Enhancement of Power Quality Using Fuzzy Logic Based Shunt Active Filter

Kamalesh sharma, Sunil kumar goyal, Nagendra kumar swarnkar

Abstract— **Power quality is a very serious issue as far as the transmission line is concern. Non-linear loads connected to AC electric mains generate undesired harmonics in the current dynamics which are usually responsible of additional power losses and the risk of equipment damage or malfunctioning of the system.**

Active power filters or active power line conditioners are developed for compensating harmonics and reactive power simultaneously. The active power filter topology can be connected in series for voltage harmonic compensation and in shunt for current harmonic compensation. Most of the industrial applications need current compensation, so the shunt active filter is popular than series active filter.

In the paper simulink model of shunt active filter mainly, used fuzzy logic controller and hysteresis current controller for reducing the harmonic distortion. Powergui tool provides the function of FFT. Analysis which is very useful to calculate total harmonic distortion in source current. By taking different firing angles the total harmonic distortion is calculated by FFT analysis.

Index Terms—**FFT, Simulink, active filter.**

I. INTRODUCTION

One of main aim in the development of AC power transmission and distribution systems at the end of the 19th century was based on sinusoidal voltage at constant-frequency generation. It is easy to design of transmission, distribution and transformers for sinusoidal voltage with constant frequency If the voltage were not sinusoidal, hues problems would appear in the design of transformers, machines, transmission and distribution systems or we can say in power system. These problems would not allow, certainly, such a development as the generalized "electrification of the human society." Today, there are very negligible communities in the worlds without ac power systems with "constant" voltage and frequency.

Then the concept of reactive power, if the current is not in phase with the voltage generally current legs voltage, and the it is it will be efficient and economical to have higher power factor, higher the power factor better the utilization of the circuit.

Since power electronics was introduced in the late 1960s, nonlinear loads that consume non sinusoidal Current have increased significantly. In some cases converters, phase controller, they represent very high percentage, the induction motor which is a linear load in steady state is now equipped with semi-conductor devices for the purpose of variable speed requirement. The induction motor together with its drive is now a nonlinear load.

Now in this scenario Non-linear loads connected to AC electric mains develop unwanted harmonics in the current dynamics which are usually responsible of additional power losses in power system and the risk of equipment damage or malfunctioning and increase operating and maintenances cost. Generally, current harmonics have been reduced with passive filters which are all passive devices, have several inherent limitations rendering their use ineffective in realistic situations characterized by different and not a priori fixable operative modes. In the last section, the fast development of power electronics components and control processors has led to a growing interest in the power system so called active power filters (APF). There are basically two types of filter which are given below:

(1) Shunt active filter
(2) Series active filter

Series active filter consists of voltage series inverter along with passive filter in the line, which injects regulated amount of voltages at the desired frequency which is used to because shunt active filter has to generate fundamental voltage in phase opposition to fundamental PCC voltage. And series active filter must have current rating equal to worst load conditions. Active filters are therefore not suitable for higher current ratings. Further it is not possible to design a large KVA rated inverter with higher current bandwidth, which requires higher switching frequency. The initial cost of the active filters is high.

Power Quality

A simpler and perhaps more compact definition might state: "Power quality is a set of electrical boundaries that allows a piece of equipment to function in its intended manner without significant loss of performance or life expectancy." This definition has two things that we demand from electrical equipment: performance and life expectancy. Any power-related problem that compromises either attribute is a power quality concern. In light of this definition of power quality, this chapter provides an introduction to the more common power quality terms.

A. POWER QUALITY IN POWER DISTRIBUTION SYSTEMS

Most of the more important international standards define the power quality as the physical characteristics of the electrical supply provided under normal operating conditions that do not disturb the customer's processes or load operation. Therefore, a power quality problem exists when any voltage, current or frequency deviation results in a failure or in a bad operation of customer's equipment or industry electrical equipment. However, it is to notice that the quality of power

Manuscript received January 23, 2015.
Kamalesh sharma, M.tech Student at Apex Institute of Engineering College, Jaipur
Sunil kumar goyal, Assistant Professor Ist at Manipal University, Jaipur
Nagendra kumar swarnkar, Associate Professor at Apex Institute of Engineering College, Jaipur

supply is basically voltage quality and supply reliability. Voltage quality problems relate to any failure of electrical equipment due to variation of the line voltage from its nominal characteristics and the supply reliability is characterized by its adequacy (ability to supply the various load), security (ability to withstand sudden change such as system faults) and availability (focusing especially on long interruptions in system).

