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Extensive Survey On Passive Filter Based Shunt Compensators with Power Theory

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Abstract-The passive filters are used to mitigate power quality problems in six-pulse ac-dc converter with R-L load. Moreover, apart from mitigating the current harmonics, the passive filters also provide reactive power compensation, thereby, further improving the system performance. For current source type of harmonic producing loads, generally, passive shunt filters are recommended. These filter apart from mitigating the current harmonics, also provide limited reactive power compensation and dc bus voltage regulation. However, the performance of these filters depends heavily on the source impedance present in the system, as these filter act as sinks for the harmonic currents. On the other hand, for voltage source type harmonic producing loads, the use of the series passive filters is recommended. These filters block the flow of harmonic current into ac mains, by providing high impedance path at certain harmonic frequencies for which the filter is tuned. Moreover, the harmonic compensation is practically independent of the source impedance. But, passive filter suffer due to the reduction in dc link voltage due to the voltage drop across the filter components at both fundamental as well as harmonic frequencies.

KEYWORDS-Active Filters, Power Distribution, Power Filters, Power Quality.

I. INTRODUCTION

Active Filters (APF) have been used as a solution to improve energy quality in electrical grids. There are different connections of APF into the electrical grid. The most common is the shunt. In this connection, the APF is connected in parallel with nonlinear loads and its main function is to compensate line harmonic currents produced by them. Another connection of APF is series with nonlinear loads. Its main function is to block harmonic voltages in the nonlinear loads from distorted electrical grid voltage.

APF improve the energy quality with pretty well accuracy and efficiency. The great disadvantage of APF is the high cost compared to passive solutions. The more voltage and current the semiconductor devices should hold, the more expensive they are.

In order to suppress this inconvenience, Hybrid Active Power Filters (HAPF) was developed. HAPF is a combination of APF and Tuned Passive Filters (TPF). HAPF may compensate line harmonic current caused by nonlinear loads and control reactive power injected into the electrical grid. In HAPF, the cost of the APF is deeply reduced due to the lower voltage or current over the semiconductor devices compared to an APF connected either in shunt or in series configuration.

Some HAPF topologies were developed along the years. The most common is one in which the APF is series connected with a TPF. The great disadvantage of this topology is the requirement of the inverter to hold all compensated current.

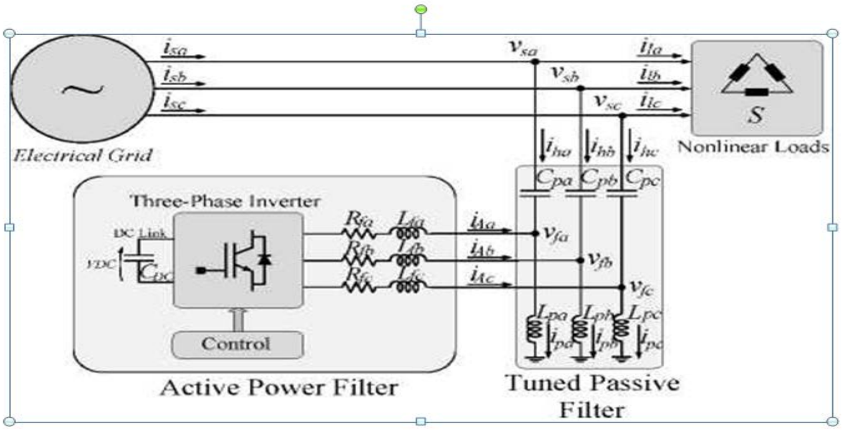

Fig.1.1. Simplified Electrical Diagram of a HAPF

Another topology of HAPF is the parallel connection of APF and the TPF inductor. In this case, the inverter does not need to hold the compensated current at the same frequency which the passive filter is tuned. In this research work, this type of HAPF is mentioned as HAPF. The Fig. 1 presents a simplified electrical diagram of a HAPF.

A control design approach of the HAPF is presented. The main advantage of the strategy covered is the simplicity of implementation. Nevertheless, there is nothing in the control that guarantees the whole eliminating of harmonic components.

The control strategy presented in based on the same principle, but the complexity of the model is meaningfully enlarged.

