

Mitigation of Current Harmonics with Combined p-q and Id-Iq Control Strategies for Fuzzy Controller Based 3Phase 4Wire Shunt Active Filter

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ABSTRACT: This paper presents complete analysis, to compare and elevate the performance of two control strategies. By using Fuzzy controller, the tracking reference currents of shunt active filters under balanced, unbalanced and non-sinusoidal conditions. There are two control methods one is instantaneous real active and reactive power method (p-q), another one is active and reactive current method (i_d-i_q) which are widely used in active filters. For both (p-q) and (I_d-I_q) methods used for different voltage conditions with fuzzy controller. The Simulation results confirm the performance of active and reactive current control strategy (i_d-i_q) more than active and reactive power control strategy (p-q) with fuzzy controller. Variable frequency drives (VFDs), electronic ballasts, battery chargers, static var compensators are installed, and the problems related to harmonics are expected to get inferior. Due to excellent harmonic compensation, the result Active power filter (APF) gains much more attention. In different control strategies, the performance of the active filter seems to be in contradictions.

KEYWORDS: Harmonic Compensation, Shunt Active Power Filter, p-q Control Strategy, i_d-i_q Control Strategy, Fuzzy Controller.

1. INTRODUCTION

In particular, highly automatic electric equipments cause enormous economic loss. The power quality problem and compensation technique are anxious for both power suppliers and power consumers. In single-phase electronic equipments have been extensively used in domestic, educational and commercial appliances. This equipment includes computers, communication equipments and electronic lighting ballasts etc. At the same time, a large number of computers are turned on. Each computer and its related devices contain a diode rectifier. A diode rectifier is used to convert AC electricity to DC one. Due to the current harmonics generated by the nonlinear loads. For the utility power supply, the non-sinusoidal current results in many problems such as low power factor, low energy efficiency, electromagnetic interference (EMI) and distortion of line voltage etc. In three-phase four-wire system, zero line may be overheated or causes fire disaster, due to excessive harmonic current Going through the zero line. Due to harmonics, a perfect compensator is necessary to avoid the consequences. The two control strategies have been developed instantaneous active and reactive currents method and instantaneous active and reactive power methods. This paper mainly focused on two control strategies (p-q and I_d-I_q) with fuzzy controller. Linear and Nonlinear loads linear loads have certain unique characteristics. The linear loads connected to a system with sinusoidal voltage forms sinusoidal currents. In linear loads, the supply voltage remains sinusoidal. Moreover, the voltage and current waveforms are of the same shape and contain only the fundamental frequency.

In contrast, the nonlinear loads connected to a system with sinusoidal voltage forms non-sinusoidal currents. Similarly, the supply voltage becomes non-sinusoidal. Moreover, the voltage and current waveform arc not of the same shape and

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it contains fundamental current as well as non-fundamental frequencies, so-called harmonics. Many solutions have been proposed, in order to face the problem of harmonics. These solutions includes modification on the load itself for less harmonic emissions similar to the case of special structure single phase and three phase rectifier and PWM rectifiers or the connection on the polluted power grids of other traditional or modern compensation systems. The majority of conventional harmonic reduction solutions comprise the use of harmonic trapping passive filters based on RLC elements calculated in accord with the harmonic ranges to be trapped. In addition, these passive filters can be designed to compensate reactive power simultaneously with the desired harmonics.

Many types of APF have been proposed and it is used in harmonic compensation. For voltage harmonics compensation, series APF is used. For current harmonics and reactive power compensation, shunt APF was proposed. The Unified Power Quality Filter or Conditioner combines the two types of shunt and series APF in one device accountable for the synchronized compensation of current harmonics, reactive power and voltage. Several arrangements of APFs with passive filters have been proposed is called as Hybrid APFs (HAPFs). The combination between the conventional and the present in one HAPF have the purpose of amelioration of different types of APF compensation performance, also the reduction of cost and complexity of compensation systems. This research work mainly focuses on developing an efficient harmonic mitigation approach using Shunt Active Power Filter (SAPF) with efficient pulse width modulation and control strategies.

