ISSN 2348 – 8034
Impact Factor- 4.022

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

HARMONICS ANALYSIS OF SYSTEM USING SHUNT ACTIVE POWER FILTER BY MATLAB SIMULATION

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ABSTRACT

The widely use of nonlinear loads, such as diode and thyristor, rectifiers, computers, consumer electronics, uninterruptible power supplies and adjustable speed drives results in the distorted current waveforms in the electrical distribution systems. Harmonics is a major problem in power systems that have become serious recently owing to the wide use of power electronics-related equipment. The input power factor of most of these equipments is poor. There is a great need to reduce these harmonic and reactive current components. Active Power Filters are a viable solution to these problems. In this project work a three-phase shunt active filter is used to eliminate supply Current harmonics, correct supply power-factor, for balanced nonlinear load. The active power filter produces equal but opposite harmonic currents to the point of connection with the nonlinear load. This results in a reduction of the original distortion and correction of the power factor. A three-phase insulated gate bipolar transistor based current controlled voltage source inverter with a dc bus capacitor is used as an active filter. The firing pulses to the shunt active filter will be generated by using sine PWM method. In this project models for three-phase active power filter controller for balanced and unbalanced non-linear load is made and is simulated using Matlab/simulink software.

Keywords- *Power System, Harmonic Distortion, Shunt Active Power Filter, Non-Linear Loads, Total Harmonic Distortion.*

I. INTRODUCTION

The main objective of the power system is generation of electrical energy to transmit and distribute to the end-user. Manypower system are internally connected into a network. If a fault exists in any one of the network, it should affect the whole power system.[2] Transients, sagging, variations in voltage, harmonics are the some of disturbances affecting power system. The aim of this paper is to suggest a method to reduce the current harmonics. Basically, AC electrical power system mainly uses non-linear loads. For these types of loads, the load current and voltages are non-sinusoidal. So it is necessary to compensate the voltage and current harmonics. Non-linear loads are mainly used in adjustable-speed drives, switch mode power supply (SMPS), and unintertable power supply (UPS). These types of loads will cause harmonic voltage drop across the network impedance, resulting in distorted voltage. Harmonics are one of the major concern in a power system. Harmonics are the non-integer multiples of the fundamental frequency. It is generated in a power system by means of non-linear loads. In order to reduce the harmonic distortion two types of filters can be used. 1) active filter 2) passive filter. A passive filter is composed of only passive elements inductor, capacitor and resistor. The passive filters are inexpensive. Since they are ineffective due to the inability to adapt to network characteristic variations, therefore the active filters are used. An active filter is implemented when orders of harmonic currents are varying. It use active components such as MOSFET, IGBT-transistors etc. Its structure may be either of the series or shunt type. Shunt active power filters are widely used for mitigating current harmonics. Series active filters are widely used for mitigating voltage harmonics. Drawbacks of series active filter are, they have to handle high load currents, which increase their current rating and increasing I2R losses. It is mainly used at the load because non-linear loads inject current harmonics.[3] It injects equal compensating currents, opposite in phase, to cancel harmonics and/or reactive currents of the non-linear load current at the point of connection. Recently, voltage source inverter or current source inverter based active power filter is used. They have many advantages as compared to the previously used methods, which include potential size, weight and cost reduction ,small size and light weight, low power losses, tracking of the power system frequency change, fast dynamic response to load changes and reduction of resonance problems. In addition, APF can provide other conditioning functions such as reactive power control, load balancing and flicker mitigation.[4] selective harmonic compensation can be used to reduce the harmonics chosen by the designer. Many theories have been developed for instantaneous currentharmonics detection in active power filter such as FFT (fast Fourier technique) technique, neural network, instantaneous p-q theory(instantaneous reactive power theory), synchronous d-q reference frame theory or by using suitable analog or digital electronic filters separating successive harmonic components, PLL with fuzzy logic controller, neural network etc. This paper basically deals with the modeling and simulation of shunt active filter with PI controller study for THD.[5].

II. FILTERS

Classification Of Filters

There are two types of filter to reduce current harmonics and improve the power factor. These filters are

1) Passive filters.
2) Active power filters.

