National conference on Engineering Innovations and Solutions (NCEIS – 2018)
International Journal of Scientific Research in Computer Science, Engineering and Information Technology
© 2018 IJSRCSEIT | Volume 4 | Issue 6 | ISSN : 2456-3307

Hybrid Filters for Power Quality Improvement

Rashmi M N, A Meenakshi, Namratha M, Nayana S V
Students, Department of Electrical and Electronics, Vidyavardhaka College of Engineering, Mysuru, Karnataka, India

ABSTRACT

The power quality problems would reduce the lifetime and efficiency of the equipment. The highly dependent end user equipment will be affected by quality of power delivered. However, the various external and internal factors have an effect on the eminence of power distributed to the end user. They are like voltage and frequency variations, faults, harmonics, outages etc. Thus, to improve the performance of end consumer equipment and the system these problems should be minimized or completely cancelled out. The main affect caused by these problems is the existence of harmonics (both current and voltage harmonics).The solution to overthrow these problems is to filter out the harmonics. In this paper a hybrid filter of shunt active filter and shunt passive filter configuration is used. And also the paper confers the hysteresis control strategy to control the filter in such a way that the harmonics are reduced. The proposed control strategy and overall power quality improvement technique is simulated in MATLAB SIMULINK and the results are presented.

Keywords: Harmonics, Non-linear load, Active power filters, Hybrid filters.

I. INTRODUCTION

Power quality improvement is one of the major analyzed case in modern power distribution system. Around twenty years ago, only passive loads and loads which are linear in nature were only installed in industries and at consumers end. The impact on power system due to non-linear loads was low due to their less usage. By means of introduction and advancement of semiconductor as well as power electronic appliances and their easy controlling techniques has resulted in wide use of nonlinear loads for example chopper, inverter, switched mode power supply(SMPS), rectifier, etc. The power in the circuit is high when modern power electronics apparatus like silicon controlled rectifier (SCR). Insulated gate bipolar transistor (IGBT), power diode, Metal oxide semiconductor field effect transistor (MOSFET) be used, which endorses their industrialized and domestic applications. Along with that, in order to increase the power factor and efficiency of wind solar and other non-conventional sources of energy different kinds of power electronic apparatus are used. While the benefits of using above devices are undoubtedly good but there also exists few disadvantages that arise due to enormous utilization of such power electronic devices. The usage of above mentioned semiconductor devices would result in harmonics and reactive power disturbances. And causes diversified problems that include excessive heating of transformers, immeasurable neutral current, low power factor, and distortion of feeder voltage problems to power electronic appliances and defects in sensitive equipment. To reduce or cancel out the harmonics in the power system, active power filters (APF) are equipped by the side of Point of common coupling (PCC). APF introduces compensating current at PCC to reduce the harmonics and to keep the current from source to be sinusoidal in nature. By installation of active power filter, harmonic pollution and power factor at lower value in the power system can be enhanced. Although APFS are extensively used in three phase system, with some alteration in the control strategy it could be enabled in the single phase system, thus harmonic problems can be minimized for low voltage system. Figure 1 depicts the general block diagram oh hybrid filter with SAPF and shunt passive filter connected at PCC of a 3 phase system.

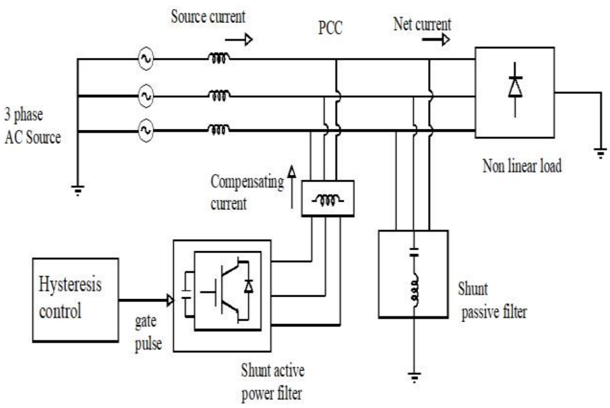

Figure 1. Block diagram of Hybrid filter connected to a System

II. PROBLEM DEFINITION

Harmonic problems in low voltage side is more important compared to high voltage side which is because of wide use of nonlinear loads (Computers, battery charger, Printers , SMPS, Inverters etc.), which is disagreeable. It would be necessary and also a challenge to reduce or completely invalidate the inadmissible current harmonics and satisfy the reactive power fulfillment in the power system. As the presence of harmonics or any other power quality problems in a system causes severe problems such as increase in losses and consequent heating of transformer and rotating machines, errors in energy meter[1]. The works of conventional proceedings i.e., the use of LC filter are not satisfactory due to its deliberate demerits. The hybrid filter contributes encouraging outcomes compared to prescribe one based upon suitable control system. The control strategy used plays an important job for enhanced dynamic performances of the SAPF in the hybrid filter.