II. AN OVERVIEW OF HARMONICS AND ITS FEATURES

Power systems are designed to operate at frequency of 50 or 60 Hz. Although, certain types of loads produce current and voltage with frequency that are integer multiples of the 50 or 60 Hz fundamental frequency. These frequency components are in the form of pollution known as harmonic distortion. There are two types of harmonics namely synchronous and Asynchronous harmonics that can be encountered in a power system.

Synchronous harmonics are sinusoids by means of frequencies which are leads to multiples of the fundamental frequency. The multiplication factor is frequently referred as the harmonic number. The synchronous harmonics can be classified into two categories.

- Sub-harmonics: when the harmonic frequency is less than the fundamental frequency.
- Super harmonics: when the harmonic frequency is more than the fundamental frequency.

In power circuits, non-linear loads produce harmonic currents that are the integer multiples of the supply fundamental frequency. The fast development of solid state Power electronics has significantly increase the number and size of these loads.

According to Fourier, all periodic non-sinusoidal signals can be defined by infinitive sum or series of sinusoids with discontinuous frequencies and it is defined in

$$i(t) = I_0 + \sum_{h=1}^{\alpha} I_h \cos(h\omega t + \varphi_h) \quad (1)$$

In the equation, component I_0 in the Fourier series is the direct component. The first term of the sum with the index $h=1$ is the fundamental of the signal. The rest of the series components are called the harmonics of the range h .

2.1 Total Harmonic Distortion (THD)

The total harmonic distortion of a signal is a dimension of the harmonic distortion present in current or voltage. It is defined as the ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency. Harmonic distortion is caused by the introduction of waveforms at frequencies in multiples of the fundamental.

$$THD(\%) = \frac{\sqrt{\sum_{i=2}^a x_i^2}}{|x_1|} \tag{2}$$

THD is a very useful quantity and it is used as a harmonic index. On the other hand, it has the restraint that, it is not a fine indicator of voltage stress within a capacitor because that is related to the peak value of voltage waveform.

III. PROPOSED SYSTEM AND SIMULATIONS

3.1 Basic Architecture of Three-Phase - Four Wire Shunt active Filter

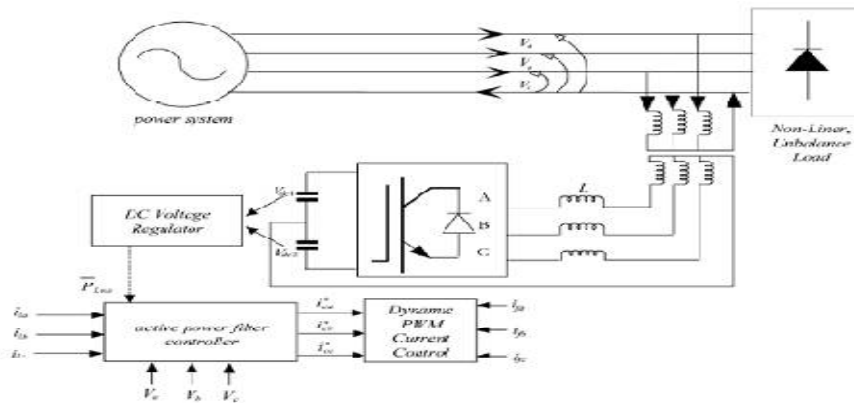


Fig .1 Architecture of 3 phase 4 wire Shunt Active Filter

The design of three phase four wire shunt active power filter is shown in Fig 1. In this method the active filter controllers are converted into dynamic PWM current control signals. The dc voltage regulates these two signals, according to current control PWM signals the voltage can be adjusted and controlled.