This research work presents a control strategy for the HAPF. The mathematical voltage-sourced inverter model is derived by using Kirchhoff Voltage and Current Laws. The control design is based on frequency response. Furthermore, the mathematical model is transformed into dq rotating reference frame in order to facilitate the control design.

1.1 ACTIVE FILTERS:

Pure active filters can be classified into two types according to their circuit configuration-

- Shunt (Parallel) active filters
- Series active filters

Shunt active filters have more advantage over series active filters regarding their form and function. So series active filters are basically suitable only for harmonic filtering. Shunt active filter circuit configuration:-

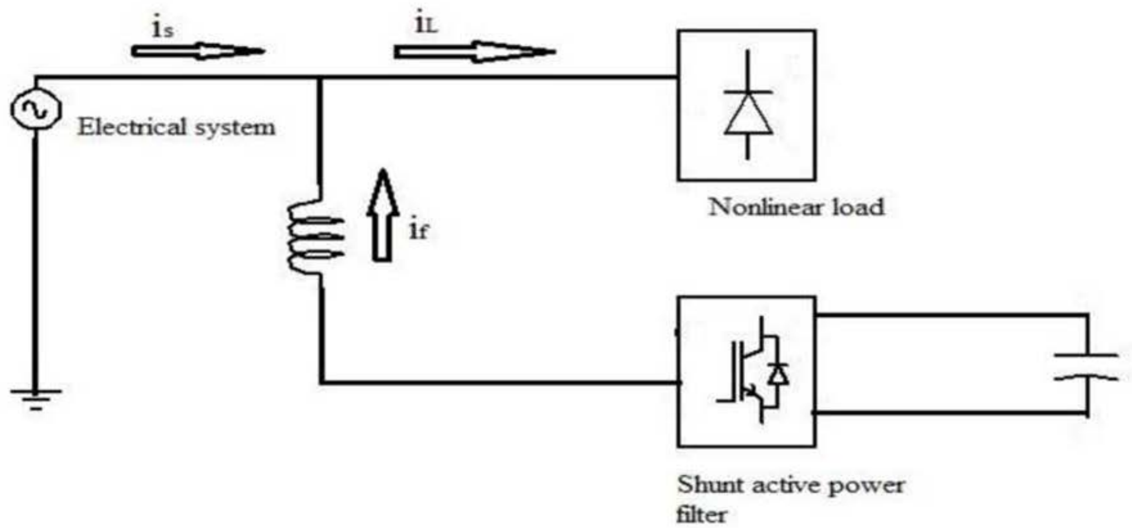

Fig. 1.2 Schematic Diagram of a Shunt active filter.

Fig.1.2 shows a 1-phase or 3-phase diode rectifier with a capacitive dc load which can filter current harmonics. This is a very fundamental system design which can be modified further. The dc load can be treated as ac motor driven by a voltage source PWM (VS-PWM) inverter. This active filter has been connected in parallel with the harmonic generating load. “Feed forward” method has been implemented to control the filter.

1. The instantaneous load current is observed by the controller.

2. From the detected load current harmonic current is pulled out with the help of DSP.

3. To cancel out the harmonic current, active power filter draws compensating current from utility supply.

Fig. 1.3 works for voltage harmonic filtering in case of 1-phase and 3-phase diode rectifier with a capacitive dc load. The series active filter is series connected with the power supply. This filter controls on the basis of “Feedback” manner

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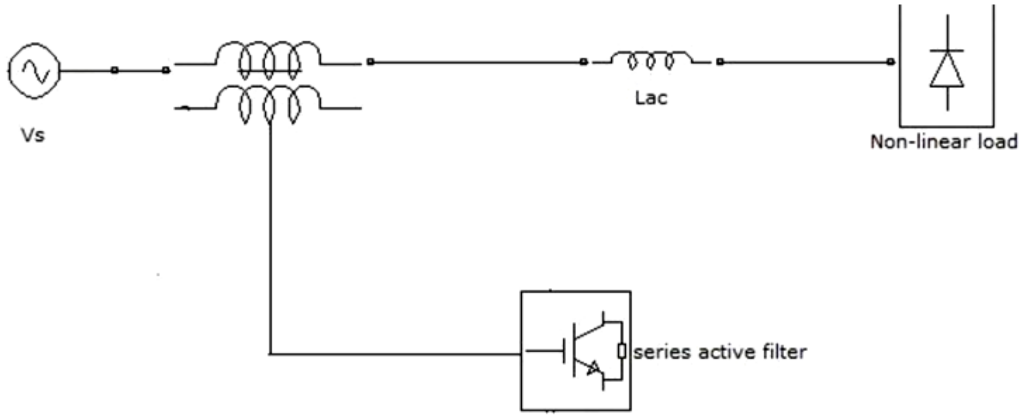