Passive Filters

Passive filters are the conventional filters used to reduce current harmonics and improve the power factor. These usually consist of a bank of tuned LC filters to suppress current harmonics generated by nonlinear loads. These filters have advantages like:

1) They are cheap and economical.
2) High efficiency

Active filters

To overcome the disadvantages of passive filters, active power filters have been presented as a currentharmonic compensator for reducing the total harmonic distortion of the current and correcting the power factor of the input source. The principle of operation of an active power filter is to generate compensating currents into the power system for canceling the current harmonics contained in the nonlinear load current. Active filters are basically categorized into three types, namely, two- wire (single phase), three-wire, and four wire three phase configuration to meet the requirements of the three types of non linear loads on supply systems . AF's can be classified based on converter type, topology, and the number of phases. The converter type can be either current source (CSI) or voltage source inverter (VSI) bridge structure. The topology can be shunt, series, or a combination of both. The third classification is based on the number of phases, such as two wire (single phase) and three-wire three phase systems.

III. PRINCIPLE OF OPERATION

The proposed three-phase active power filter is shown in Fig 5 It consists of a power converter, a DC-link capacitor and a filter inductor. To eliminate current harmonic Components generated by nonlinear loads, the active power filter produces equal but opposite harmonic currents to the point of connection with the nonlinear load. This results in a reduction of the original distortion and correction of the power factor. For the sake of simplicity, in the calculation of reference currents and description of the control scheme.

IV. INSTANTANEOUS CURRENT METHOD (D-Q METHOD)

This method, also called instantaneous current id,iq, the load current are transformed from three phase frame reference abc into synchronous in order to separate the harmonic contents from the fundamentals. It gives better performance even in the case where the three phase voltage is not ideal.fig 4 presents the diagram block of this extraction method.

ISSN 2348 – 8034
Impact Factor- 4.022

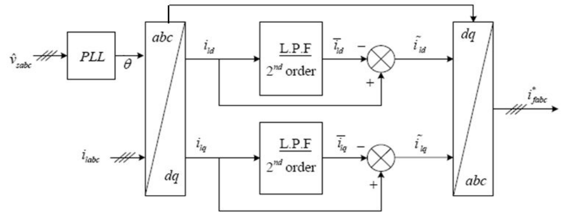


Fig.1.D-Qtheory

V. MODELLING OF SHUNT ACTIVE POWER FILTER

The simulation model of system without SAPF is shown in fig 2 and the simulation model of system with SAPF is shown in fig 3 which shunt active power filter (SAPF) is connected across the non linear load. The control of Shunt active power filter (SAPF) is divided in two parts. First part is used for the harmonic current extraction. There are instantaneous active and reactive power method (p-q method). Second part is used for the generation of gate pulse to control of voltage source inverter. Hysteresis Current Control Method is used.

Simulation Modelwithout Sapf

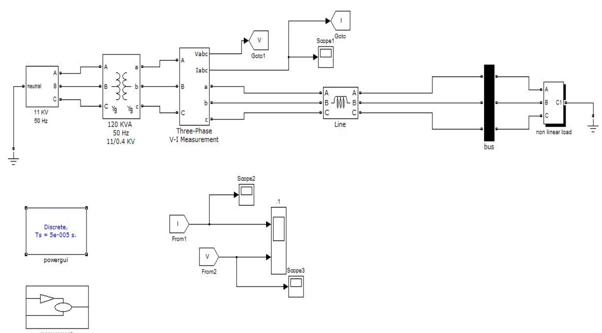
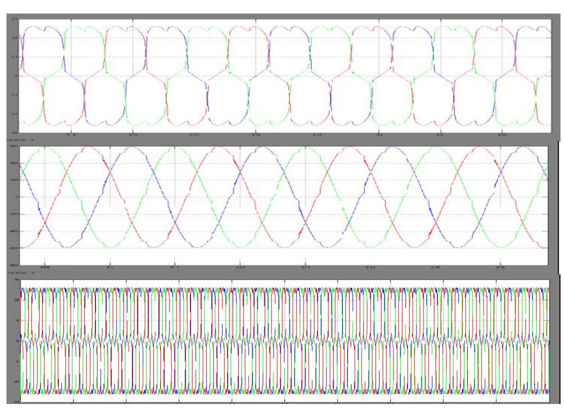


Fig.2.