3.2 Control Block Diagram of Shunt Active Power Filter

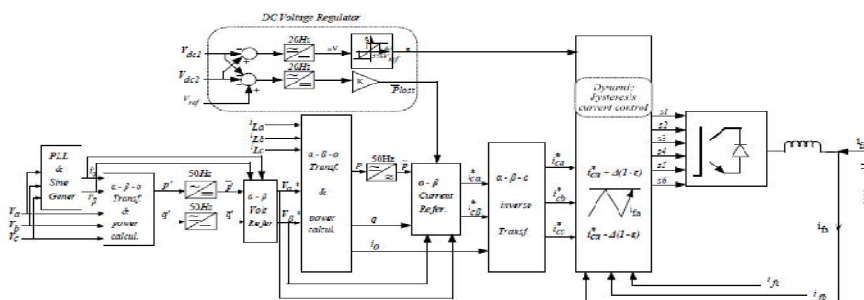


Fig.2 Control Block Diagram of Shunt Active Power Filter

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The block diagram of shunt active power filter is shown in Fig 2 and its control is dynamic voltage controller and it will control the dynamic hysteresis current control system. The phase locked loop (PLL) and sine wave generator is send signal through the voltage and current controlled system. Its signals are using Park's inverse transformation technique the dynamic hysteresis current control is controlled.

3.3 Active Powers Filter Control Circuit

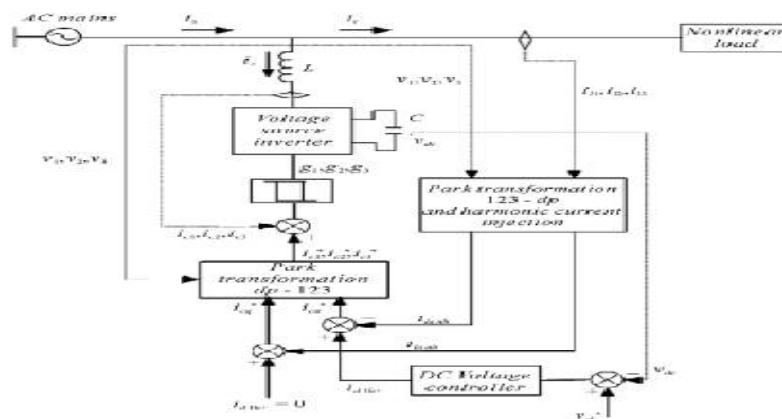


Fig .3 Active Powers Filter Control Circuit

The dc voltage controller is send to the signals in Park's transformation system dp-123. If the Park's transformation 123-dp and harmonic current infection is presented in the current signals, the signals are compared with Park's transformation dp-123 system and these signals are sending with voltage regulator.

The ac main supply is connected with non linear load. The SAPF is connected within parallel to the load. The controls signals are compared when the main ac signal gets disturbed. The SAPF is voltage source inverter and current controller is active with reference signals.

3.4 Park Transformations and Harmonic Current Circuit

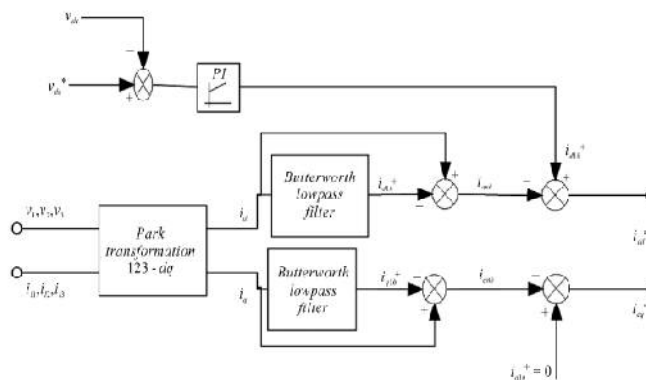


Fig.4 Park Transformations and Harmonic Current Circuit

Fig 4 shows Park's transformations and Harmonic current circuit. In this method voltage and currents are given as input and the output is taken as i_d & i_q . The both current are compared with present system and the signal is send through PWM conversion.

IV. SIMULATION RESULTS

4.1 Control Circuit Diagram

Fig 5 shows that the main control circuit diagrams for the shunt active power filter (SAPF). The circuit is connected with nonlinear load system.