III. OBJECTIVES

- ✓ To discuss about harmonics and its disadvantages that arises due to operation of non-linear loads.
- ✓ To study different control strategies that has been estimated for controlling a 3 phase SAPF.
- ✓ Design of hysteresis current controller.
- ✓ To model and simulate three phase APF in MATLAB/SIMULINK software.
- ✓ To model and simulate hybrid filter in MATLAB/SIMULINK environment.

IV. METHODOLOGY

The influence of voltage or current harmonics will affect characteristic of power distributed to end user. Consecutively to minimize the current harmonics, filters is used at PCC, where the load is associated to the supply. Different types of filters are available to serve this purpose.

A. Passive Filters

These filters mainly comprise of passive elements like-capacitor, inductor and resistor. These are generally utilized for the reason that their low cost and simplicity in control. The passive filters also afford reactive power despite of only filtering the harmonics. The operation of these filters is mainly depends on the system impedance. These are categorized into two types- low pass and high pass. Usage of passive filters is limited due to origin of resonance and not suitable for variable loads. They provide low impedance path to the harmonic current to flow so that high order harmonics will be reduced.

B. Active Filters

To overcome or to completely reduce the negative aspect of passive filter, active compensation known as Active Power Filter is prominently employed. VSI or SAPF would inject the compensating current or voltage based on the network configuration. But it increases the cost of the project while using high rated active filters. The injected compensating current will be phase reversal with the harmonic current so that it cancels out the harmonics [4].

C. Hybrid Filters

On using both active and passive filters, both of its advantages can be obtained simultaneously. Among different configurations hybrid filters, a shunt active and shunt passive filter configuration is used [5]. The SAPF insisted for the power quality improvement is admitted as a Voltage Source Inverter (VSI). Either a three-phase VSI or a three single-phase VSI can be used. The VSI will be connected in parallel with the source impedance. A capacitor is used at the input of the voltage source inverter or active power filter to provide constant input voltage to VSI. A high order passive filter is also allied at the PCC. In some definite instance there may be two or more LC branches adjusted to eradicate some of the specific harmonic order (say 5th and 7[th] order harmonics). Thus, with a proficient control strategy, the APF counterbalances the current distortion. The control strategy is designed or premeditated such that the SAPF along with the passive filter acts as a balanced resistive load on the overall system. In a four-wire system, the harmonic currents distributed in the neutral wire are also diminished due to shunt active power filter. Figure 2 illustrates the circuit diagram of hybrid filter connected to the system which is also employed for modeling and simulation.

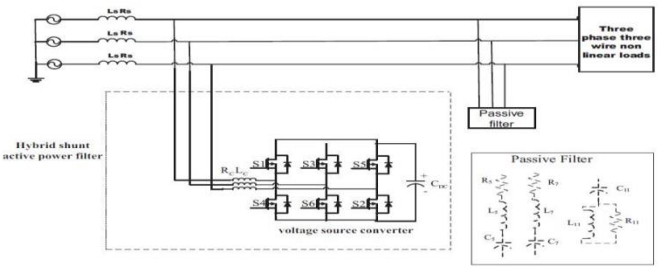

Figure 2. Circuit diagram of Hybrid filter connected to a System

D. Hysteresis Current Controller

The controlling pattern of the inverter is generated by the hysteresis band current controller. There is abundant current restrain technique, but fast current controlling ability and effortless implementation formulate the hysteresis current control method much more advanced or better quality than any other current control routine. The injection of compensating current by SAPF is controlled by providing gate pulses to the switches in the inverter. The controller compares between the reference current and actual current in the SAPF and generates gate pulses [3]. The accuracy of the controller will be enhanced if the operated band width is smaller. When current happen to be higher than the scheduled high limit of the hysteresis band (+h), then switch in the top part of the inverter arm happen to be turned off and the switch assigned in the lower arm turns on. Hence, the current initiates to decline. While reducing if the current reduces below the lower limit of the hysteresis band (-h), the lower switch of the inverter arm turns to off condition and the other switch goes into on condition. As a result, the current returns back into the hysteresis band. So, the actual current would compulsorily go after the reference current within the hysteresis band. Variable switching frequency is the drawback of this technique.

