

# A FEW ASPECTS OF POWER QUALITY IMPROVEMENT USING SHUNT ACTIVE POWER FILTER

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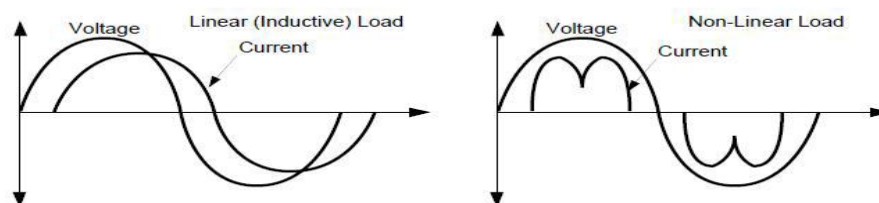
## ABSTRACT

Power quality standards (IEEE-519) require to limit the total harmonic distortion within the suitable range. This paper mainly deal with shunt active power filter which has been generally used for harmonic removal. Active power filter which has been used here monitor the load current continually and always settle in to the changes in load harmonics. The performance of three phase shunt active power filter using instant power theory with PI and Hysteresis current controller is explain in this paper.

**Index Terms-** Active power filters (APF), composite load, harmonic compensation, linear and non linear load, reactive power.

## I. INTRODUCTION

harmonic is a component of a periodic wave having a frequency that is an integral multiple of the fundamental power line frequency. Harmonics are the multiple of the fundamental frequency, and whereas total harmonic distortion is the contribution of all the harmonic frequency currents to the fundamental. Harmonics are the by products of modern electronics. They occur frequently when there are large numbers of personal computers (single phase loads), uninterruptible power supplies (UPSs), variable frequency drives (AC and DC) or any electronic device using solid state power switching supplies to convert incoming AC to DC. Non-linear loads create harmonics by drawing current in abrupt short pulses, rather than in a smooth sinusoidal manner



**Fig.1 Difference between linear and non linear loa**

The terms “linear” and “non-linear” define the relationship of current to the voltage waveform. A linear relationship exists between the voltage and current, which is typical of an across-the-line load. A non-linear load

has a discontinuous current relationship that does not correspond to the applied voltage waveform. All variable frequency drives cause harmonics because of the nature of the frontend rectifier.

## 1.1 Need For Harmonic Compensation:

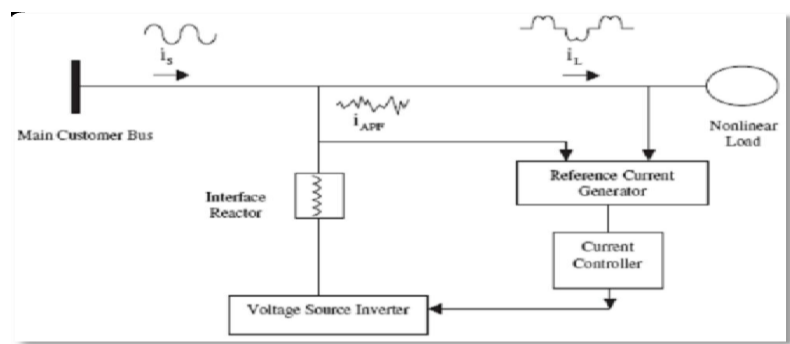
The implementation of Active Filters in this modern electronic age has become an increasingly essential element to the power network. With advancements in technology since the early eighties and significant trends of power electronic devices among consumers and industry, utilities are continually pressured in providing a quality and reliable supply. Power electronic devices such as computers, printers, faxes, fluorescent lighting and most other office equipment all create harmonics. These types of devices are commonly classified collectively as 'nonlinear loads'. Nonlinear loads create harmonics by drawing current in abrupt short pulses rather than in a smooth sinusoidal manner. The major issues associated with the supply of harmonics to nonlinear loads are severe overheating and insulation damage. Increased operating temperatures of generators and transformers degrade the insulation material of its windings. If this heating were continued to the point at which the insulation fails, a flashover may occur should it be combined with leakage current from its conductors. This would permanently damage the device and result in loss of generation causing widespread blackouts. One solution to this foreseeable problem is to install active filters for each nonlinear load in the power system network. Although presently very uneconomical, the installation of active filters proves indispensable for solving power quality problems in distribution networks such as harmonic current compensation, reactive current compensation, voltage sag compensation, voltage flicker compensation and negative phase sequence current compensation. Ultimately, this would ensure a polluted free system with increased reliability and quality. The objective of this project is to understand the modeling and analysis of a shunt active power filter. In doing so, the accuracy of current compensation for current harmonics found at a nonlinear load, for the PQ theory control technique is supported and also substantiates the reliability and effectiveness of this model for integration into a power system network. The model is implemented across a two bus network including generation to the application of the nonlinear load.

