wire system can be extended to three phase four wire system with different conditions like considering the zero sequence voltage
present in the system. FPGA based controller for Active Filter can be developed to reduce the hardware requirement. For sustainable growth in power system, recently Renewable and Non-Renewable Energy source are gaining lot of attention. Hence such energy sources feeding the nonlinear load can be investigated for further work in the field of power quality. Further enhancing the coordinated control of the proposed Distributed Active Filters incorporating the design of adaptive gains can also be implemented. Another attractive aspect that can be investigated is the finding the solutions of power quality issues by other emerging Evolutionary algorithm like Ant-Colony Optimization and bacteria forging techniques. Thus, the quality of the power network can be expressively enhanced, and high reliability can be provided.