ANALYSIS, DESIGN AND DEVELOPMENT OF THREE PHASE HYBRID POWER FILTERS

By

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Filters
Power filters
Hybrid power filters

CERTIFICATE

This is to certify that the thesis entitled, **"Analysis, Design and Development of Three Phase Hybrid Power Filters"** being submitted by **Mr. Vishal Verma** for the award of the degree of **Doctor of Philosophy** is a record of bonafide research work carried out by him in the Electrical Engineering Department of Indian Institute of Technology, Delhi.

Mr. Vishal Verma worked under my guidance and supervision and has fulfilled the requirements for the submission of this thesis, which to my knowledge has reached the requisite standard. The matter embodied in this thesis has not been submitted in part or in full to any other university or institute for the award of any degree.

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ABSTRACT

This thesis deals with the analysis, design and development of three-phase hybrid power filters for power quality improvement. Passive filters and active filters are generally employed to eliminate the harmonics in the ac mains. Passive filters provide limited and fixed compensation of harmonics and cause severe threats to ac system when they fall in resonance thereby amplifying certain harmonic currents. Active filters are very effective for compensation of harmonics and other power quality related problems. However, high cost of active filters is the main hindrance for their adoption in the ac system for power quality improvement, and thus cannot be regarded as cost effective solution. The hybrid of one or more passive and active filters combinations provides cost effective and efficient solution to power quality problems, particularly compensation of harmonics.

An attempt has been made in this research work to analyze, design and develop hybrid filters with low power rated voltage source inverters (VSI) having different topologies of passive filters and simplified control schemes under non-ideal ac mains conditions. A comprehensive study of different components of hybrid filters, viz, different topologies of passive filters, shunt and series active filters and hybrid combination of them have been made for power quality improvement. Some new topologies of hybrid filters and new control schemes for operation of their active filter elements have been analyzed, designed and implemented. The research work in this thesis has been dealt with four main objectives.

The first objective deals with the design of passive filters as the constituent part of hybrid filters. The design of passive filter is carried out with the emphasis on reduction of harmonics without any increase in net ac mains rms current. Passive filters are designed, modelled and simulated to study their performance using MATLAB (a standard software platform) and experimentally

validated the results. Besides this a novel topology of hybrid filter is proposed which eliminates the short falls of both series and shunt passive filters.

The second part of the thesis covers the analysis and performance evaluation of active filters and hybrid filters with new schemes for varying loads under non-ideal ac mains conditions. It consists of development of new topologies, and new control techniques and analysis of performance of the hybrid filters during transient and steady state operating conditions. Two topologies of hybrid filter system i.e. series hybrid filter and parallel hybrid filter are designed, analyzed, and mathematically modeled and their dynamic responses are simulated under varying load conditions. Experimental studies are also conducted to verify their simulated performance. Three novel topologies of front-end series conditioners are also proposed which are capable of providing compensation to both voltage and current based power quality problems without additional hardware. The performance of proposed new conditioners is evaluated through simulation results.

The third part of this work deals with a simplified, multifunctional and comprehensive control scheme of active filter as a component of hybrid filters. Since, the performance of the hybrid filter system mainly depends on the control scheme employed for generation of reference signals, the efforts are made to minimize phase shift delay and to minimize time of computation. The mutifunctionality of the control scheme is demonstrated through decomposition algorithm adopted to deal with power quality components other than harmonics. Two new techniques are developed for generation of reference signals for active filters used as part of hybrid filters. The technique based on detection of voltage signals for voltage quality, estimates positive sequence fundamental frequency in phase current component. The first of the two techniques based on detection of current signals for current quality, decomposes the components of current into

positive and negative sequence real and reactive fundamental component and harmonic component based on estimation in d-q synchronous reference frame and the other scheme utilizes Adaline based estimation.

The fourth part of the research work deals with new topology of unified hybrid power filters. A comprehensive study is made to compensate harmonics in load current alongwith compensation in voltage distortions at point of common coupling during transient and steady state operating conditions. Studies are also carried out on the combination of three element hybrid filter consisting of series active filter, parallel active filter and passive filters for harmonic compensation in current and voltage. The filter system is analyzed, and dynamic response is simulated under varying load conditions. The simulation is carried out using different harmonic current extraction schemes alongwith estimation of fundamental component responsible for maintaining the DC bus voltage of the active filter. Dynamic responses of the filter system are studied for switching in, and load perturbation during transient and steady state conditions. The performance analysis of the filter system is carried using MATLAB (a standard software platform) alongwith its Simulink and Power System Blockset (PSB) toolboxes.

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