Fig.1.3 Schematic diagram of series active filter

• Instantaneous supply current is detected by controller.

• Harmonic currents are extracted from the supply current by means of DSP.The active filter applies the compensating voltage across the primary of transformer. This reduces the supply harmonics significantly

II. SYSTEM MODEL

2.1 TOPOLOGY OF SINGLE PHASE SHUNT ACTIVE POWER FILTER:

The SPSAPF shown in fig.2.1 consists of a single-phase full-bridge voltage-source PWM inverter, a DC bus capacitor and an inductor. The inductance, through which the inverter is connected to the power supply network, ensures, firstly, the controllability of the active filter current and acts, secondly, as a first-order passive filter attenuating, thus, the high frequency ripples generated by the inverter. The filter operates as current source, which cancels the current-type harmonics and exchanges the necessary reactive energy required by

the non-linear load. A single-phase diode bridge rectifier feeding a series R-L circuit is chosen to represent the non-linear load.

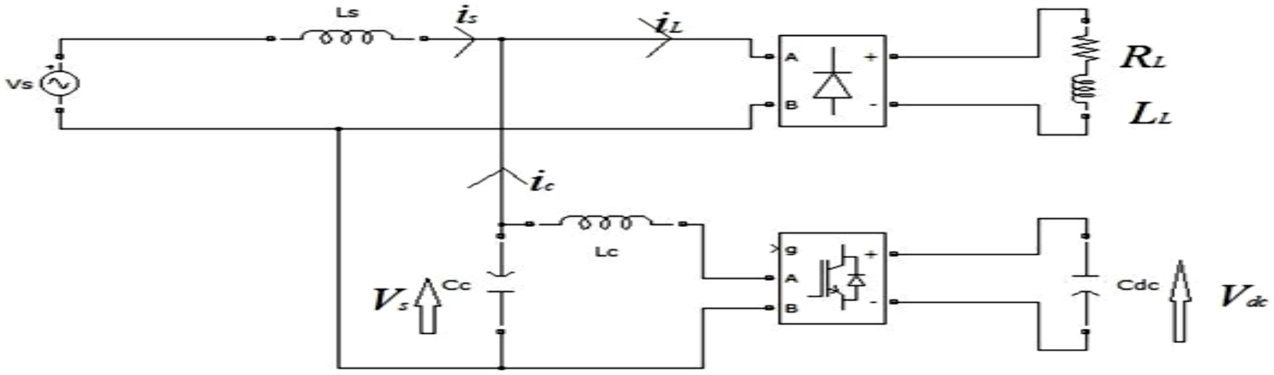

Fig.2.1. Single phase shunt active power filter.

2.3. Single phase shunt hybrid power filter topology:

The SPSHPF shown in fig.2.2 consists of a full-bridge voltage-source PWM inverter, a DC side capacitor, an inductor, a transformer and a power factor correction (PFC) capacitor. The primary winding of the transformer is fed by the inverter. The PFC capacitor and the secondary winding of the transformer are connected in series to form a branch parallel to the non-linear load. The iron core of the transformer contains an air-gap in order to reduce its magnetizing inductance. The PFC capacitor and the magnetizing inductance L^ create a second-order filter tuned at the third harmonic.

