Hybrid Series and Shunt Filter with Power Quality Monitoring System

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Abstract— Power system harmonics are a menace to electric power systems with disastrous consequences. The line current harmonics cause increase in losses, instability, and also voltage distortion. With the proliferation of the power electronics converters and increased use of magnetic, power lines have become highly polluted. Both passive and active filters have been used near harmonic producing loads or at the point of common coupling to block current harmonics. Shunt filters still dominate the harmonic compensation at medium/high voltage level, whereas active filters have been proclaimed for low/medium voltage ratings. With diverse applications involving reactive power together with harmonic compensation, passive filters are found suitable. Passive filtering has been preferred for harmonic compensation in distribution systems due to low cost, simplicity, reliability, and control less operation. The uncontrolled ac-dc converter suffers from operating problems of poor power factor, injection of harmonics into the ac mains, variations in dc link voltage of input ac supply, equipment overheating due to harmonic current absorption, voltage distortion due to the voltage drop caused by harmonic currents flowing through system impedances, interference on telephone and communication line etc. The circuit topologies such as passive filters, ac-dc converter, based improved power quality ac dc converters are designed, modeled and implemented. The main emphasis of this investigation has been on a compactness of configurations, simplicity in control, reduction in rating of components, thus finally leading to saving in overall cost. Based on thesis considerations, a wide range of configurations of power quality mitigators are developed, which is expected to provide detailed exposure to design engineers to choose a particular configuration for a specific application under the given constraints of economy and desired performance. For bidirectional power flow applications, the current source converter is designed and simulated with R-L load.

Keywords: Hybrid, Series, Shunt, Power Quality Monitoring

I. Introduction

Power Quality (PQ) issues are becoming a major concern of today's power system (PS) engineers. Harmonics play significant role in deteriorating PQ, called harmonic distortion. Harmonic distortion in electric distribution system is increasingly growing due to the widespread use of nonlinear loads. Large considerations of these loads have the potential to raise harmonic voltage and currents in an electrical distribution system to unacceptable high levels that can adversely affect the system currents. IEEE standards have defined limits for harmonic voltages and harmonic [1].It has been lost in distribution system, current harmonics cause serious harmonic problems in distribution feeders for sensitive consumers .some technology solutions have been reported in order to solve PQ. Initially, passive power filters (PPF) (combinations of capacitors and inductors) were normally used to mitigate the PQ problems. These approaches were extensively used in high voltage DC transmission (HVDC) for filtering the harmonics on the AC and DC sides. However, this approach is unsuitable at the distribution level as PPF can only correct specific load conditions or a particular state of the power system. These filters are unable to follow the changing system conditions. Thus, the active power filter (APF) was introduced to compensate harmonics and reactive power. There are three types of APF which are shunt APF, series APF and hybrid APF which is the combination of AP with PPF. The purpose of APF power line conditioner is to compensate the utility line current waveform so that it approximates a sine wave in phase with the line voltage when a nonlinear load is connected to the system. Classically, shunt power line conditioner (shunt PPF) consists of tuned LC filters and/or high pass filters are used to suppress harmonics and power capacitors are employed to improve the power factor (PF) of the utility/mains. But these conventional methods have the limitations of fixed compensation, large size and can also excite resonance conditions [1, 4]. Hence APF is introduced as a viable alternative to compensate harmonics and improve PF. This project is focusing on the application of APF in treating the harmonics distortion in distribution system by determining low Total Harmonics Distortion (THD) value and improving the system's power factor (PF).

Harmonics play significant role in deteriorating PQ, called harmonic distortion. Harmonic distortion in electric distribution system is increasingly growing due to the widespread use of nonlinear loads. The main problem that needs to be solved is to reduce the harmonics level in the line current. Non-linear loads create harmonic current and increase the deterioration of the PS voltage and current waveforms. These loads cause the sine wave of the current to deform [6]. Harmonics in the PS can be measured through the measurement of THD. As a result, APF is used to implement in the PS for harmonics compensation purpose.

To overcome the problems caused by harmonics, filters are used. There are different filter topologies present in the literature for this purpose. At first passive filters are used but they are dependent heavily on the system parameters. They also have the problems of resonance with system impedance and are suitable for filtering out a particular frequency harmonics. Therefore, to overcome the problems of passive filters, active filters are used.

