A Review on Various Shunt Active Filters

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Abstract- In this review paper we have studied various techniques of power filters designed for large-power applications, where complex digital control circuit and expensive batteries are often used. In this study, a simple and low-cost active power filters circuit using an analog-based hysteresis current controller and capacitive energy storage. The filter is intended to be a low-power add-on unit to reduce the AC harmonic currents of existing electronic equipment (e.g., personal computers), which impose nonlinear loads to the AC mains. The operation principle, design criteria, and control strategy of the proposed filter are discussed.

Keywords: Power Active Filters.

I. INTRODUCTION

The application of power electronic in power conversion shows drawbacks that lead to power quality problems which could relate to harmonics affecting communication interference, heating, solid-state devices malfunction, resonance. Solutions involve several techniques that include the use of passive and active power filter (APF). A more advance approach is the use of hybrid filters amongst other involves the use of both the passive filter and shunt APF in combination. They are being used to eliminate both the lower order and higher order harmonics. The passive filter is normally designed to eliminate the bulk of load-current harmonic leaving the more complex problems to be solved by the APF.

Shunt APF normally operates using pulse width modulation (PWM) inverter techniques to inject the required non-sinusoidal current requirements of nonlinear loads but is complex with the number of switches in use . Another approach is the use of series active power filter that uses basic bridge-diode circuit, boost circuit and an inductor. Single phase converter produces a relatively high proportion of ac ripple voltage at its dc terminal; it is undesirable because of its heat producing effect. A smoothing needed to get continuous operation. It can be minimized by increasing number of pulses. Three phase ac supply with a suitable transformer connection permits an increasing the pulse number. When the number of pulses increased out put voltage gets smoothen. So here we are implementing an extension of single phase hybrid active power filter with three phases HAPF.

II. SHUNT ACTIVE POWER FILTER

The shunt topology is more popular as compared to others due to its performance and easy implementation. The shunt APF injects harmonic current in opposition to the load harmonics so as to cancel the effect of harmonics in the system as shown in fig. 1. The instantaneous power (*p-q*) theory is used for current reference generation and is implemented in simulink.

Hybrid active filters have been presented in the literature as a lower cost alternative to purely active filters for harmonic compensation. Hybrid filters use combinations of passive elements to reduce the ratings of the active element required, [1-4]. The development of hybrid filter topologies has followed a natural progression from purely passive tuned filters which have been used for many years, to simplified passive structures with one active element. These passive structures have been largely based on the original tuned structures. This paper systematically reviews the possible alternatives for hybrid active filter topologies and identifies those most suitable for harmonic reduction with low active component ratings. The method used is to:

- select suitable models for the load
- determine the desirable attributes of a filter
- generate possible topologies and identify useful filters

This approach uncovers existing and new topologies and establishes a systematic framework for describing active filters.

III. LITERATURE SURVEY

Chi-Seng Lam; Wai-Hei Choi; Man-Chung Wong; Ying-Duo Han [1] in 2012 presents the reference dc-link voltage is classified into certain levels for selection in order to alleviate the problem of dc voltage fluctuation caused by its reference frequent variation, and hence reducing the fluctuation impact on the compensation performances. Finally, representative simulation and experimental results of a three-phase four-wire center-split LC -HAPF are presented to verify the validity and effectiveness of the proposed adaptive dc-link voltage-controlled LC-HAPF in dynamic reactive power compensation.

Patel, P.; Mullay, M. A. [2] in 2012 worked on most common problem arising in supply network is current harmonics because of the increased use of nonlinear loads. Traditionally passive and active filters are best solutions for harmonic removal, but they have some practical limitations. Solution to these limitations is to use hybrid active power filters (HAPF) which are different combinations of passive and/or active filters. HAPF inherit the efficiency of passive filters and the improved performance of active filters. In HAPF, filtering characteristics of passive filter is improved by active power filter. Three different types of HAPF are discussed in this paper. All topologies are presented and are verified via simulation study in PSIM software. Performance parameters of all the topologies are compared based on supply current THD, load voltage THD and fundamental voltage/current values for similar supply and load conditions.

Lam, C.-S.; Wong, M.-C.; Han, Y.-D [3] in 2012 presented a hysteresis pulse width modulation study for a inductor-capacitor (LC)-coupling hybrid active power filter (HAPF). As the coupling LC impedance yields a non-linear inverter current slope, this can affect the controllability of using the conventional hysteresis control method and generate unexpected trigger signals to the switching devices. This results in deteriorating the system operating performances. The design criteria of hysteresis band and sampling time can then be derived. Single-phase simulation and experimental results are given to verify the hysteresis control study of HAPF compared with active power filter.

Bhattacharya, A.; Chakraborty, C.; Bhattacharya, S.[4] in 2012 proposed a combination of low- and high-frequency hybrid active power filter (APF) to operate in parallel for better performance. The individual hybrid APF is a series combination of L-C filter with the corresponding voltage source inverter. The dc links of both the inverters are connected in parallel, and the voltage of the dc link is maintained by the low-frequency inverter (LFI). The low- and high-frequency inverters eliminate lower order and higher order harmonics, respectively. In addition, it is possible to design the LFI such that it can also compensate the reactive power of the load. The individual L-C filter of the hybrid topology is designed to take care of specific order of harmonics that are predominant in the load. A combination of feedforward and feedback controller is designed for the proposed conditioner.