The shunt-connected active power filter, with a self-controlled dc bus, has a topology similar to that of a static compensator (STATCOM) used for reactive power compensation in power transmission systems. Shunt active power filters compensate load current harmonics by injecting equal-but opposite harmonic compensating current. In this case the shunt active power filter operates as a current source injecting the harmonic components generated by the load but phase-shifted by 180°.shows the connection of a shunt active power filter and Figure 2.3

shows how the active filter works to compensate the load harmonic currents.

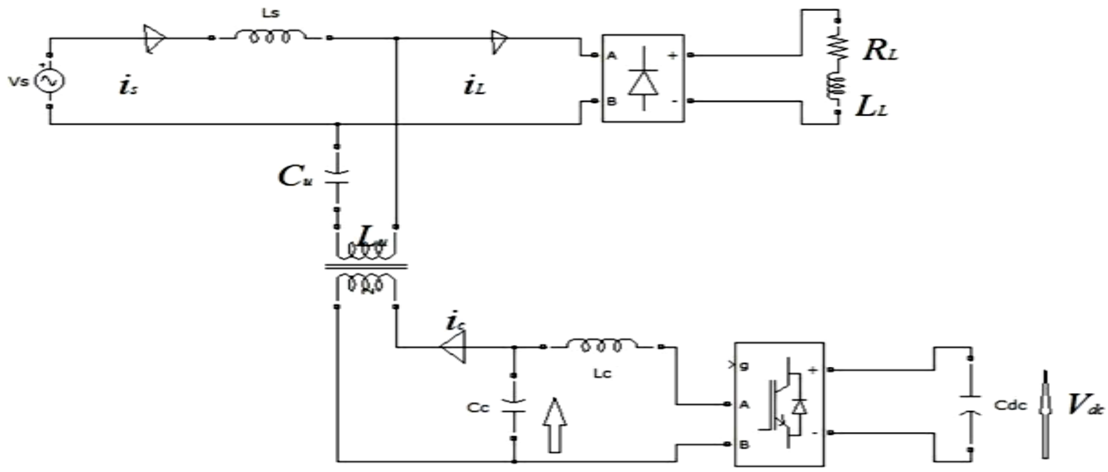

Fig.2.2. Single phase hybrid power filter.

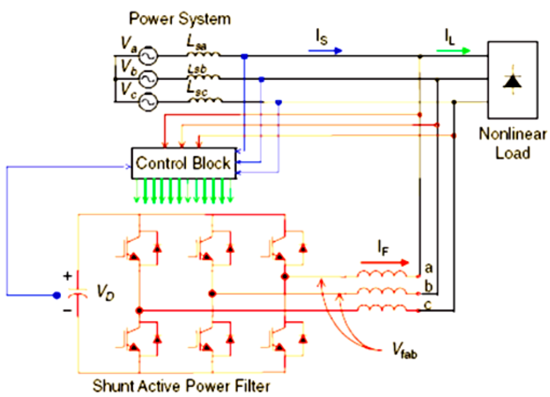

Fig.2.3 Shunt active power filter topology

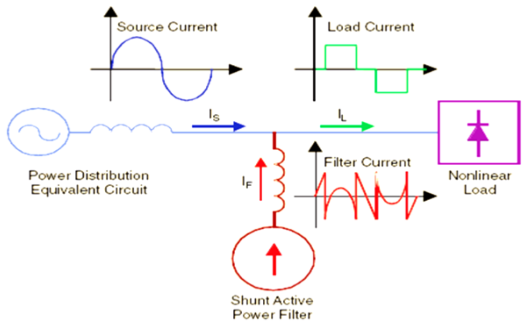

Fig.2.4 Filter current IF generated to compensate load-current harmonics.