The aim of the system simulation is to verify the active filters effectiveness for a nonlinear load. In simulation, total harmonic distortion measurements are undertaken along with a variety of waveforms and the results are justified accordingly. One of the most important features of the shunt active filter system proposed is its versatility over a variety of different conditions. The application of the positive sequence voltage detector from within the active filter controller is the key component of the system. The positive sequence voltage detector gives incredible versatility to the application of the active filter, because it can be installed and compensate for load current harmonics even when the input voltage is highly distorted. When filters alike do not contain this feature and is installed with a distorted voltage input, the outcome is a low efficient current harmonic compensator with poor accuracy of compensation current determination.

## 1.2 Harmonic filters:

Harmonic filters are used to eliminate the harmonic distortion caused by nonlinear loads. Specifically, harmonic filters are designed to attenuate or in some filters eliminate the potentially dangerous effects of harmonic currents active within the power distribution system. Filters can be designed to trap these currents and, through the use of a series of capacitors, coils, and resistors, shunt them to ground. A filter may contain several of these elements, each designed to compensate a particular frequency or an array of frequencies

## 1.3 Representation of harmonics:



**Fig. of harmonics from a non-linear load.**

The current waveform for cancelling harmonics is achieved with the voltage source inverter and reactor. The reactor converts the voltage signal created by the inverter to a current signal. The desired waveform is obtained by accurately controlling the switches in the inverter. Control of the current wave shape is limited by the switching frequency of the inverter and by the available driving voltage across the interface reactor. The driving voltage across the reactor determines the maximum di/dt that can be achieved by the filter. This is important because relatively high values of di/dt may be needed to cancel higher order harmonic components.

## III. TYPES OF HARMONIC FILTERS INVOLVED IN HARMONIC COMPENSATION

### 3.1 Passive Filters:

Passive filters are generally constructed from passive elements such as resistances, inductances, and capacitances. The values of the elements of the filter circuit are designed to produce the required impedance pattern. There are many types of passive filters, the most common ones are single-tuned filters and high-pass filters. This type of filter removes the harmonics by providing a very low impedance path to the ground for harmonic signals.

### 3.2 Active Filters:

The increasing use of power electronics-based loads (adjustable speed drives, switch mode power supplies, etc.) to improve system efficiency and controllability is increasing the concern for harmonic distortion levels in end use facilities and on the overall power system. The application of passive tuned filters creates new system resonances which dependent on specific system conditions. In addition, passive filters often need to be significantly overrated to account for possible harmonic absorption from the power system. Passive filter ratings must be co-coordinated with reactive power requirements of the loads and it is often difficult to design the filters

to avoid leading power factor operation for some load conditions. Active filters have the advantage of being able to compensate for harmonic without fundamental frequency reactive power concerns. This means that the rating of the active power can be less than comparable passive filter for the same non-linear load and the active filter will not introduce system resonances that can move a harmonic problem from one frequency to another.

### 3.3 Types of Active Filters:

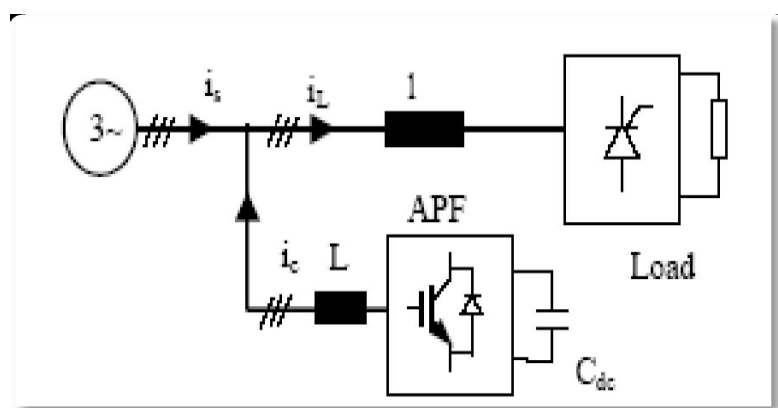
Active filter can be classified based on the connection scheme as:

- Shunt active filter
- Series active filter and
- Hybrid active filter.

