CHAPTER 7

CONCLUSIONS AND SUGGESTIONS FOR FUTURE WORK

The objective of this work is to design, fabricate and test a harmonic filter configuration, with simple and effective control algorithm under both steady state and dynamic load conditions. The controller and hence the filter configuration is expected to work under following system conditions:

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

For this purpose three different types of nonlinear loads have been selected which are:

(i) Three phase thyristor converter fed R-L load alone or in parallel with unbalanced resistive load
(ii) Three phase thyristor converter fed DC motor.
(iii) Thyristor based phase controller fed three phase induction motor.

The major conclusions of this work have been presented in different chapters. A summary of these conclusions and suggestions for further work are presented in this section.

As load conditions change, harmonic current in the network also changes. A fixed element passive filter provides inadequate or more than adequate reactive power compensation at variable load conditions. Therefore, LC elements of filter are to be selected and changed based on the harmonic content and reactive power drawn from source. Hence an adaptive shunt passive filter is proposed to meet these requirements. An ANN based control algorithm is developed to select the required element values. The inputs to the controller are distorted load currents and voltages at PCC and the controller effectively chooses appropriate element values of filter. This controller is easy to program and is flexible. This adaptive shunt passive filter is proved to be a better solution for harmonics and reactive power compensation, when compared to a traditional passive filter, where fixed elements are always used.

However, detailed studies show that this adaptive shunt passive filter is also incapable of complete harmonic and reactive compensation. Therefore, for the complete harmonic and
reactive compensation, a shunt active filter is considered. Bhuvaneswari and Manjula [4] have proposed an active filter working on $\text{Icos}\phi$ algorithm. This algorithm was implemented by means of analog circuits. The analog circuit is bulky in size and difficult to manufacture in large quantities. Hence as a natural extension of this configuration, an ANN based digital controller with reduced size and flexibility is proposed and developed for the shunt active filter. It uses a digital controller based on artificial neural networks. On comparing the performances of shunt active filters, with $\text{Icos}\phi$ control algorithm and with ANN controller (proposed and implemented by author), performances of both the active filters are good in mitigating harmonics. But, if shunt active filter alone is used to provide complete harmonic and reactive compensation, its rating is high.

Investigation is done whether the combination of adaptive shunt passive filter and active filter is a right choice from the point of view of controllability and rating of the filter, in addition to all other performance requirements. Thus, as a harmonic filter configuration with reduced rated active filter, an adaptive shunt hybrid filter is put forward. The proposed adaptive shunt hybrid filter used in this work is a combination of an adaptive shunt passive filter and an ANN controller based shunt active filter.

In this research work, the author has developed the following filter configurations for harmonic and reactive power compensation - adaptive shunt passive filter, ANN controller based shunt active filter and adaptive shunt hybrid filter controlled by digital controller. Since the objective of the research work is to develop a harmonic filter configuration which can compensate harmonics and reactive power with reduced active filter rating, the significant parameters selected for comparison are source power factor, fundamental component of source current, THD in source current, and active filter current. The performances of these three filter configurations are compared with fixed element passive filter and analog $\text{Icos}\phi$ controller based shunt active filter (Figure 7.1)
Figure 7.1 (a) Variation in source power factor with firing angle

Figure 7.1(b) Variation in fundamental source current with firing angle

Figure 7.1(c) Variation in source current THD with firing angle
The significant conclusions are as follows:

1. Fixed element shunt passive filters cannot provide variable reactive power compensation or power factor correction under varying load conditions. Also they draw higher currents under light loaded conditions. Adaptive shunt passive filter is capable of providing variable reactive compensation with the help of TSC-TSR and digital controllers. The operation is fast and controller cost is negligible.

2. Both the fixed element shunt passive filters and the adaptive shunt passive filters are capable of reducing the THD, but could not meet the IEEE standards for the loads considered. In addition, they are not capable of unbalance correction of load currents.

3. The ANN controlled shunt active filter provides perfect reactive compensation under balanced/unbalanced steady state and dynamic conditions. It is capable of keeping source current THD within IEEE standard limits. The digital ANN controller to control shunt active filter is flexible and easy to implement. But, if active filter alone is used, rating of active filter is much high.

4. To reduce the rating of active filter, the adaptive shunt hybrid filter is implemented, which uses a single controller for controlling both adaptive shunt passive filter and ANN controlled shunt active filter. It helps in reduction of reactive power consumed from the source and THD in source current, with lower rated active filter.
It is concluded that adaptive shunt hybrid filter controlled by a single ANN controller is a viable alternative, provides complete compensation for reactive power, current harmonics and source current imbalance with lower rated active filter. The controller is flexible and easy to program.

7.1 Scope for future research

This research work can be extended to the research areas like:

Power systems have evolved from isolated generators feeding their own loads to huge interconnected systems which are spread across the country. Interconnected systems are more reliable, because in case of disruption in one part of the system, power can be fed from alternate paths and thus can maintain continuity of the system. However, harmonic distortions introduced by the nonlinear loads will propagate throughout the system. This issue may be solved by installing filters of suitably designed ratings at optimal locations in the interconnected power system. The optimal allocation and rating of these filters can be determined with help of evolutionary algorithms such as Genetic Algorithm.

For sustainable growth in power system, it is needed to utilize the renewable energy resources like wind, biomass, hydel power, co-generation, etc. The integration of wind energy into existing power system generates power quality issues such as voltage transients, instability, etc. When induction generator is used as wind power generator, it requires reactive power for magnetization. When the generated active power of an induction generator is varied due to wind, the absorbed reactive power and terminal voltage of an induction generator are significantly affected. A proper control scheme in wind energy generation system is required under normal operating condition to allow the proper control over the active power production. Adaptive shunt hybrid filters are suggested for improving power quality issues, when generation rapidly changes with wind speed.