II. Problem Identification

A. *Problem Identification:*

1) The studies are mainly confined with the use of passive filters.
2) It is found that passive filters are dependent heavily on the system parameters.

3) They also have the problems of resonance with system impedance.
4) Suitable for filtering out a particular frequency harmonics.
5) High converter ratings are required.
6) Costlier when compared to its counterpart.
7) Huge size.
8) Increased losses.

B. Motivation and Aim:

This gives the motivation for developing a system for harmonic reduction using the active filter to reduce the harmonics caused by non-linear loads. To overcome the problems of passive filters, active filters are used.

III. METHODOLOGY

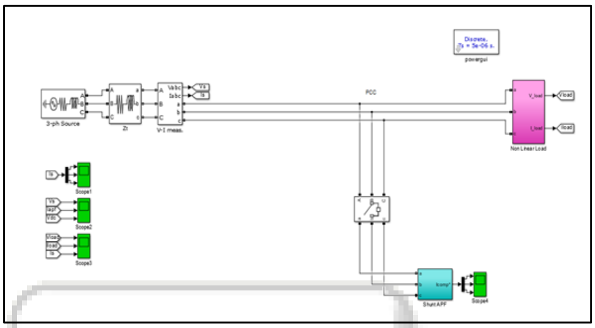

Fig. 3.1: Simulink model of shunt active power filter

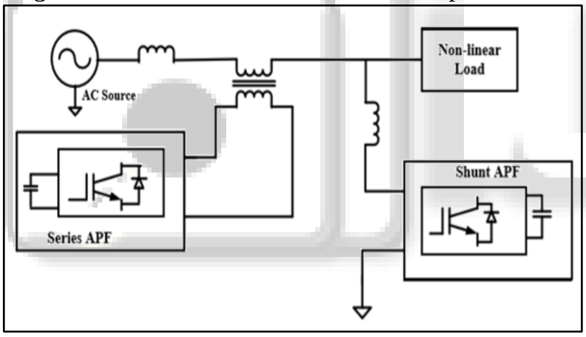

Fig. 3.2: Shunt APF and Series APF Combination

This filter combination has the advantage of both series connected APF i.e., elimination of voltage harmonics and that of shunt connected APF of eliminating current harmonics. The circuit diagram is shown in Figure 3.2. This combination finds its application in Flexible AC Transmission Systems (FACTS). But the control of APF is complex and this combination involves two APF and hence the control of this filter configuration is even more complex. Thus, this filter combination is not used widely.

A. Series APF with Shunt Connected Passive Filter:

The Series APF and Shunt APF combination seen in Figure 4.14 has the problem of complex control strategy. To overcome this drawback, the shunt APF is replaced by a shunt connected passive filter. The passive power filter does not require any additional control circuit and the cost is also less. This filter combination is shown in Figure 4.14.

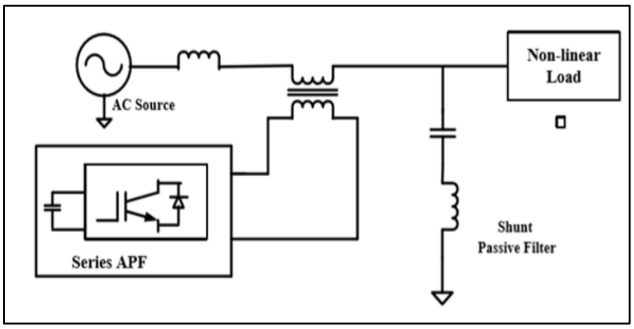

Fig. 3.3: Series APF with Shunt Connected Passive Filter

Here the series connected APF provides low impedance (almost zero) for low frequency components whereas the shunt connected APF provides less impedance for high frequency components and filters out all higher order harmonics. So this filter configuration is the most beneficial of all others and has the advantage of reducing both current and voltage harmonics.

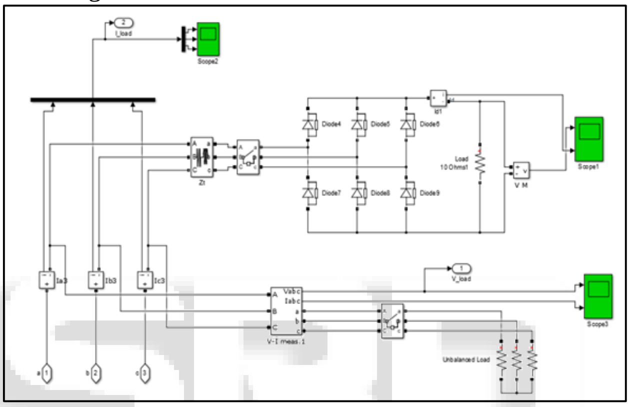

Fig. 3.4: Non-linear load model

Electrical circuit breaker is a switching device which can be operated automatically or manually for protecting and controlling of electrical power system. In the modern power system the design of the circuit breaker has changed depending upon the huge currents and to prevent from arc while operating.

