# *A Study on Harmonic Reduction and Power Quality Improvement by Using Shunt Active Power Filters in Renewable Energy Generations*

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## *Abstract*

*Recently, there's associate increasing concern regarding the atmosphere. The requirement to come up with pollution-free energy has triggered considerable effort toward renewable energy (RE). RE sources like star, wind, flowing water and biomass supply the promise of unpolluted and plenteous energy. once energy is generated through renewable sources like star, wind, energy there's a necessity to enhance power quality and scale back harmonics thus we tend to develop the active power filter that is a complicated power device, which may be used for compensating harmonics and up power quality. the various forms of active power filters are: shunt active power, series active power and hybrid active power filters. Among the 3 sorts, the shunt active power filter injects an acceptable compensating current at purpose of common coupling so the harmonics gift within the line square measure off out and therefore the curved nature of voltage and current waveforms ar remodeled. A PI managementler primarily based control algorithmic rule is developed to manage the 3 section shunt active power filter to compensate harmonics created by the nonlinear load to enhance power quality. The fast p-q theory is employed for extracting the harmonic current. conjointly a PI controller is developed to take care of a relentless DC voltage across the capacitance of DC bus aspect of the electrical converter. The 3 section shunt active power is developed by victimisation* *turbine. The projected shunt active power will suppress harmonics generated by the non liner load and it will maintain the doctorate value inside the quality limit.*

**Keywords:** *Three phases shunt active power, PI controller, Harmonics, power quality.*

## 1. INTRODUCTION

With the rapid development in semiconductor industry, power electronics devices have gained popularity in industries and also in household electrical appliances. Although these power electronics devices have benefited the electrical and electronics industry, these non-linear devices are the main source of harmonics in the power system. Harmonic is a sinusoidal component of a periodic wave and its frequency is an integral multiple of the fundamental frequency. These power harmonics are called electrical pollution which will degrade the quality of the power supply. They also cause disturbance to other consumers and interference in nearby communication networks, low system efficiency and poor power factor. The active power filter based on power electronics technology is a viable solution for power conditioning to suppress the harmonics in the power system.

Some renewable sources by which power is generated are as follows:-

### *a) Wind Power*

The terms "wind energy" or "wind power" describe the process by which the wind is used to generate mechanical power or electricity. Wind turbines convert the kinetic energy in the wind into mechanical power and this mechanical power is converted into electrical power by using alternator. Wind farms consist of many individual wind turbines which are connected to the electric power transmission network.

### *b) Solar Power*

Solar power is the conversion of sunlight into electricity, either directly using photovoltaic (PV), or indirectly using concentrated solar power (CSP). Concentrated solar power systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam.

Photovoltaic convert light into an electric current using the photovoltaic effect.

*c) Geothermal Power*

Geothermal power plants use steam produced from reservoirs of hot water found a few miles or more below the Earth's surface to produce electricity. The steam rotates a turbine that activates a generator, which produces electricity.