Simulation Model With Sapf

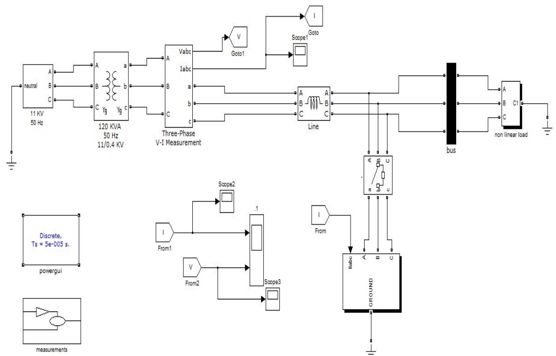
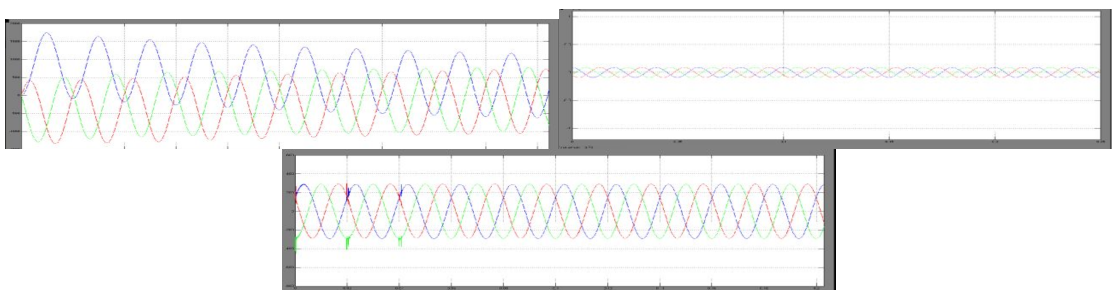


Fig.3.

Simulation Result With Sapf



VI. CONCLUSION

The three phase three wire shunt active filter with controller based on instantaneous active and reactive power (p-q) theory is simulated in MATLAB/SIMULINK to compensate the problems of the harmonics and reactive power which are encountered from power electronic non-linear loads. The performance of the shunt active power filter is investigated under different scenarios. It is investigated that the p-q theory based active filter manages to compensate the harmonics and reactive power of the power distribution network even under unbalanced and distorted supply voltages. The active power filter is able to reduce the THD in source current at a level well below the defined standards specified by power quality standards The THD in source current after the active filtering is not exactly zero. It is because internal switching of the compensator itself generates some harmonics. In each of the case the case, the source current after the working of the active filter becomes perfectly sinusoidal, free from harmonics and in-phase with voltage of the main supply maintaining the unity power factor. In each simulation studied, multiple non-linear loads have been used to investigate the time response of the active filter. In each case it has noted that filter is successfully able to follow the reference currents with one power cycle with change in loads. It has been noted that if voltage unbalance or distortion or both are present in the system, the simple p-q theory didn’t work well. It give rise the demand of the fundamental positive sequence voltage detector to extract the fundamental positive voltage form the unbalanced or distorted voltage. Once the fundamental positive sequence voltage is extracted, the theory worked very well. Even though the p-q theory has managed to compensate the harmonics and reactive power of the system and to produce the sinusoidal source current with unity power factor and free from harmonics.

[Pardhi, **4(4): April 2017]** **ISSN 2348 – 8034**
DOI- 10.5281/zenodo.570074 **Impact Factor- 4.022**

VII. FUTURE WORK

The scope of the future work can be to look for the solution of the following points:
This work is based on three phase three wire system and the active filter does not work well if there is a zero sequence in the supply voltage. In future, a detailed analysis can be carried out for a 3 phase four wire filter in order to compensate the zero sequence present in the system. The APF for the compensation of harmonics and zero sequence

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