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COMPARATIVE STUDY OF IMPROVEMENT OF THE ELECTRIC POWER QUALITY USING FACTS DEVICES & SERIES ACTIVE AND SHUNT PASSIVE FILTERS

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ABSTRACT *– This paper presents A control algorithm for a three-phase hybrid power filter is proposed. It is constituted by a series active filter and a passive filter connected in parallel with the load. The control strategy is based on the vectorial theory dual formulation of instantaneous reactive power, so that the voltage waveform injected by the active filter is able to compensate the reactive power and the load current harmonics and to balance asymmetrical loads. The proposed algorithm also improves the behavior of the passive filter. Simulations have been carried out on the MATLAB-Simulink platform with different loads and with variation in the source impedance. This analysis allowed an experimental prototype to be developed. Experimental and simulation results are presented.*

Index Terms – Active Power Filter, Passive Filters, Reactive Power, Hybrid Filter, Power Quality.

I. INTRODUCTION

The increase of nonlinear loads due to the proliferation of electronic equipment causes power quality in the power system to deteriorate. Harmonic current drawn from a supply by the nonlinear load results in the distortion of the supply voltage waveform at the point of common coupling (PCC) due to the source impedance. Both distorted current and voltage may cause
end-user equipment to malfunction, conductors to overheat and
may reduce the efficiency and life expectancy of the equipment
connected at the PCC. Traditionally, a passive LC power filter is used to eliminate current harmonics when it is connected in parallel with the load. This compensation equipment has some drawbacks, due to which the passive filter cannot provide a complete solution. These disadvantages are mainly the following.

—The compensation characteristics heavily depend on the system impedance because the filter impedance has to be smaller than the source impedance in order to eliminate source current harmonics.

—Overloads can happen in the passive filter due to the circulation of harmonics coming from nonlinear loads connected near the connection point of the passive filter.

—They are not suitable for variable loads, since, on one hand, they are designed for a specific reactive power, and on the other hand, the variation of the load impedance can detune the filter.

—Series and/or parallel resonances with the rest of the system can appear.

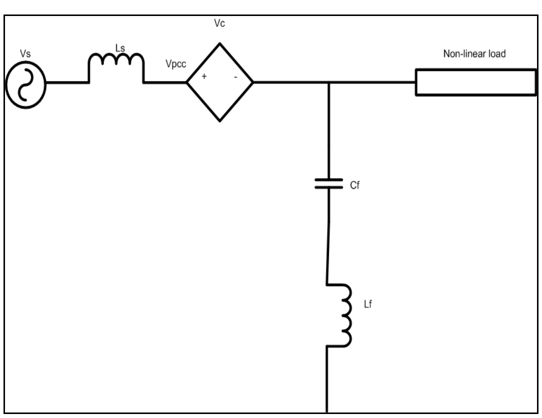

Fig.1. Series active filter and parallel passive filter

An active power filter, APF, typically consists of a three phase pulse width modulation (PWM) voltage source inverter. When this equipment is connected in series to the ac source impedance it is possible to improve the compensation characteristics of the passive filters in parallel connection. This
topology is shown in Fig. 1, where the active filter is represented by a controlled source, where is the voltage that the inverter should generate to achieve the objective of the proposed control algorithm. Different techniques have been applied to obtain a control signal for the active filter. One such is the generation of a voltage proportional to the source current harmonics .With this control algorithm, the elimination of series and/or parallel resonances with the rest of the system is possible. The active filter can prevent the passive filter becoming a harmonics drain on the close loads. Additionally, it can prevent the compensation features depending on the system impedance. From the theoretical point of view, the ideal situation would be that the proportionality constant, k, between the active filter output voltage and source current harmonics, had a high value. However, at the limit this would be an infinite value and would mean that the control objective was impossible to achieve. The chosen k value is usually small so as to avoid high power active filters and instabilities in the system. However, the choice of the appropriate k value is an unsolved question since it is related to the passive filter and the source impedance values. Besides, this strategy is not suitable for use in systems with variable loads because the passive filter reactive power is constant, and therefore, the set compensation equipment and load has a variable power factor.

In another proposed control technique, the APF generates a
voltage waveform similar to the voltage harmonics at the load side but in opposition. This strategy only prevents the parallel passive filter depending on the source impedance; the other limitations of the passive filter nevertheless remain.

II. LITERATURE REVIEW

Power quality problem exists if any voltage, current or frequency deviation results in a faliure or in a bad operation of customer's equipment. One more problem is harmonics. Harmonics are produced due to non linear load. A flexible and versatile solution to power quality problem are offerd by active power filters. Here are various literature review on the the improvement of power quality.

P. Salmeron and S. P. Litran (2010), proposed a control algorithm for three phase hybrid power filter. This is constituted by a series active filter and passive filter connected in parallel with the load. The control stratergy is based on the Vectorial Theory dual formulation of instantaneous reactive power so that the voltage waveform injected by active filter is able to compensate the reactive power and the load current harmonics and to balance a symmetrical load the proposed algorithm also improves the behaviour of passive filter [1].