E. Instantaneous Reactive Power Theory

The “Generalized Theory of the Instantaneous Reactive Power in Three-phase Circuits”, also recognized as the p-q hypothesis, is an appealing method to be used to be in command of APF, and also to examine 3 phase power systems in sequence to become aware of tribulations associated to harmonics, reactive power and unbalance. The p-q theory can be employed to 3 phase system either balanced or unbalanced , being lesser in complexity it does not require phase angle of the system to calculate the reference current or to calculate active and reactive power components of the load[2]. The main aim of using power theory is to generate the reference current which is to be supplied to controller. The p-q theory executes a conversion of voltage and current from a stationary reference system i.e., a-b-c coordinate to a system with co-ordinates α-β-0 corresponds by an algebraic transformation, well-known as **Clarke transformation,** even which engenders a stationary reference system, in where coordinates α-β are at 90° to each other and coordinate 0 is the zero-sequence component. The zero sequence component computed at this point fluctuates from the one gained by the symmetrical components transformation by a √3 factor.

V. MODELLING AND SIMULATION

Simulink model of a 3 phase system supplying a non-linear load is as shown in Figure 3. The nonlinear load selected here is a three phase full way rectifier as it seen in every electronic device which we use in day to day life. The model i.e., without connecting any filter to PCC or without usage of any power quality technique has been run for 0.2 seconds in MATLAB/SIMULINK software. By using FFT analysis the THD of a system can be obtained as shown in Figure 4, here which can be observed as 30.26%.

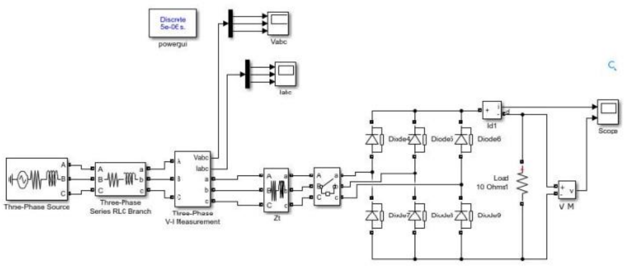

Figure 3. Simulink model of a 3 phase system with a non linear load

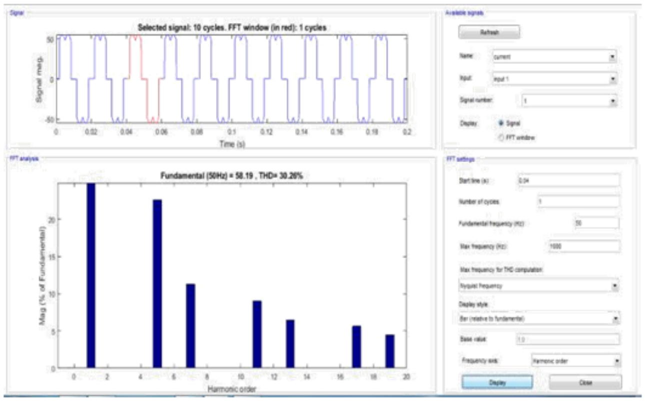

Figure 4. FFT analysis of the system without any filter

When the 3 phase shunt active filter is connected to the circuit then there will be large inrush current which is minimized by the DC link capacitor. The controller used is system current controlling the principle is explained by graph when the current should not run the upper or lower bend it should be within reference current. The shunt active filter connected to the circuit will inject a current such that it is in phase reversal with the source current. The THD of the system when active filter was connected would reduce to 5.10% for phase A. The Simulink model of the system with SAPF is as shown in Figure 5. The PQ theory and hysteresis current controller block is as shown inFigure 6. Through FFT analysis, the THD of the source current when only SAPF assisted to the system is shown inFigure 7.

