A THREE PHASE SHUNT ACTIVE POWER FILTER FOR HARMONICS REDUCTION

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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. The proposed active power filter can largely reduce the total harmonic distortion of current and correct the power factor to unity with balanced and unbalanced nonlinear load.*

Key Words: *Active filter, Harmonics Reduction, Switching angles, THD.*

1. INTRODUCTION

Power electronic equipment usually introduces current harmonics. These current harmonics result in problems such as a low power factor, low efficiency, power system voltage fluctuations and communications interference. Traditional solutions for these problems are based on passive filters due to their easy design, simple structure, low cost and high efficiency. These usually consist of a bank of tuned LC filters to suppress current harmonics generated by nonlinear loads. Passive filters have many disadvantages, such as resonance, large size, fixed compensation character and possible overload. To overcome these disad-vantages, active power filters have been presented as a current-harmonic compensator for reducing the total harmonic distortion of the current and correcting the power factor of the input source .Fig. 3.1 shows the configuration of a three-phase active power filter.

A personal computer (PC) based digital control is used to implement the control scheme. The active power filter is connected in parallel with a nonlinear load. Its main power circuit is composed of a pulse-width-modulation (PWM) converter. The inductor L2 is used to perform the voltage boost operation in combination with the DC-link capacitor C2 and functions as a low pass filter for the line current of an active power filter. 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. This will thus result in sinusoidal line currents and unity power factor in the input power system. At present, calculation of the magnitude of the compensating currents of an active power filter is based either on the instantaneous real and reactive powers of nonlinear loads or the integrative methods of Fourier analysis Both these approaches neglect the delay time caused by low pass high pass filters when compensating current calculations.

It consists of a cascade of a low pass filter and an adaptive predictive filter. Although this method can effectively reduce the delay time, it is complicated and difficult to design the current regulators and the DC-link voltage regulator. In addition, no experiment was given to verify the performance of the adaptive filter system. The studies on active power filters which appeared in the literature [02 & 03] all ignore the delay time such as current response delay generated by the boost inductors and DC-link voltage feedback delay due to the detecting circuits. The concept of delay time was discussed in [04] in detail, where a new input-output instantaneous power balancing approach for an integrated rectifier inverter system was proposed.

2. 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.

2.1 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
3) Maintenance of these filters are simple.

However Passive filters have many disadvantages, such as Resonance, Large size, fixed compensation character and possible overloads. Therefore the conventional passive filter cannot provide complete solution.

2.2 ACTIVE FILTERS:

To overcome the disadvantages of passive filters, active power filters have been presented as a current-harmonic 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.

2.3 CLASSIFICATION OF ACTIVE POWER FILTERS:

Active power filters can be classified using the following criteria.

(a) Topology -based classification

(b) Classification based on the Converter type

(c) Classification based on the supply system

2.3.1 Topology -based classification

According to the topologies of the converters, active filters can be classified into shunt active filters as shown in Fig1, series active filters shown in Fig 2, universal active filters as in Fig 3 and hybrid active filters in Fig 4

(i) **Shunt active filter:** The shunt active filter is the filter that draws a compensating current from a power line to cancel harmonic currents on the source side, a grid location where power quality becomes important. It is widely used to eliminate current harmonics, compensate reactive power and balance unbalanced currents by injecting (drawing) additional current.

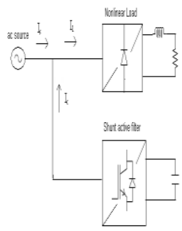


Fig 1 Shunt active power filter

(ii) Series active filter: The Series active filter is the filter that is connected in series with the utility through a matching transformer, so it is controlled to eliminate voltage harmonics and regulate the terminal voltage of the load or line through the

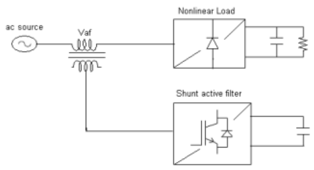


Fig 2 Series active power filter

(iii) Universal active filter: The universal active filter (Unified Power Flow Controller, UPFC)) is the filter that combines a shunt and a series active filters as shown in Fig 2.3. It is controlled for both voltage and current harmonics cancellation.

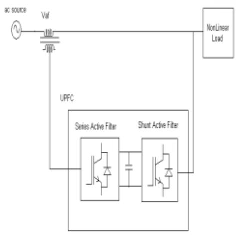


Fig 3 Universal active filter

Hybrid active filter: The hybrid active filter is the filter that combines an active filter and a passive filter to reduce costs and improve efficiency. Due to the passive components, it often suffers significant parameter and frequency sensitivity.