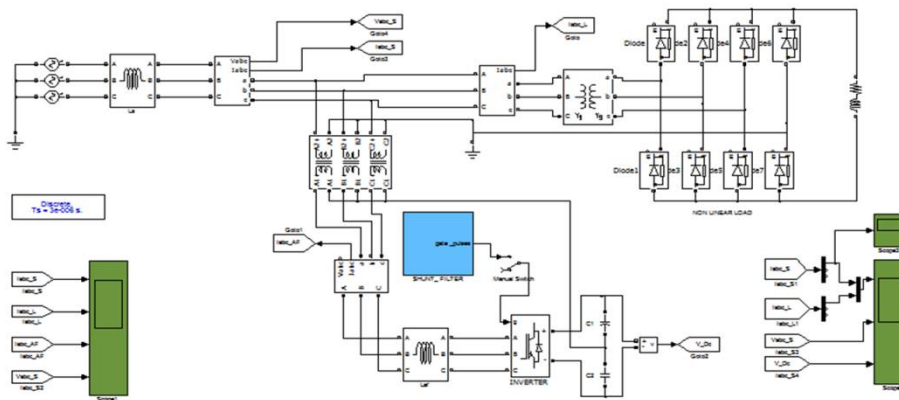


Fig.5 Control Circuit Diagram

4.2 Output Waveform before Switching SAPF

Fig 6 shows the waveform of grid voltage, load current, filter current and supply voltage. SAPF is switched off position; the grid voltage waveform is non sinusoidal waveform. Harmonics are presented in this grid voltage.

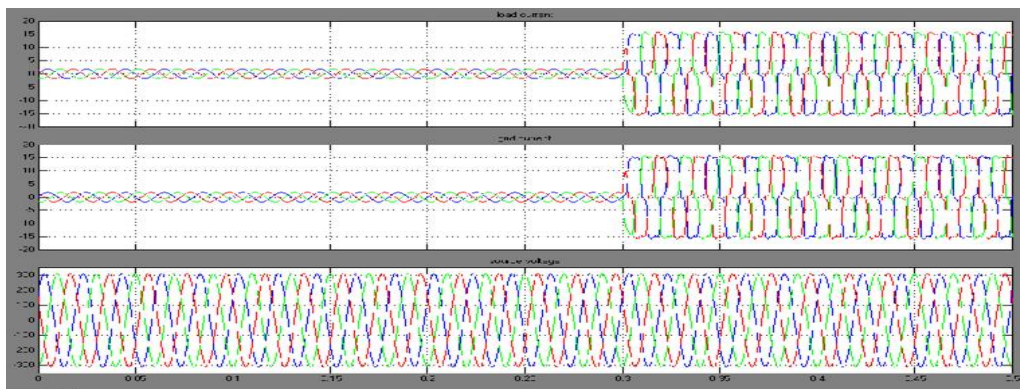


Fig 6 Output Waveform before Switching SAPF

4.3 Output Waveform after Switching SAPF

Fig 7 shows the waveform of grid voltage, load current, filter current and supply voltage. After SAPF is switched on, the grid voltage becomes normal sinusoidal waveform. Before presented harmonics are reduced and removed.