B. Singh, K. Al-Hadad, and A.Chandra (1999), proposed active filtering of electric power has become a mature technology for harmonic and reactive power compensation in two wire (single phase), three wire (three phase without neutral), and four wire (three phase with neutral) ac power networks with nonlinear load. they proposed a comprehensive review of active filter configurations, control strategy, selection of compontants, other related economic and technical consideration, and their selection for specific applications. It is aimed at providing a broad perspective on the status of AF technology to researchers and application engineers dealing with power quality issues.[2]

J. W. Dixon, G. Venegas, and L. A. Moran (1997), proposed a series active power filter working as a sinusoidal current source, in phase with the mains voltage. The amplitude of the fundamental current in the series filter is controlled through the error signal generated between the load voltage and a pre established reference. The control allows an effective correction of power factor, harmonic distortion, and load voltage regulation. Compared with previous methods of control developed for series active filters, this method is simper to implement, because it is only required to generate a sinusoidal current, in phase with the mains voltage, the amplitude of which is controlled through the error in the load voltage [3].

R. S. Herrera and P. Salmeron (2007)the behavior of different active power filter (APF) control algorithms resulting from five formulations of the instantaneous power theory: – original theory,– transformation, modified or cross product formulation, – – reference frame and vectorial theory are analyzed. A simulation platform with control + APF + load is built to test the different algorithms. The results obtained in an unbalanced and nonsinusoidal three-phase four-wire system are compared. The final analysis shows that from the five formulations, only the vectorial one allows balanced and sinusoidal source currents after compensation.[4]

Darwin Rivas, Luis Moran, Juan W. Dixon and Jose R. Espinoza (2003), proposed the performance analysis of a hybrid
filter composed of passive and active filters connected in series.
The analysis is done by evaluating the influence of passive
filter parameters variations and the effects that different active
power filter's gain have in the compensation performance of the hybrid scheme.[5]

J. C. Das (2004), proposed new topologies for harmonic mitigation and active filters have come long way & these address the line harmonic control at the source.[6]

F.Z. Peng and D. J. Adams (1999), proposed 22 configurations of power filters for harmonic compensation of non linear load.[7]

H. Akagi (2005), proposed unlike traditional paassive harmonic filters, modern active harmonic filters have the following multiple function: harmonic filtering, damping, isolation and termination, reactive-power control for power factore correction and voltage regulation, load balancing, voltage flicker reduction, and/or their combination.[8]

J. K. Pomilio and S.M. Deckmann(2007), proposed usage of data obtained from laboratory measurement of typical home application to verify whether these nonlinear loads behave similar to current or voltage type harmonic source [9]. C. Sankaran, provides complete knowledge about quality.[10]

III.SERIES ACTIVE FILTER AND PARALLEL PASSIVE FILTER

The project provides a new control strategy based on the dual formulation of the electric power vectorial theory is proposed. For this, a balanced and resistive load is considered as reference load. The strategy obtains the voltage that the active filter has to generate to attain the objective of achieving ideal behavior for the set hybrid filter-load. When the source voltages are sinusoidal and balanced the power factor is unity, in other words, the load reactive power is compensated and the source current harmonics are eliminated. By this means, it is possible to improve the passive filter compensation characteristics without depending on the system impedance, since the set load-filter would present resistive behavior. It also avoids the danger that the passive filter behaves as a harmonic drain of close loads and likewise the risk of possible series and/or parallel resonances with the rest of the system. In addition, the compensation is also possible with variable loads, not affecting the possible the passive filter detuning.

Although the APF series control based on the instantaneous reactive power theory is not new, in this paper the authors propose a new formulation that has consequences in the control loop design. In fact, the instantaneous reactive power here is defined from a dot product whereas in it is defined as a cross product; this results in a remarkable simplification in the implementation of the reference generation method. The final development allows any compensation strategy to be obtained, among them, unit power factor.

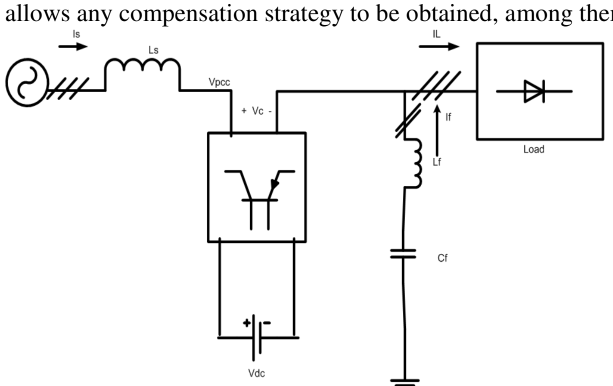

Fig.2. System with compensating equipment

IV. COMPARISON WITH FACTS DEVICE

The series and shunt compensation are able to increase the maximum transfer capabilities of power network .Concerning to voltage stability, such compensation has the purpose of injecting reactive power to maintain the voltage magnitude in the nodes close to the nominal values, besides, to reduce line currents and therefore the total system losses. At the present time, thanks to the development in the power electronics devices, the voltage magnitude in some node of the system can be adjusted through sophisticated and versatile devices named FACTS. One of them is the static synchronous compensator STATCOM.

VI. CONCLUSION

A control algorithm for a hybrid power filter constituted by a series active filter and a passive filter connected in parallel with the load is proposed. The control strategy is based on the dual vectorial theory of electric power. The new control approach achieves the following targets.

—The compensation characteristics of the hybrid compensator do not depend on the system impedance.

—The set hybrid filter and load presents a resistive behavior. This fact eliminates the risk of overload due to the current harmonics of nonlinear loads close to the compensated system.

—This compensator can be applied to loads with random power variation as it is not affected by changes in the tuning frequency of the passive filter. Furthermore, the reactive power variation is compensated by the active filter.

—Series and/or parallel resonances with the rest of the system are avoided because compensation equipment and load presents resistive behavior.

Therefore, with the proposed control algorithm, the active filter improves the harmonic compensation features of the passive filter and the power factor of the load.

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