Design, Simulation and Analysis of Shunt Active Filter

Monika Patel[1] Mr.Mihir Parikh[2]
[1]Student [2]Faculty
[1,2]Department of Electrical engineering
[1,2]Kalol institute of technology and research center, Kalol, Gujarat, India

Abstract— Power Quality is a major area of concern for industrial as well as domestic loads. Thus power electronics has proved as a major field in the area of power quality improvement. Active Power Filters are implemented on a wide scale where voltage as well as current compensation is required. The active filtering is that it automatically adapts to changes in the network and load fluctuations. They can compensate for several harmonic orders, and are not affected by major changes in network characteristics, eliminating the risk of resonance between the filter and network impedance. The shunt active filter for reducing the current harmonics, increasing the power factor and voltage profile. Here the current reference required by the voltage source inverter is the use of the instantaneous reactive power theory. By this method we take reference current and voltage and match with actual current and reduced the error by current controller then gives the opposite with same magnitude of current harmonics to the system.

Keywords: *p-q theory, instantaneous power theory, load current.*

I. INTRODUCTION

In an industrial environment, a variety of loads may be encountered. An increasing percentage of these loads introduces harmonic distortion by injecting harmonic current components in the supply system. At present, power electronics based equipment is the main source of the harmonic pollution in the low voltage network, although other loads may also be sources of some distortion. Harmonic pollution causes a number of problems. Some possible problems are the overheating of transformers, cables, power capacitors and electrical motors. This results in a premature ageing of the whole electrical installation. In addition, harmonic pollution may cause fuses to blow unexpectedly and breakers to trip. Other effects include wrong firing pulses being applied to thyristors and control circuits that malfunction.

Shunt active power filters compensate current harmonics by injecting equal but opposite harmonic compensating current. In this case, the shunt active power filter operates as a current source injecting the harmonic components generated by the load but phase shifted by 180. As a result, components of harmonic currents contained in the load current are cancelled by the effect of the active filter, and the source current remains sinusoidal and in phase with the respective phase to neutral voltage. This principle is applicable to any type of load considered as an harmonic source. Moreover, with an appropriate control scheme, the active power filter can also compensate the load power factor. In this way, the power distribution system sees the non-linear load and the active power filter as an ideal resistor.

A. Function:

Eliminate of the current harmonics, reactive power compensation and voltage regulation are the main function of active filters for the improve of power quality.

B. Control strategies of shunt active filter:

(1) Constant instantaneous power control strategy[1]
(2) Sinusoidal current control strategy
(3) Generalized Fryze current control strategy

C. Model:

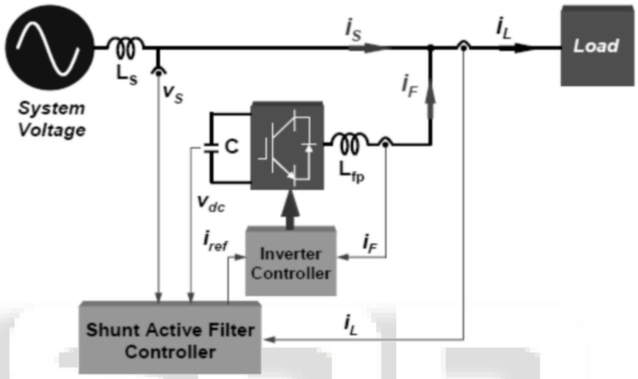


Fig.1: Shunt Active Filter model[2]

II. CONTROL SCHEME

The control scheme of a shunt active power filter must calculate the current reference waveform for each phase of the inverter, maintain the dc voltage constant, and generate the inverter gating signals. The block diagram of the control scheme of a shunt active power filter. The current reference circuit generates the reference currents required to compensate the load current harmonics and reactive power, and also try to maintain constant the dc voltage across the electrolytic capacitors. There are many possibilities to implement this type of control, and two of them will be explained in this chapter. Also, the compensation effectiveness of an active power filter depends on its ability to follow with a minimum error and time delay the reference signal calculated to compensate the distorted load current. Finally, the dc voltage control unit must keep the total dc bus voltage constant and equal to a given reference value. The dc voltage control is achieved by adjusting the small amount of real power absorbed by the inverter. This small amount of real power is adjusted by changing the amplitude of the fundamental component of the reference current.

III. INSTANTANEOUS POWER THEORY[1]

The p-q theory is the based on a set of instantaneous powers defined in the time domain. No restrictions are imposed on the voltage or current waveforms, and it can be applied to three phase systems with or without neutral wire for three phase generic voltage and current waveform. Thus, it is valid not only in the steady state, but also in transient state. As will be seen in this theory is very efficient and flexible in designing controllers for power conditioner based on the power electronic devices.