III. LITERATURE SURVEY

K. Hiranandani [1] "Effects of harmonics on the current carrying capacity of insulated power cables used in three phase electrical power distribution systems simulated that the non-linear loads are becoming a bigger part of the electrical load in industrial and commercial power system-such as solid-state energy conversion devices, traction drives industrial variable speed drives, andarc welding equipment. Non-linear loads generate harmonics in line currents resulting in additional conductor heating, this heating results in a higher temperature rise of the cable if it is not sized to can harmonic currents. To include the effects of harmonics the frequency spectrum of the load has to be known. In three phase we connected electrical power distribution systems with neutrals, sinusoidal line currents are symmetrical resulting in zero neutral current whereas line currents with harmonics such as those supplying non-linear loads result in non-zero neutral currents due to the summation of zero sequence currents in the neutral conductor. Present standards by NEQ National Electric Code) [5] and IEEE [8] define cable current ratings for sinusoidal (fundamental) currents only and do not provide a suitable transformation for cable current ratings for non-linear loads. This research work defines a suitable transformation to convert standard sinusoidal current ratings to those suitable for non-linear loads by use of harmonic derating factors based on the harmonic spectrum of the load which can be used to size line and neutral conductors of three phase electrical power distribution system[l]. Harmonics generated by non-linear loads decrease the quality of power supplied.

P. E. C. Stone, J. Wang, Y. J. Shin and R. A. Dougal[2], "Efficient Harmonic Filter Allocation in an Industrial Distribution System,“proposed that the In order to properly suppress the harmonic current in a power system, the harmonic similarity metric is developed in this research work and used to establish an efficient strategy for harmonic filter placement. To validate the strategy, an industrial distribution system is analyzed under two harmonic current injection scenarios. It is demonstrated that the proposed strategy has a robust ability to successfully determine the most efficient and effective location for placing a harmonic filter bank based upon the desired objectives. The two harmonic current injection scenarios serve to validate the proposed strategy regardless of the power distribution level at which harmonic current is injected.

A. Hamadi, S. Rahmani and K. Al-Haddad [3], "A Hybrid Passive Filter Configuration for VAR Control and Harmonic Compensation,"It investigated that the research work proposes a novel topology for a three-phase hybrid passive filter (HPF) to compensate for reactive power and harmonics. The HPF consists of a series passive filter and a thyristor-controlled-reactor-based variable-impedance shunt passive filter (SPF). A mutual-inductance design concept is used to reduce the series passive filter inductance rating. The special features of the proposed HPF system are as follows: 1) insensitivity to source-impedance variations; 2) no series or parallel resonance problems; 3) fast dynamic response; and 4) significant size reduction in an SPF capacitor. The performance of the proposed HPF system is validated by simulation, as well as by experimentation, under different load conditions. Experimental and simulation results show that the proposed system can effectively compensate all voltage and current harmonics and reactive power for large non linear loads.

V. Dzhankhotov and J. Pyrhönen [4], "Passive LC Filter Design Considerations for Motor Applications. In this research work it provides design guidelines for the passive LC filters. Based on these guidelines, a method to design a new type of a passive filter, called hybrid LC filter, is proposed. A filter design example accompanies the considerations; simulation and test results of the proposed filter in time and frequency domains are shown.

III. PROBLEM DESCRIPTION

The existing research work proposed two shunt compensators to help a TPF and a capacitor bank. The TPF and the capacitor bank are kept introduced and unaltered. One compensator was intended to repay consonant current created by nonlinear loads and to increase the loss of filtering adequacy due to the TPF parameter variety. The other compensator was intended to repay responsive vitality and load unbalance. A contextual analysis was performed to check the adequacy of the compensators. A shunt active power filter has been investigated for power quality improvement various simulations are carried out to analyze the performance of the system. Our proposed methodology is to reduce the system complication and improve the quality of power system.

IV. CONCLUSION

This Research work describes a comparative study between single-phase shunt active power filter (SPSAPF) and a single-phase shunt hybrid power filter (SPSHPF). Simulation results proved that performance of the SPSHPF is much better than the SPSAPF. The DC link voltage of SPSAPF is twice more than that of SPSHPF. SPSHPF has a filter current which is reduced by factor 2 also switching frequency reduced by a factor 3 compared to SPSAPF. The application of UPWM to generate gating signals has advantages such as elimination of group of harmonics that centred on odd multiples of switching frequency. The combined system of passive and an active filter has following features- 1. Source impedance no longer governs the filtering characteristics. 2. The active filter has the ability to dump the parallel and series resonance between the source and the passive filter. 3. In this case the required rating of active filter is much less than a conventional active filter used alone. This happens due to passive filters having high quality factor, as the rating of active filter connected in series will come down in inverse proportion of quality factor of passive filter.

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