### *1.1 Overview of Harmonic*

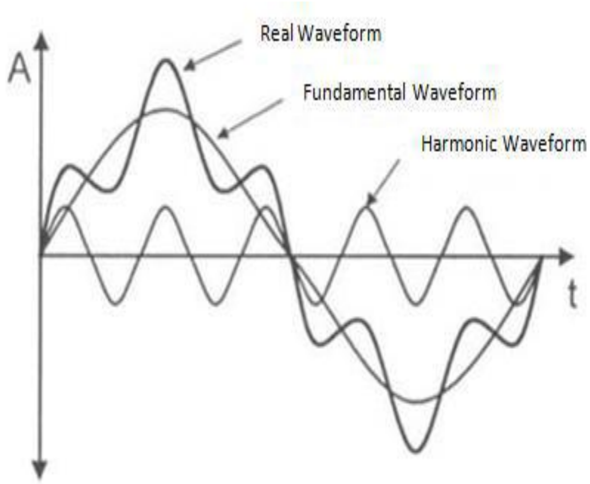


***Figure 1.1:- Basic Waveform of the Effects of Harmonic Distortion Overview of Harmonic (Source - INTERNET)***

### *1.2 Mitigation of Harmonics*

The presence of harmonics causes poor power factor, low efficiency, neutral conductor bursting and interference with nearby communication networks. It can also result in malfunction or damage to other equipment sharing the source. Traditionally passive L-C filters were used to reduce harmonics generated by non-linear loads. However, the compensation characteristics of passive filters are influenced by the power system equivalent impedance and they can generate parallel or series resonance within the utility power supply. They also have the demerits of fixed compensation, large size, detuning with age and resonating with the supply impedance. Active power filters are powerful tools for the compensation not only of current harmonics produced by non-linear loads but also of reactive power and unbalance of non-linear and fluctuating loads. They are also used to eliminate voltage harmonics, to regulate terminal voltage, to suppress voltage flicker and to improve voltage balance in three phase systems. The shunt active filter is the most widely used type to eliminate current harmonics, reactive power compensation, and balancing unbalanced currents. It is mainly used at the load end, because current harmonics are injected by non-linear loads. It injects equal compensating currents, opposite in phase, to cancel harmonics and reactive components of the nonlinear load current at the point of connection.

### *1.3 Objectives*

In the development of Active Power Filter, there are a number of issues in current, voltage control and in reference current extraction to be addressed. The present work focuses on developing suitable control techniques and reference current extraction method for the shunt active filter for three phase 3-wire system. The main objectives of this work identified are as follows:

- To study, identify and make analysis of the impact, causes, and how to solve the problem that created by harmonics produced in renewable energy generation.
- To study, identify and carry out suitable control methods to reduce the harmonic effects using shunt active power filters.
- To design a three phase shunt active power filter for harmonic reduction in Matlab/Simulink.

### *1.4 Scope of Project*

The scope of this project is to design a system that can be used to filter and reduce the harmonic distortion in industry. This project also includes the review on harmonic distortion and its impact on the industrial and also to find the main sources of the harmonics. The main focus of the work is first to develop a suitable harmonic extraction method for the three phase Shunt Active Power Filter to reduce harmonic distortion. Next, it aims to develop current control strategies to get PWM pulses to the filter.

## 2. METHODOLOGY

### *2.1 Harmonic Extraction Methods*

The effectiveness of active power filters in reducing the harmonic contents of the supply currents strictly depends on the ability of the algorithm used to extract the reference compensation current from the load current. A number of methods have been developed and analyzed for the generation of reference current. They can be divided into time and frequency domain methods.

### *2.1.1 Frequency domain methods*

In the frequency domain approach, the Fourier transform is applied to the distorted voltage or current signals to extract the compensating signals. The Fast Fourier Transform (FFT) method calculates the magnitude and phase of the load current. Then the component corresponding to the fundamental active current is removed. Finally, the reference current is obtained by taking inverse FFT for the remaining frequency components. The advantage of the frequency domain based method is that the magnitude of the frequency components is known. Hence by manipulation of the magnitudes, overloading of the shunt AF can be prevented. Furthermore, selective conditioning is made possible which is useful in some applications, where the focus is to reduce some specific harmonic component of the load current. However, the calculations involved are cumbersome and also the lack of information regarding the sequences, i.e. positive- or negative-sequences, of the conditioning components makes the FFT method less practicable.

### *2.1.2 Time domain methods*

Harmonic extraction methods in the time domain are based on instantaneous derivation of compensating signals in the form of either voltage or current signals from the distorted voltage or current signals. The various time domain methods include instantaneous “p–q” theory , synchronous d–q reference frame method, synchronous detection method, flux based controller, notch filter method, P–I controller, and sliding-mode controller. The instantaneous active and reactive power (p-q) theory is based on transformation of voltage and current signals to derive compensating signals. The instant active and reactive power will be computed in terms of remodeled voltage and current signals. From instant active and reactive power, harmonics active and reactive power ar extracted mistreatment low pass and high pass filters.

For a three phase power system, the instantaneous reactive power theorem or p-q theorem is expressed as an instantaneous space vectors in voltage or current form. The main advantage of the time-domain methods is its fast response which is necessary for on line applications. But, the performance of these approaches may not be satisfactorily under noisy voltage or current conditions.

## 3. ANALYSIS

As the analysis consist of Formulas, Flow diagram, Simulation diagram which are as follows:-

### *3.1 Formula*

The two most commonly used indices for measuring the harmonic content of a waveform are the Total Harmonic Distortion (THD) and the Total Demand Distortion (TDD).

