Design and Implementation of Electric Power Quality Enhancement Using Series Active and Shunt Passive Filters with Regenerative Wind System

Miss. Damini V. Gattewar[1], Prof. S. S. Raut[2]

[1]*Student, Department of Electrical Engineering, Shri Sai College of Engineering and Technology, Bhadrawati, Maharashtra, India*
[2]*Professor, Department of Engineering, Shri Sai College of Engineering and Technology, Bhadrawati, Maharashtra, India*

ABSTRACT

Poor quality of electric supply is normally caused by power line disturbances such as transients notches, momentary interruptions, voltage sag and swell, over voltage, under voltage and harmonic distortions. Filter are used for improving the power quality. An active and passive filter eliminates major fluctuating factors. This paper presents A control calculation for a three-phase hybrid power filter is proposed. It is comprised by a series active filter and shunt passive filter associated with the load. The control technique depends on the vectorial theory dual formulation plan of instantaneous reactive power (P-Q Theory), with the goal that the voltage waveform infused by the active filter can remunerate the reactive power and the load current harmonics and to adjust asymmetrical loads. The proposed calculation additionally works on the way of behaving of the passive filter. Simulations have been done on the MATLAB-Simulink stage with various loads and with variety in the source impedance. This examination permitted a trial model to be created. Trial and simulation results are introduced.

Keyword: - *Series Active Filter, Shunt Passive Filters, Reactive Power, Power Quality Improvement.*

---

1. Introduction

Today, when we observe constantly increasing electricity consumption and extremely rapid technological progress, it is necessary to pay attention to responsible energy utilization. The shift from fossil fuels to clean energy sources is inevitable, and the increased demand for energy makes power quality (PQ) issues very important.

Ensuring an adequate level of power quality becomes more difficult as the number of loads that have a negative impact on PQ indicators increases. The distortion of voltage and current waveforms caused by nonlinear loads and manifested by higher harmonics is one of the most important parameters of power quality. The elimination of higher harmonics is one of the basic tasks for power quality improvement systems.

The placement of harmonic reduction devices, including active power filters (APFs), in power systems is one of the key elements in the successful improvement of power quality, not only from a technical, but also from economic, point of view [3]. In many cases, filters must be used in complex and large power networks with many nonlinear loads and a significant number of nodes. Among these nodes, there are many to which an APF or other high-quality power supply equipment can be connected. Therefore, the system designer must be able to solve the optimization problem consisting in the location of devices, ensuring, among other things, the effective elimination of higher harmonics, while keeping solution costs under control.

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.

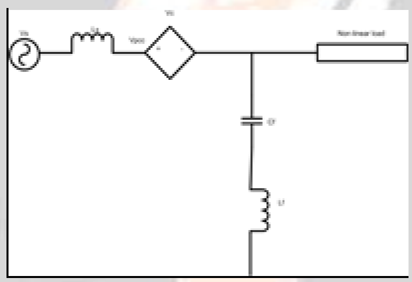

Fig.1. Series active filter and shunt passive filter

A active power filter, APF, regularly comprises of a three phase pulse width modulation (PWM) voltage source inverter. At the point when this system is associated in series to the ac source impedance further developing the compensation characteristics of the passive filter in parallel connection is conceivable. Where the active filter is addressed by a controlled source, where is the voltage that the inverter ought to produce to accomplish the target of the proposed control algorithm. Various strategies have been applied to acquire a control signal for the active filter. One such is the generation of a voltage relative to the source current harmonics .With this control algorithm, the end of series as well as parallel resonances with the rest of the framework is conceivable. The active filter can prevent the passive filter becoming a harmonics drain on the close loads.

2. LITERATURE REVIEW

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

1) 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].

2) 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]

3) 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].

4) 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]

5) 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]

6) 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]

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

8) 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]

9) 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].

10) C. Sankaran, provides complete knowledge about quality.[10]

3. SERIES ACTIVE FILTER AND SHUNT 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.

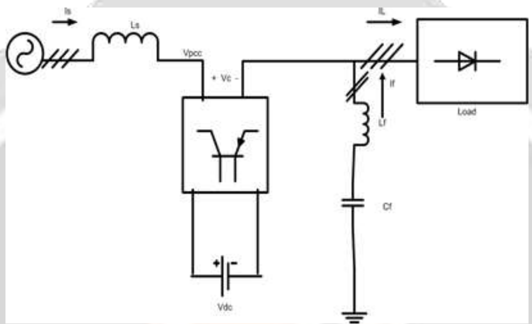

Fig.2. System with compensating equipment

4. 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.

5. CONCLUSION

A control calculation for a hybrid power filter comprised by a series active filter and a passive filter associated in parallel with the load is proposed. The control procedure depends on the dual vectorial theory of electric power. The new control approach accomplishes 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.

6. REFERENCES

[1]. P. Salmerón and S. P. Litrán, “Improvement of the electric power quality using series active and shunt passive filters,” IEEE Trans. Power Del., vol.25, no. 2, Apr. 2010.

[2]. B. Singh, K. Al-Haddad, and A. Chandra, “A review of active filters for power quality improvement,” IEEE Trans. Ind. Electron., vol. 46, no. 5, pp. 960–971, Oct. 1999.

[3]. J. W. Dixon, G. Venegas, and L. A. Moran, “A series active power filter based on a sinusoidal current-controlled voltage-source inverter,” IEEE Trans. Ind. Electron., vol. 44, no. 5, pp. 612–620, Oct. 1997.

[4]. R.S.Herrera and P. Salmerón, “Instantaneous reactive power theory: A comparative evaluation of different formulations,” IEEE Trans. Power Del., vol. 22, no. 1, pp. 595–604, Jan. 2007

[5]. Darwin Rivas, Luis Morán, Juan W. Dixon and José R. Espinoza, “Improving passive filter compensation performance with active techniques,” IEEE Trans. Ind. Electronics,vol. 50, no. 1, Feb 2003.

[6]. J. C. Das, “Passive filters-potentialities and limitations,” IEEE Trans.Ind. Appli., vol. 40, no. 1, pp. 232–241, Jan. 2004.

[7]. F. Z. Peng and D. J. Adams, “Harmonics sources and filtering approaches,” in Proc. Industry Applications Conf., Oct. 1999, vol. 1, pp. 448–455.

[8]. H. Akagi, “Active harmonic filters,” Proc. IEEE, vol. 93, no. 12, pp. 2128–2141, Dec. 2005.

[9]. J. A. Pomilio and S. M. Deckmann, “Characterization and compensation of harmonics and reactive power of residential and commercial loads,” IEEE Trans. Power Del., vol. 22, no. 2, pp. 1049–1055, Apr. 2007.

[10]. C. Sankaran, "Power Quality" CRC Press.