Other traditional concepts of power are characterized by treating a three phase system as three single phase circuits. The p-q theory first transformer voltage and currents from abc to αβ0 coordinates, and then define instantaneous power on these coordinates. Hence, these theory always consider three phase system as a unit, not a superposition or sum of three single phase circuits.

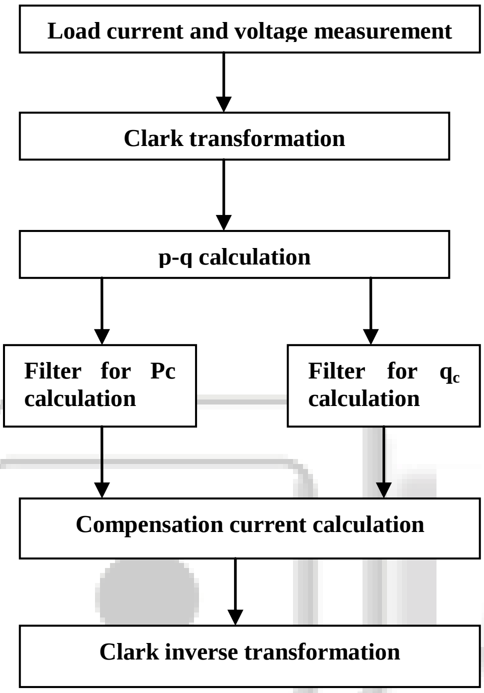


Fig.2: algorithm of control strategies[3]

The FOC consists of controlling the components of the motor stator currents, represented by a vector, in a rotating reference frame *d*,*q* aligned with the rotor flux. The vector control system requires the dynamic model equations of the induction motor and returns the instantaneous currents and voltages in order to calculate and control the variables. The electric torque of an AC induction motor can be described by the interaction between the rotor currents and the flux wave resulting from the stator currents induction. Since the rotor currents cannot be measured with cage motors, this current is replaced by an equivalent quantity described in a rotating system coordinates called *d*,*q* following the rotor flux.

The Clarke transform uses three-phase currents ia, ib and ic to calculate currents in the two-phase orthogonal stator axis: ia and ib. These two currents in the fixed coordinate stator phase are transformed to the isd and isq currents components in the d,q frame with the Park transform. These currents isd, isq and the instantaneous flux angle r , calculated by the motor flux model, are used to calculate the electric torque of an AC induction motor.

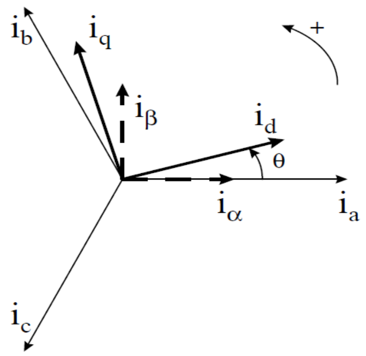


Fig.03: Stator current in the d,q rotating reference frame and its relationship with the a,b and c stationary reference frame.

The instantaneous power theory or p-q theory was introduced by Akagi in 1983. This method uses algebra transformation also know as Clarke transform for three phase voltage and current. The three phase voltage and current are converted into α-β using eq. where iabc are three phase line current and vabc are three phase line voltage.

$$i\alpha\beta 0 = \sqrt{2}/3 \begin{bmatrix} 1 & -1/2 & -1/2 \\ 0 & \sqrt{3}/2 & -\sqrt{3}/2 \\ 1/\sqrt{2} & 1/\sqrt{2} & 1/\sqrt{2} \end{bmatrix} i_{abc}$$

$$V\alpha\beta 0 = \sqrt{2}/3 \begin{bmatrix} 1 & -1/2 & -1/2 \\ 0 & \sqrt{3}/2 & -\sqrt{3}/2 \\ 1/\sqrt{2} & 1/\sqrt{2} & 1/\sqrt{2} \end{bmatrix} V_{abc}$$

$$P = v\alpha i\beta + v\alpha i\beta$$

$$q = v\alpha i\beta - v\beta i\alpha$$

Then according to p-q theory the active power is represented by DC part of α-β reference current, which is rearranged as shown in eq. Therefore three phase actual current reference for active filter.