Electricity which is coming to the houses or offices or schools or industries or to any other places from the power distribution grids forms a large circuit. Those lines which are connected to the power plant forming at one end is called the hot wire and the other lines connecting to ground forming other end. Whenever the electrical charge flows between these two lines it develops potential between them. For the complete circuit the connection of loads (appliances) offers resistance to the flow of charge and the whole electrical system inside the house or industries will work smoothly.

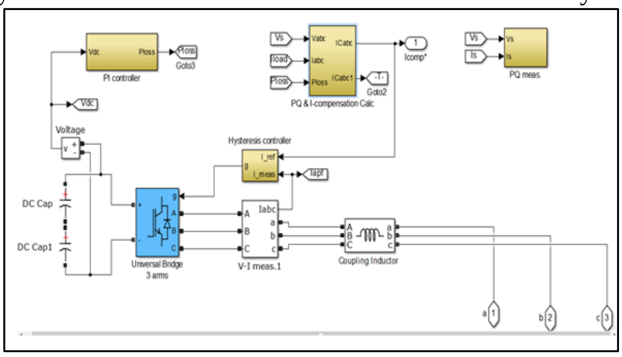

Fig. 3.5: Shunt active filter model

IV. RESULT

The active filters add compensating currents to the RYB phase of the three phase input signal shown in figure 4.2. The compensating currents are shown in figure 4.1 below.

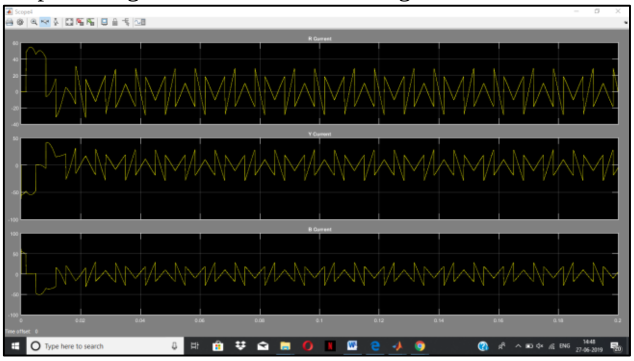

Fig. 4.1: Compensating current for RYB phase

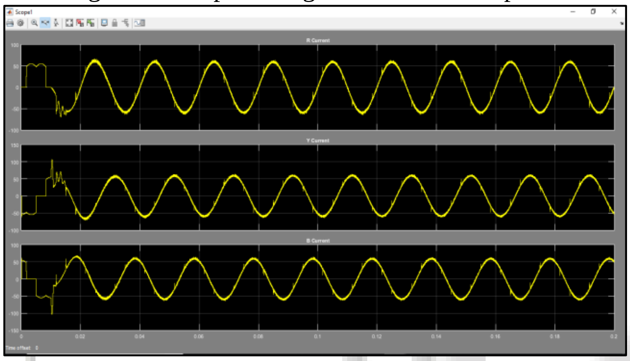

Fig. 4.2: Source current

The figure 4.3 below shows the three phase voltage source, the current output source of the active power filter. A dc voltage is added is added to the three phase voltage source to achieve the active power filter output.