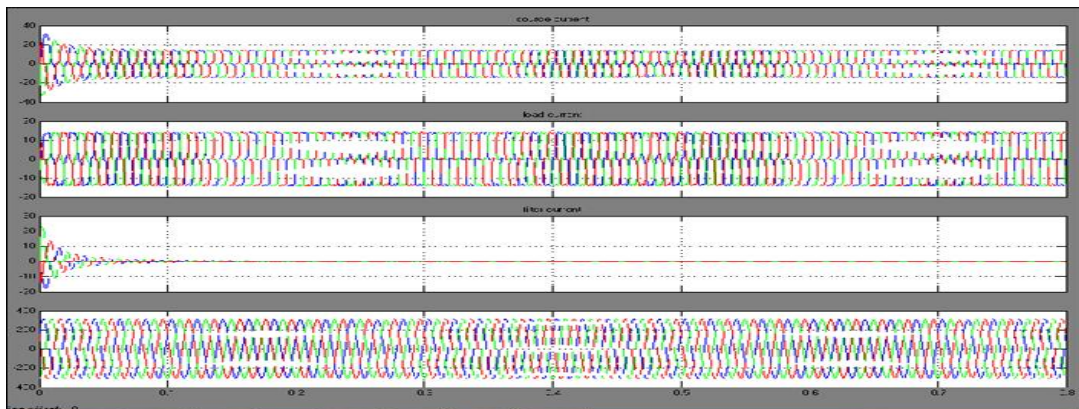


Fig 7 Output Waveform after Switching SAPF

4.4 Output of THD (Before Switching)

In a main control circuit the shunt active power filter (SAPF) is switched off position then the Total Harmonic Distortion (THD %) is verified with graph. Fig 8 shows that THD percentage of present level. THD is 19.98%.

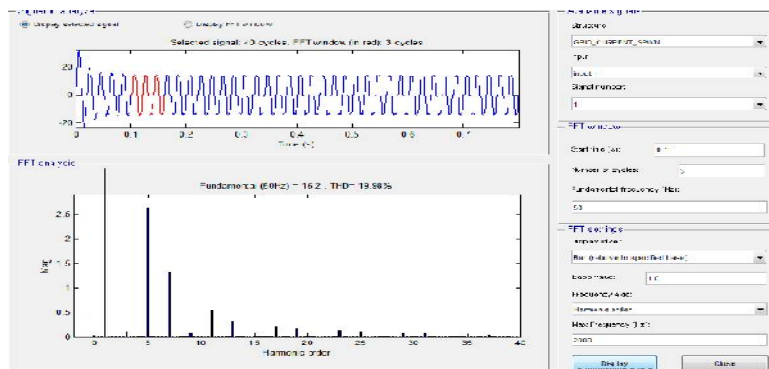


Fig .8 Output of THD (Before Switching)

4.5 Output of THD (After Switching)

In a main control circuit the shunt active power filter (SAPF) is switched on then the Total Harmonic Distortion (THD %) is verified with graph. Fig 9 shows that THD percentage of present level. THD is 2.78%.

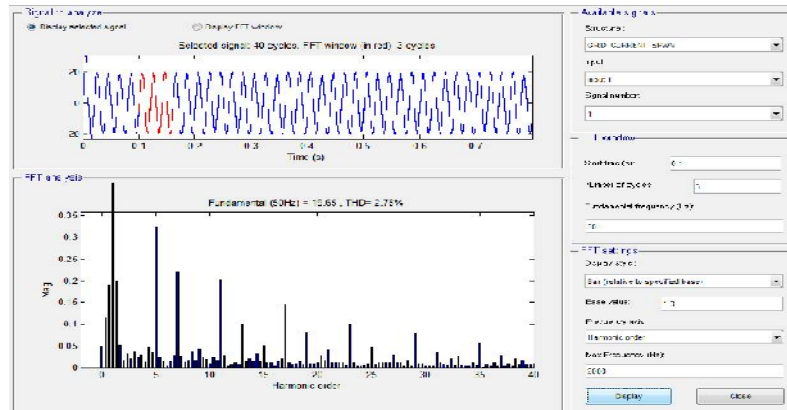


Fig.9 Output of THD (After Switching)

V. CONCLUSION

Thus the mitigation of the current harmonic problem, the shunt Active power filter (SAPF) is proposed in this work. The instantaneous active and reactive current control Strategy is used to find the required reference (INJECT) current to the system. The (id-iq) control strategy is fast & reliable current Reference tracking controller for non linear & unbalanced load Conditioner compared with conventional current controllers. More over the proposed SAPF and the corresponding Control strategy is used to improve the power quality of the System such as (THD, PF).

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