 

$$THD = \frac{\sqrt{\sum_{h>1}^{h_{max}} M_h^2}}{M_1}$$

Where MHz is the rms value of harmonic component h of the quantity M.

$$TDD = \frac{\sqrt{\sum_{h>1}^{h_{max}} I_h^2}}{I_L}$$

$I_k$ is the rms value of harmonic component k, IL is the peak or maximum demand load current at the fundamental frequency component measured at the Point of Common Coupling.

### *3.2 Flow diagram*

### *3.2.1 Proposed shunt active filter*

Figure shows the schematic representation of a shunt active filter connected in a three phase system feeding a non-linear load. Voltages Va, Vb, Vc and current Ia, Ib, Ic indicate the phase voltages and currents at the load side respectively. The active filter is connected in parallel with the load to suppress the harmonics. The shunt active filter generates the compensating currents Ica, Icb, Icc to compensate the load currents Ica, Icb, Icc so as to make the current drawn from the source as sinusoidal and balanced.

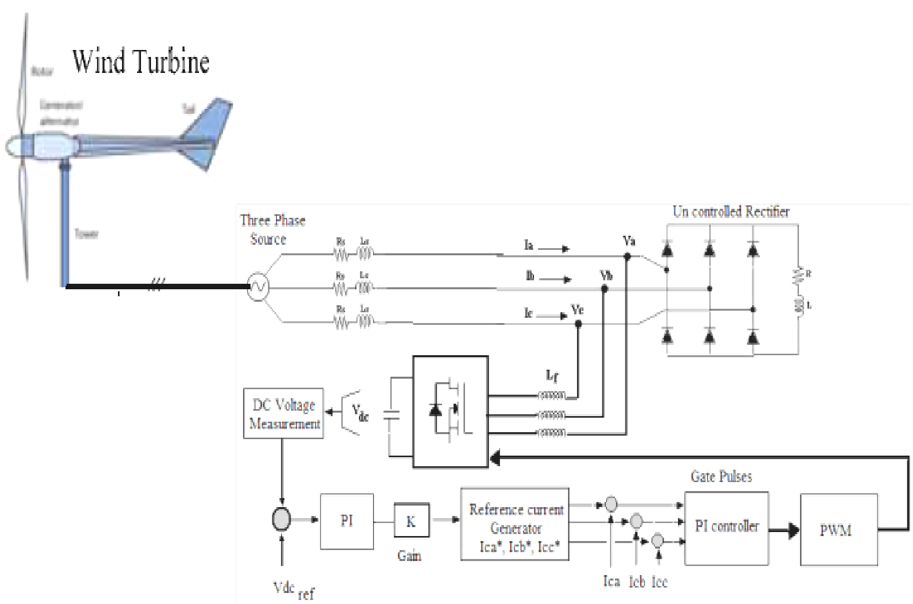


***Fig. 3: Schematic Representation of Active Power Filter with the Proposed Control Technique. (Source-reference 6.2)***