B. SOLUTIONS TO POWER QUALITY

There are two methods to the mitigation of power quality problems. The first method is called load conditioning, which ensures that the equipment is less sensitive to power disturbances, allowing the operation even under significant voltage distortion. The other method is to install line conditioning systems that suppress or counteracts the power system disturbances.

A flexible and versatile solution is active power filters for voltage quality problems. Presently they are based on PWM converters and they connect to low and medium voltage distribution system in shunt or in series. Series active power filters must operate in conjunction with shunt passive filters in order to compensate load current harmonics. Shunt active power filters operate as a controllable current source and series active power filters operates as a controllable voltage source. Both schemes are implemented preferable with voltage source PWM inverters, with a dc bus having a reactive element such as a capacitor. Active power filters can perform one or more of the functions required to compensate power systems and improving power quality. As it will be illustrated in this paper, their performance depends on the power rating and the speed of response. The selection of the type of active power filter to improve power quality depends on the source of the problem as can be seen in Table

Active filter connection	Load on AC supply	AC supply on load
Shunt	-current harmonic filtering. -reactive current compensation. -Current unbalance. -Voltage flickering.	
Series	-current harmonic filtering. -reactive current compensation. -current unbalance. -voltage flickering. -voltage unbalance.	-voltage sag/swell. -voltage unbalance. -voltage distortion. -voltage interruption. -voltage flickering. -voltage notchings

TABLE

II. ACTIVE POWER SOLUTIONS OF POWER QUALITY PROBLEMS

HARMONICS:

Increased use of power electronics in the applications power systems, drives, computer industry and lightening applications led to development of more efficient power converters and efficient switching devices. And these power converters are non linear loads, because switching devices form heart of the power converters and power electronic devices, and these devices operate in the saturation mode to have very low power loss as compared to active mode, and in the saturation mode the devices act as switches, and during saturation conditions these devices form non linear characteristics, during switch on there is drop in voltage and rise in current, and during switch off mode , reverse breakdown voltage increases and current decreases rapidly, and gives non linear characteristics.

Sinusoidal sources are of 50 Hz systems, but due to the pollution of harmonics, system comprises of frequencies if integral multiply of natural frequency. It consists of 150th, 250th, 350th, etc that distort the voltage and current waveforms. And third harmonics and its multiples can be removed by three phase sources.

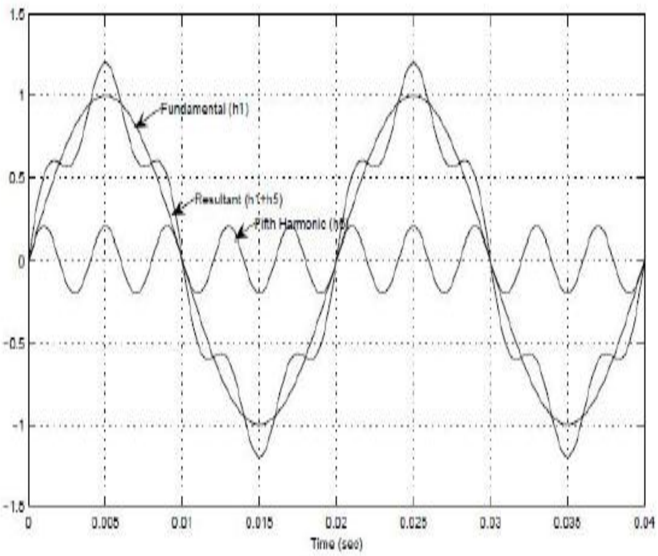

Fig. Typical 50 Hz waveform along with 5th harmonic component.