Mulla, M.A.; Patel, P.; Chudamani, R.; Chowdhury, A.[5] in 2012done research on power quality problems have received increasing attentions in recent years due to proliferation of nonlinear and sensitive loads as well as unpredictable and unavoidable system faults. Power quality problems mainly include current harmonics, reactive power, supply unbalance, sag, swell etc. Series Hybrid Active Power Filters (SHAPF) has been the main topic of interest for researchers working in the area of active power filters (APF). SHAPF provides cost-effective solution as compared to standalone active filters and are preferred to compensate both voltage and current type harmonics. This paper present simplified control strategy for SHAPF with added functionality of compensating voltage sag, swell and unbalance. Mathematical formulation of reference generation scheme with simulation verification of SHAPF model is tested for compensation of voltage sag, swell, unbalance and harmonics is presented.

Wai-Hei Choi; Chi-Seng Lam; Man-Chung Wong; Ying-Duo Han, [7] in 2013 investigated different dc-link voltage control strategies in a three-phase four-wire LC coupling hybrid active power filter (LC -HAPF) for reactive power compensation. By using direct current (current reference) pulsewidth modulation (PWM) control method, to achieve dc-link voltage self-charging function during LC -HAPF start-up process, the dc-link voltage control signal feedback as reactive current component is more effective than the traditional method as an active current component.

IV. PROPOSED METHODOLOGY

The new proposed hybrid APF consists of two types of filter; simple LC passive filter and a PAPF for removing both high order and low order harmonic components. Fig. 1 shows the arrangement of proposed hybrid APF and in block diagram of Fig. 2 with its control components of the PAPF is used to inject equal but opposite current into the system to mitigate the distortion current to a sinusoidal form; in phase and time with the voltage supply. The new proposed PAPF topology only consist a single active power switch (IGBT) in order to simplify the compensation circuit and reduce the switching stress.

The SCCL (fig.1) is used to monitor the supply current waveform and make corrections by current compensation techniques. If the supply current is distorted, the SCCL will respond by providing switching signal to the IGBT that will inject the current compensation from the PAPF circuit to the mains to compensate the distorted supply current into a sinusoidal form. Unipolar switching is proposed due to the use of one power switch in the system. The compensation circuit uses a boost and PWM technique to generate the injected current into the system.

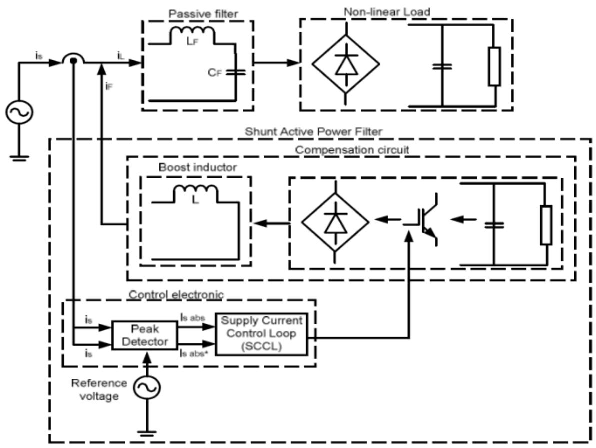

Fig. 1: The Proposed Hybrid APF Arrangement

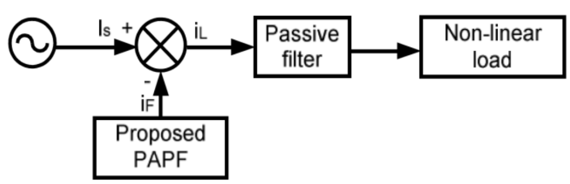

Fig. 2: Functional Block Diagram of Hybrid APF

In this work, active PWM as active current wave shaping is used for switching control. This technique allows active comparison of the error signal with the carrier signal to ensure error is kept within the boundaries of the carrier peaks at all times. The active PWM operates by comparing the corrected signal with the carrier signal to produce the required PWM control. When sinusoidal signal has magnitude larger than or equal to the carrier signal, the comparator output (PWM sequence) is higher. A proportional integral (PI) control algorithm is used to regulate the error.

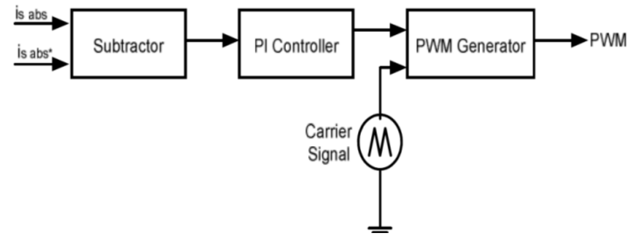

Fig. 3: Control Components of PAPF

The operation of the PAPF is best described by the illustration as shown in Figure 4 to inject the required current into the system. When switch is turned ON (Figure 4(a)), diode D5 is reversed biased. Thus the output stage is isolated from the system. The input supplies energy to the boost inductor that causes inductor current to increase linearly with ramp behaviour. The energy stored in the inductor can be used for compensation purposes. When the switch is turned OFF, diode D5 is forward biased as shown in the equivalent circuit of Fig. 4(b). There exists a change in current. Since the inductor cannot change instantaneously, the voltage in the inductor reverses its polarity to maintain constant current. In this stage, the current will flow through the inductor, diode D5 and the compensating load.

V. CONCLUSION AND FUTURE SCOPE

The introduced mathematical tool proposes a general alternative to calculate the instantaneous power, based on a formal definition regardless of the reference frame and phases number of the power system. This new formulation allows the estimate of the reference currents for APFs control from a geometric point of view. This is accomplished by measuring of the shape deviations (changes in the dimensions) in each component of the power tensor proposed. Besides, an active power filter can be implemented with the simulation that has been studied.

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