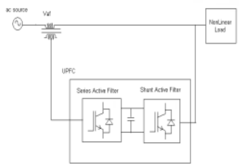


Fig 4 Universal active filter

3. ACTIVE POWER FILTER CONTROL

The active power filter was a recently developed piece of equipment for simultaneously suppressing the current harmonics and compensating the reactive power. Fig 3.1 shows the configuration of a three-phase active power filter. A personal computer (PC) based digital control is used to implement the control scheme. The active power filter is connected in parallel with a nonlinear load. Its main power circuit is composed of a pulse-width modulation (PWM) converter.

The inductor L_2 is used to perform the voltage boost operation in combination with the DC-link capacitor C_2 and functions as a low pass filter for the line current of an active power filter. 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. This will thus result in sinusoidal line currents and unity power factor in the input power system.

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.

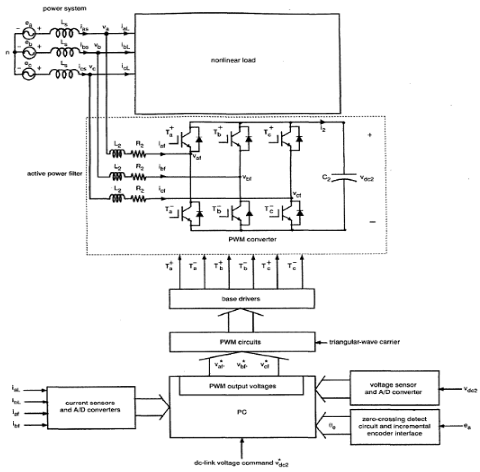
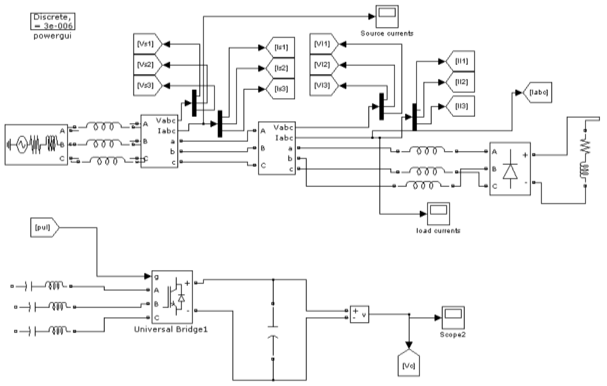
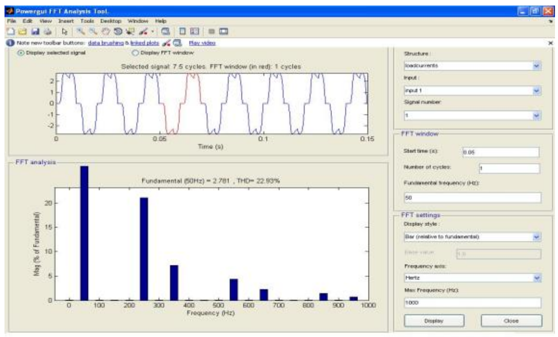


Fig 5 Configuration of active power filter

4. SIMULATION RESULTS

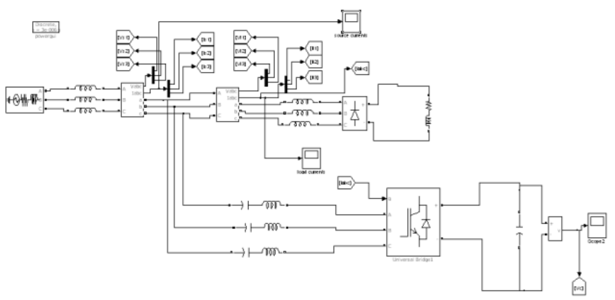
Simulation of Load without APFC:





FFT analysis for load currents without APFC

Simulation of Load with APFC:



Total harmonic distortion (THD):

6. FFT analysis for load currents with APFC

CONCLUSION:

The active power filter controller has become the most important technique for reduction of current harmonics in electric power distribution system. In this project a model for three-phase active power filter for balanced non-linear load is made and simulated using Matlab/Simulink software for the reduction harmonics in source current. The simulation result indicates that the total harmonic distortion (THD) of the current reduced from 0.1725 with out active power filter to 0.0726 with active power filter for balanced nonlinear load and 0.3577 with out active power filter to 0.1912 with active power filter for unbalanced nonlinear load and the power factor improved .

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