#### 3.3.1 Shunt Active Filter:

The active filter concept uses power electronic equipment to produce harmonic current components that cancel the harmonic current components that cancel the harmonic current components from the nonlinear loads.. In this configuration, the filter is connected in parallel with the load being compensated .Therefore the configuration is often referred to as an active parallel or shunt filter. Fig 3 illustrates the concept of the harmonic current cancellation so that the current being supplied from the source is sinusoidal. The voltage source inverter used in the active filter makes the harmonic control possible. This inverter uses dc capacitors as the supply and can switch at a high frequency to generate a signal that will cancel the harmonics from the nonlinear load. The active filter does not need to provide any real power to cancel harmonic currents from the load.

The harmonic currents to be cancelled show up as reactive power. Reduction in the harmonic Voltage distortion occurs because the harmonic currents flowing through the source impedance are reduced. Therefore, the dc capacitors and the filter components must be rated based on the reactive power associated with the harmonics to be cancelled and on the actual current waveform (rms and peak current magnitude) that must be generated to achieve the cancellation.



**Fig.Shunt Active Power Filter**

The current wave form for canceling harmonics is achieved with the voltage source inverter in the current controlled mode and an interfacing filter. The filter provides smoothing and isolation for high frequency components. The desired current waveform is obtained by accurately controlling the switching of the insulated

gate bipolar transistors (IGBT's) in the inverter. Control of the current wave shape is limited by the switching frequency of the inverter and by the available driving voltage across the interfacing inductance.

The driving voltage across the interfacing inductance determines the maximum di/dt that can be achieved by the filter. This is important because relatively high values of di/dt may be needed to cancel higher order harmonic components. Therefore, there is trade –off involved in sizing the interface inductor. A large inductor is better for isolation from the power system and protection from transient disturbances. However, the larger inductor limits the ability of the active filter to cancel higher order harmonics. The inverter in the Shunt Active Power filter is a bilateral converter and it is controlled in the current Regulated mode i.e. the switching of the inverter is done in such a way that it delivers a current which is equal to the set value of current in the current control loop. Thus the basic principle of Shunt Active Filter is that it generates a current equal and opposite to the harmonic current drawn by the load and injects it to the point of coupling there by forcing the source current to be pure sinusoidal. This type of Shunt Active Filter is called the Current Injection Type APF.

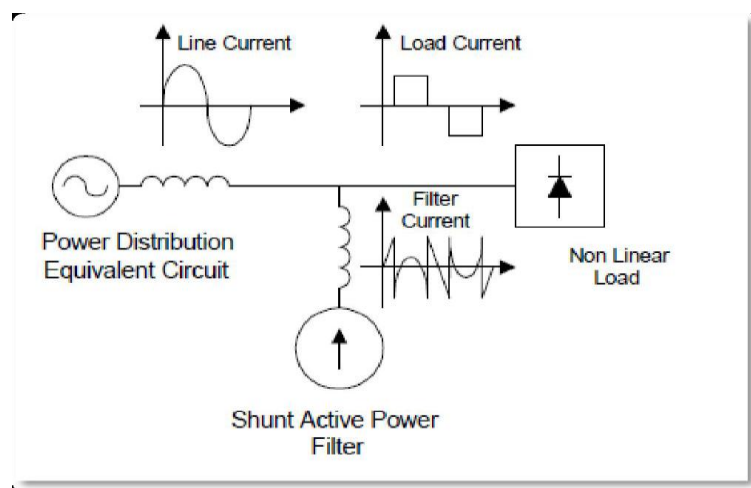


Fig.Shows Need Shunt Active Filter

### 3.4 Harmonic compensation

#### 3.4.1 Current Harmonic Compensation:

Current harmonic compensation strategies are exceptionally important .Current harmonics are greatly reduced by the compensation of voltage harmonics at the consumer's point of common coupling. The reduction in current harmonics is not only important for reasons such as device heating and reduction in life of devices but also in design of power system equipment. One of the major design criteria covers the magnitude of the current and its waveform. This is to reduce cable and feeder losses. Since the root mean square (RMS) of the load current incorporates the sum of squares of individual harmonics, true current harmonic compensation will aid system designers for better approached power rating equipment.