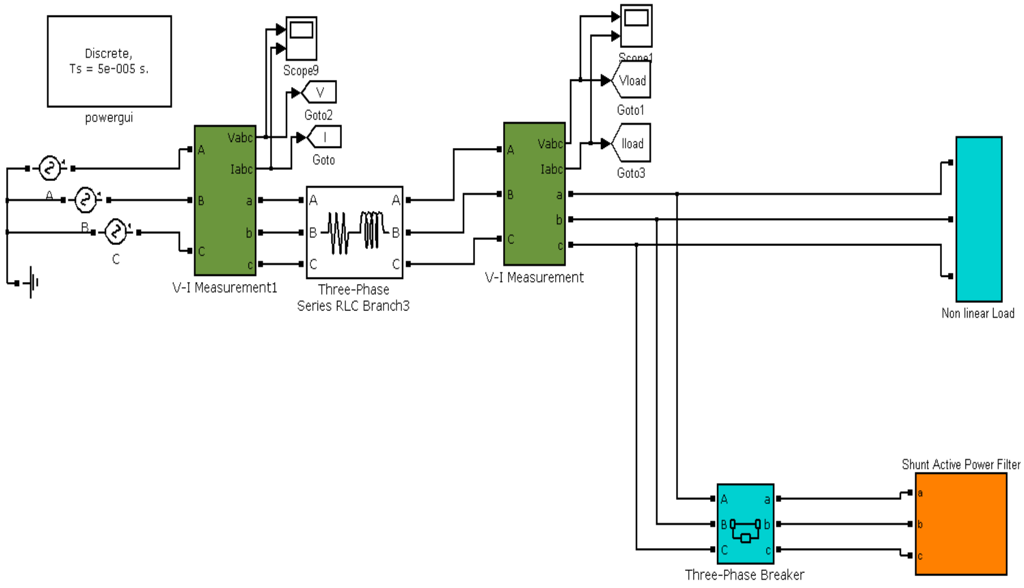


***Fig. 3.3.1: Simulation in Shunt Active for Harmonic Reduction. (Source-reference 6.1)***

### *3.3.1 Simulation Model*

The Matlab/Simulink simulation tool was used to develop a model that allowed the simulation and testing of the p-q theory calculations, which were implemented in the controller of the shunt active power filter for three phase systems. **See Fig:3.3.1**

## 4. RESULT

### *4.1. Simulation Results with Shunt Active Power Filter*

Figure present simulation using Matlab/ Simulink for a three-phase power system with a shunt active filter. And the Figures 11 and 12 present simulation results for a three-phase power system with a shunt active filter. In this simulation model the circuit breaker is placed in the shunt active power filter. The circuit breaker is in closed condition, the load current connected with the filter current to reduce the harmonics current on the load side. The with shunt active power filter wave form is shown in the Figure.

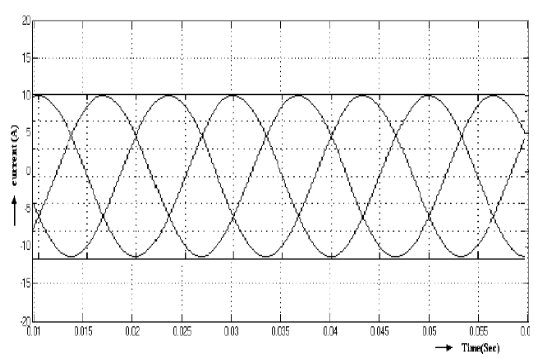


***Figure 4.1:- Load current wave form with Shunt Active Filter (Source- reference 6.2)***

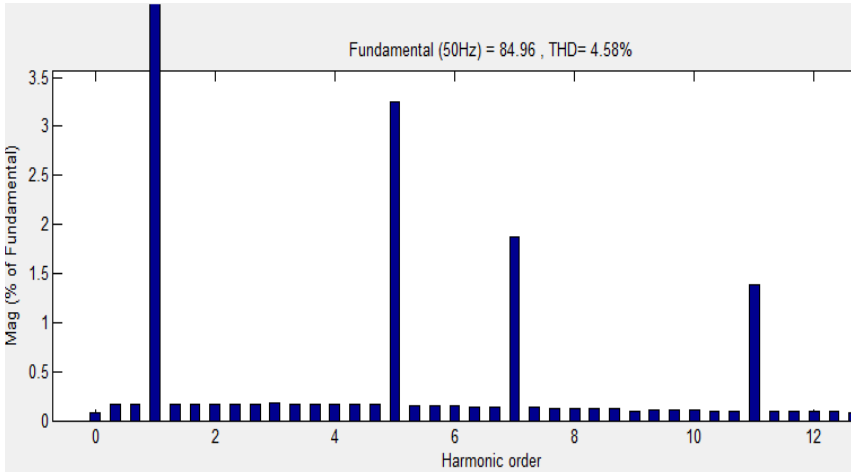


***Figure 4.2: THD Spectrum with active power filter. (Source-reference 6.2)***

## CONCLUSION

This section has presented PI controller, PWM techniques and inverter based approach for developing the active filter for three-phase three-wire system which is supplied with wind power plant. Modified p-q theory was employed for effectively computing the reference current under non-ideal source voltage conditions. The active filter has been simulated using MATLAB/SIMULINK and the performance has been analyzed in a sample power system with a source and set of non-linear loads. The simulation results show that the proposed technique is effective in current harmonic filtering. Further the proposed technique has quick response time and it keeps the switching frequency nearly constant with good quality of filtering.

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