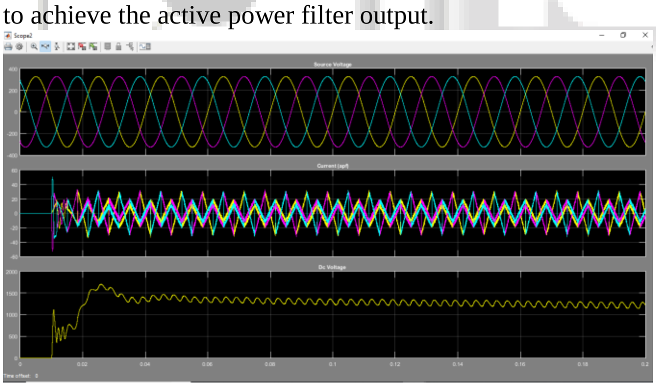

Fig. 4.3: Source voltage, APF system Current output, DC voltage

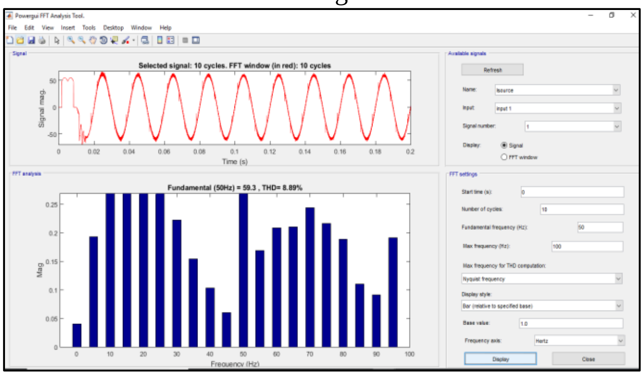

Fig. 4.4: Fast Fourier Transform and Total Harmonic Distortion of the input signal

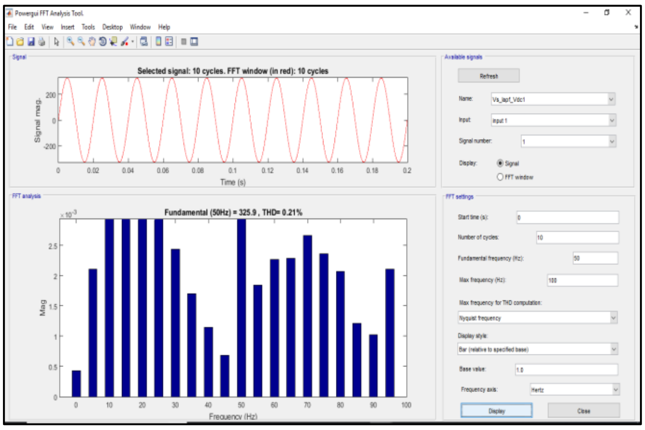

Fig. 4.5: Fast Fourier Transform and Total Harmonic Distortion of the APF output signal

The output of the active power filter provides the reduced total harmonic distortion of the input signal. Figure 5.4 shows the fast fourier transform and the total harmonic distortion of the input signal. The input signal has the distortion of 8.89%. The output signal of the active power filter has reduced distortion of 0.21%.

V. CONCLUSION

A Shunt Active Filter is controlled current or voltage power electronics converter that facilitates its performance in different modes like current harmonics compensation, reactive power compensation, power factor correction and load balancing in the distribution system. The compensation process uses different control approaches to extract the reference current but they all share a common objective i.e imposing sinusoidal currents in the grid, eventually with unity power factor and load balancing. The prominence of the application of the AI tools has been felt in all the areas of the Power Systems and the need is emphasized. The main aim of the research work is to enhance the power quality using Active Filters. In this thesis three phase three wire voltage source Shunt Active Filter has been implemented. It mainly deals with improvement of major power quality issues like harmonic elimination, reactive power compensation, power factor correction and load balancing due to nonlinear load. The thesis provides a complete framework for the analysis of power quality issues and replaces the conventional PI controller by intelligent computational techniques for more accuracy.

Shunt Active Filter is a potential tool for the growing power quality problems for damping the harmonic resonance, reactive power compensation and load balancing.

VI. FUTURE SCOPE

The thesis presented here concern the development of the various techniques and their validation in different conditions for the enhancement of power quality using Active Filters. This research work can be extended to a multilevel inverter implemented for power conditioning. Three phase three wire system can be extended to three phase four wire system with different conditions like considering the zero sequence voltage present in the system. FPGA based controller for Active Filter can be developed to reduce the hardware requirement. For sustainable growth in power system, recently Renewable and Non-Renewable Energy source are gaining lot of attention. Hence such energy sources feeding the nonlinear load can be investigated for further work in the field of power quality. Further enhancing the coordinated control of the proposed Distributed Active Filters incorporating the design of adaptive gains can also be implemented. Another attractive aspect that can be investigated is the finding the solutions of power quality issues by other emerging Evolutionary algorithm like AntColony Optimization and bacteria forging techniques. Thus, the quality of the power network can be expressively enhanced, and high reliability can be provided.

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