III. FILTERS:

Due to increasing of loads and nonlinear equipment's in a advance power system, advance power systems have been demanding the compensation of the disturbances caused for them. These non-linear loads may cause poor power factor and high degree of harmonics. Harmonics distort the source voltage and current and increase losses of the system. To eliminate the harmonic distortion from the source voltages and currents filters are very useful. Here in this chapter a brief classification regarding different types of filter is given. Mainly two types of filters are there which can be classified as follows.

(1) Passive Filters
(2) Active Filters

IV. SIMULINK MODEL FOR THE NON-LINEAR LOAD SYSTEM WITH SHUNT ACTIVE FILTER

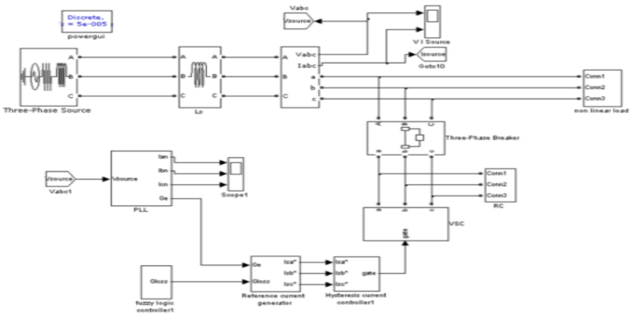

Fig. Modelling for non-linear load with shunt active filter

Fig. shows the modelling for fuzzy logic based shunt active filter with non-linear load for the power quality improvement from harmonic distortion. Whenever circuit breaker is closed the filter is connected with the system of non linear load. In addition to the previous modelling scheme, several other blocks are provided to form a complete modelling scheme for fuzzy logic based shunt active filter which are described briefly in the successive points.

V. SIMULATION RESULTS

This paper provides the simulation results of simulink models for non linear load with and without using shunt active filter which have been discussed in previous chapter. It has been noted that whenever shunt active filter is not connected in the system, source voltages and currents are more distorted and when shunt active filter is connected with the system the source currents and voltages are very less distorted. The brief result analysis of both the cases are explained in succeeding points.

WITHOUT SHUNT ACTIVE FILTER

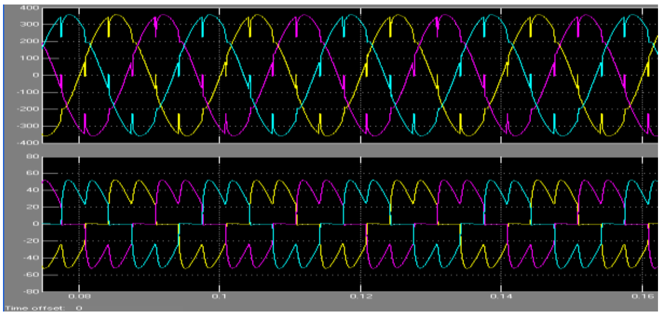

Fig. Waveforms of voltages and currents without shunt active filter

WITH SHUNT ACTIVE FILTER

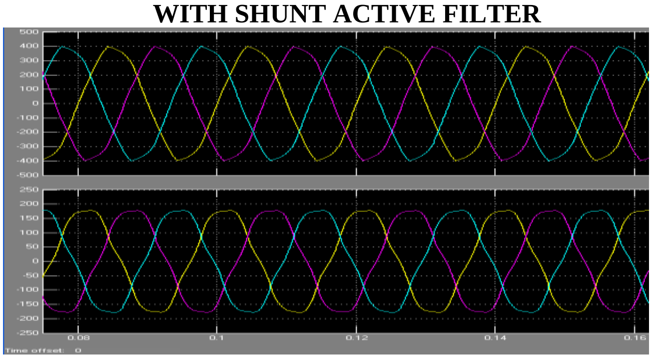

Fig. Waveforms of source voltages and currents with shunt active filter

VI. CONCLUSION:

This paper has described and illustrated that when the shunt active filter is connected with the system of non-linear load, current and voltage can be prevented effectively from harmonic distortion. Therefore simulink model of the shunt active filter is very useful for getting the newer controlled strategy or advanced techniques for the filtering of non-linear load. In addition to this powergui FFT analysis provides effective percentage values of total harmonic distortion for different firing angles provided with the system of non linear load which provides prediction of harmonic distortion in current according to the specifications of the system.

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