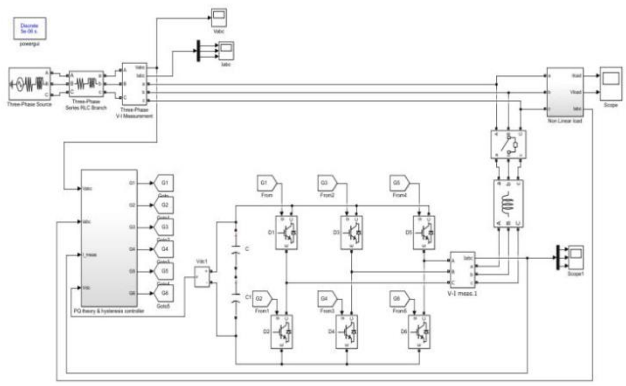

Figure 5. Simulink model of a SAPF connected to 3 phase system

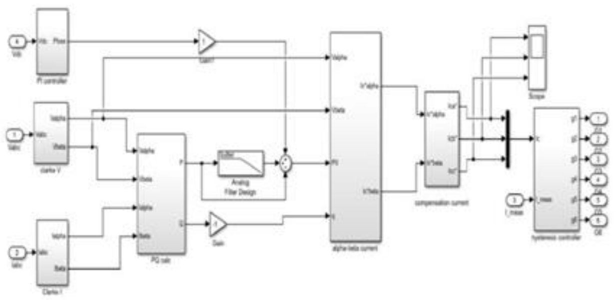

Figure 6. P-Q Theory and Hysteresis controller block

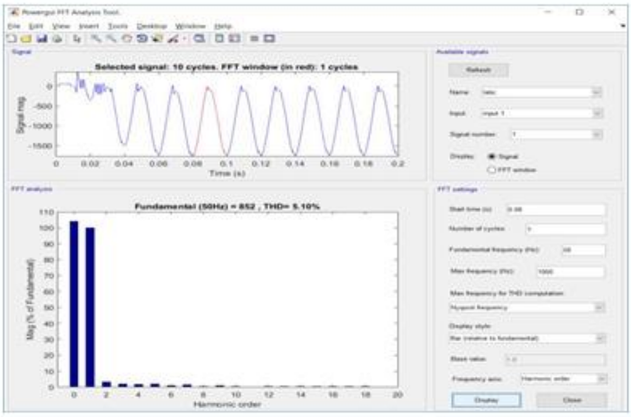

Figure 7. FFT analysis of the system with only SAPF

Later, a well-designed passive filter is introduced in shunt to the system. Here a second order high pass filter is connected to the system. The block consists of a 3 phase rectifier as load which is a nonlinear load, IGBT based VSI and a hysteresis controller as subsystem which control the gate pulse of the VSI. The control subsystem also contains PI controller which has definite values in it. Simulink model of hybrid filter with shunt active filter and shunt passive filter configuration is as shown in Figure 8 is connected to the system and is run for 0.2 seconds in MATLAB/SIMULINK software. The THD of the system is obtained through FFT analysis and is found to be 1.96% as in Figure 9.

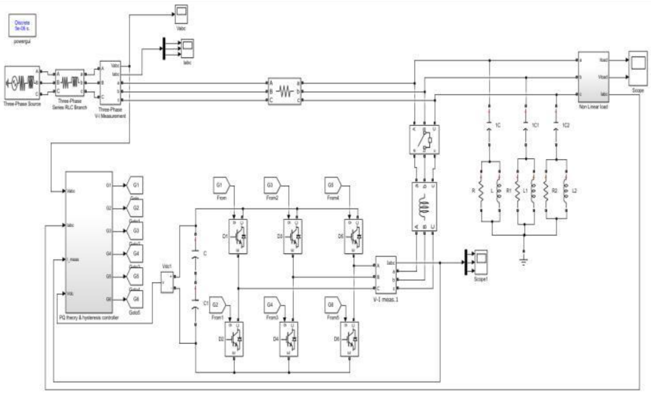

Figure 8. Simulink model of Hybrid filter connected to 3 phase system

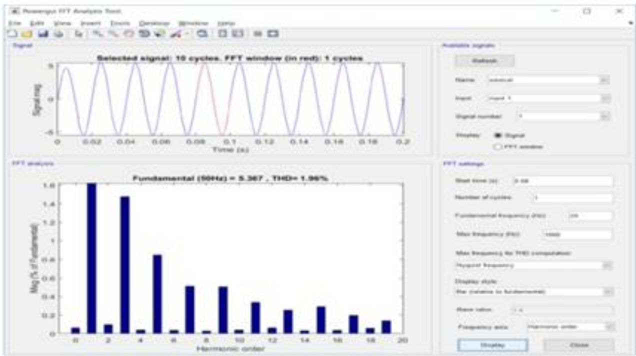

Figure 9. FFT analysis of the system with hybrid filter

Overall result: The main concept here is to improve the power quality using hybrid filter consisting of both passive filter and active filter with a hysteresis controller. THD being the measurement of harmonics in a system. Table 1 depicts the overall THD of the system for different connections of filters.