#### 3.4.2 Harmonic detection and extraction:

A shunt active filter acts as a controllable harmonic current source. In principle, harmonic compensation is achieved when the current source is commanded to inject harmonic currents of the same magnitude but opposite phase to the load harmonic currents. Before the inverter can subtly inject opposing harmonic currents into the power system, appropriate harmonic detection strategies must be implemented to efficiently sense and determine the harmonic current from the nonlinear load.

### III. SHUNT ACTIVE POWER FILTER

#### 3.1) Introduction to Open Loop System:

In typical distribution systems the proliferation of diode rectifiers has resulted in serious utility interface issues as well as power quality degradation such as supply current and voltage harmonics, reactive power, flicker and resonance problems in industrial applications. Voltage distortion due to current harmonics is becoming a major problem for the utilities at distribution levels. Utilities more frequently encounter harmonic related problems, such as higher transformer and line losses, reactive power and resonance problems, required derating of distribution equipment, harmonic interactions between customers or between the utility and load, reduced system stability and reduced safe operating margins. This has led to the proposal of more stringent requirements regarding power quality; standards such as IEEE-519 [5] reflect these preoccupations. Passive filters are being used widely for harmonic elimination. However, they may create system resonances, need to be significantly overrated to account for possible harmonic absorption from the power system, must be coordinated with reactive power requirements of the loads and need a separate filter for each harmonic frequency to be cancelled. The concept of using active power filters to mitigate harmonic problems and to compensate reactive power was proposed more than two decades ago. Since then the theories and applications of active power filters have become more popular and have attracted great attention. The concept of using active power filters to mitigate harmonic problems and to compensate reactive power was proposed more than two decades ago.

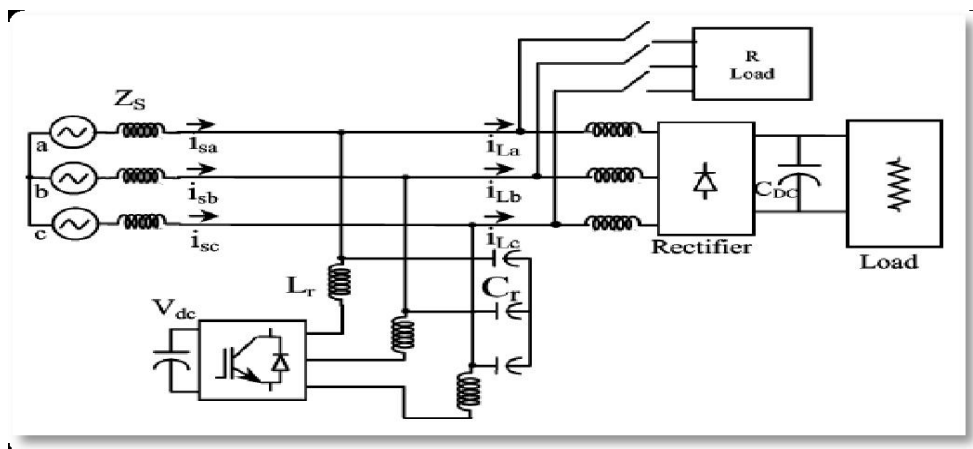


Fig:5 Main block diagram of an open loop system

Without the drawbacks of passive harmonic filters, the active power filter appears to be a viable solution for reactive power compensation as well as for eliminating harmonic currents. The schematic diagram of a power conditioner system employing shunt APF is as shown above. The composite load includes a three-phase diode rectifier, and a three phase R load. The ac side inductance is often sufficiently provided by the connected transformer. The unbalance in the present study is created by connecting resistive load between two phases.

### IV. BENEFITS OF POWER FACTOR IMPROVEMENT:

- i) Reduction in kVAR Demand
- ii) Reduction in kVA Demand
- iii) Reduction in Transformer Rating

- iv) Reduction in Line Current
- v) Reduction in Cable Size
- vi) Reduction in Switchgear rating vii) Reduction in Power Loss

## V.CONCLUSION

A current decomposition technique based on instantaneous power theory for shunt active power filters is studied, a simulink model is designed and total harmonic distortion is calculated using FFT analysis. Active power filter which has been used here monitors the load current constantly and continuously adapt to the changes in load harmonics. The performance of three phase shunt active power filter using instantaneous power theory with PI and hysteresis current controller is explained in this paper.

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