Table 1. Hd Of The Sysytem

Particulars	**Phases of the Balanced 3 Phase System**		
	Phase A	***Phase B***	***Phase C***
Without any Filter	30.26%	30.26%	30.26%
With SAPF	5.10%	5.36%	3.60

			%
With Hybrid Filter	1.96%	1.09%	1.58 %

Applications

- ✓ TRAIC based controller for heating applications.
- ✓ High power factor pre regulator.
- ✓ UPS based applications.

VI.CONCLUSION

Herein, the paper provides a way out to further enrich the electric power quality by making use of Hybrid Filter. On or after the analyze of Hybrid Filter for power quality improvement the following conclusions are drawn-

- The majority of the loads associated to the system are non-linear in nature, which is the foremost cause of harmonics in the system. The non-linear load entices non-linear current from the supply. Thus, the voltage at PCC is also non-linear, which badly affects the operation of end user Equipment
- A filter at the PCC is to recompense the load harmonics and also which injects the compensating current. In order to achieve this, a Hybrid power filter of SAPF and shunt connected passive filter configuration is used.
- The APF is controlled on basis of Instantaneous Reactive Power Theory to compensate the load harmonics. On simulation of hysteresis current controller based shunt APF, it was originated that the THD of source current was decreased to 5.10% from 30.26% after utilizing filter in the system.
- On simulation of Hybrid filter involving a shunt APF and a shunt passive filter. It was established that THD of source current is demoted to 1.96% from 30.26% after connection of filter to the system.

As a result, it can be concluded that the hybrid filter comprising shunt APF and a shunt passive filter is a reasonable financial explanation or the answer for advancing the power quality in electric power system.

VII. REFERENCES

[1] Ghasem Ahrabian, Farhad Shahnia, and Mehrdad Tarafar Haque, "Hybrid filter applications for power quality improvement of power distribution networks utilizing renewable energies",IEEE ISIE 2006, July 9-12,2006,Montreal,Quebec,Canada, 1-4244-0497-5.

[2] Joao L.Afonso, M J Sepulveda Fretias, and Julio S.Martins, "P-Q theory power components calculations", IEEE 0-7803-7912-8.

[3] Narendra Babu P, Biwajith Kar, and Biswajith Halder, "Modeling and analysis of a hybrid active power filter for power quality improvement using hysteresis current control technique", NIT Meghalaya, Shillong, India,IEEE 978-1-5090-4530-3.

[4] Yejjala Naveen Kumar, N Jayanth, and V B Borghate, "Analysis and simulation of shunt active power filter to address power quality problems", VNIT Nagpur, India, IJERTV3IS031982.

[5] Miss.Prajkta R.Gangurde, and Prof.M.M.Hapse, "Harmonics cancellation in distribution systems by using a hybrid filter", Pune, India, IJRITCC, ISSN:2321-8169.

[6] Joao Afonso, Carlos Couto, and Julio Martins, "Active filters with control based on the p-q theory", Guimaraes, Portugal, vol.47, n^{0}3, Sept.2000, ISSN:0746-1240, pp.5-10.

[7] K.Dharageshwari, and C.Nayantara, “Power quality improvement using hybrid filters for the integration of hybrid distributed generations to the grid”, Chennai, Tamilnadu, India, paper id: SUB151665.

[8] Anuj Chauhan, and Ritula Thakur, “Power quality improvement using passive and active filters”, Uttrakhand, India, ISSN:2231-5381.

[9] Mohammed Thousif, M.S Samukha, and Mrs.Archana K, “Modelling and simulation of shunt active filter for harmonic reduction”, IJERT, ISSN: 2278-0181.

[10] Mrs.Archana K, “Harmonic reduction using fuzzy logic controller for power quality improvement”, IEEE conference ICRTEST.