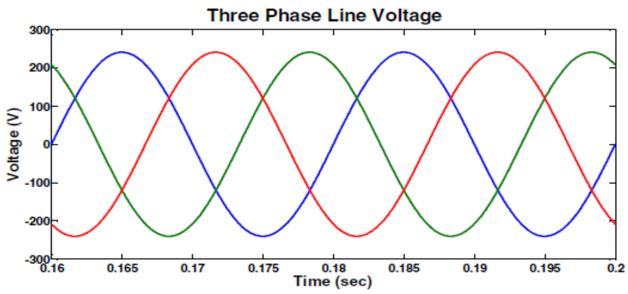


Fig.07: Three phase line voltage[4]

IV. CLARKE TRANSFORMATION CIRCUIT

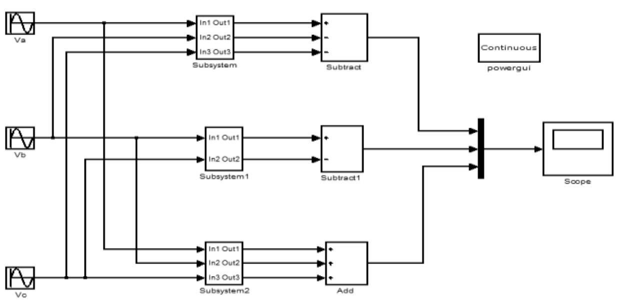


Fig. 09 Clarke transformation V_a,V_b,V_c[5]

A. Wave form of Va,Vb,Vc

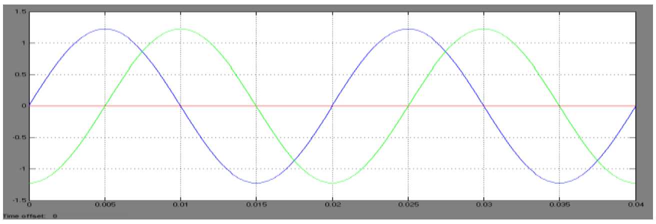


Fig.10: Wave form of alpha,beta

Calculation for P & Q

P= Vα*Iα +Vβ*Iβ

Q=Vβ*Iα – Vα*Iβ

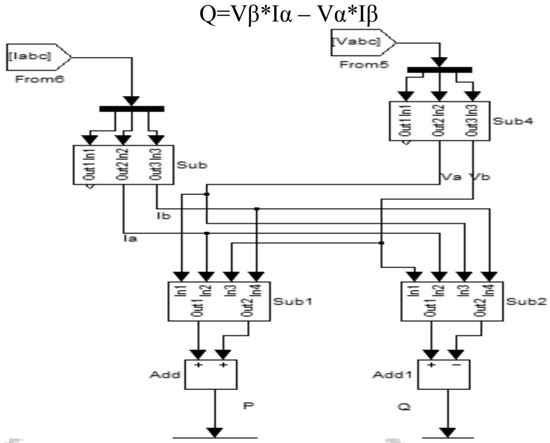
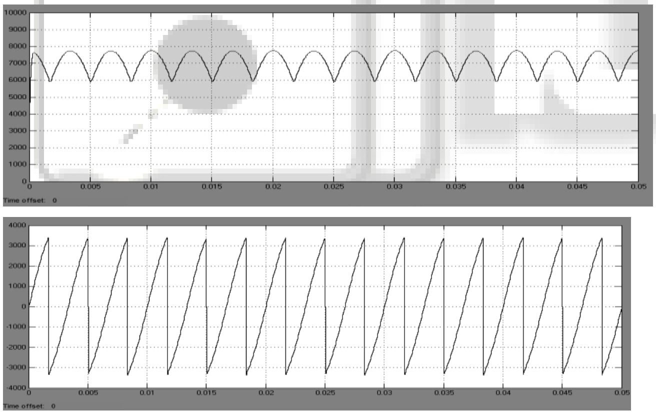


Fig.13:P&Q component

B. Wave form of P & Q



Calculation of Icα* & Icβ* :-

To find $i_{c\alpha}^*$ & $i_{c\beta}^*$

$$\begin{bmatrix} Ic\alpha * \\ Ic\beta * \end{bmatrix} = \frac{1}{V\alpha^2+V\beta^2}\begin{bmatrix} V\alpha & V\beta \\ V\beta & -V\alpha \end{bmatrix}\begin{bmatrix} -\check{P} + \overline{Ploss} \\ -q \end{bmatrix}$$

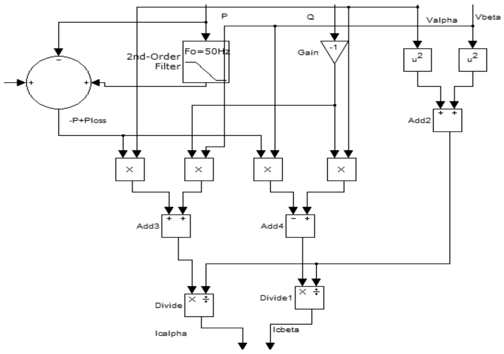
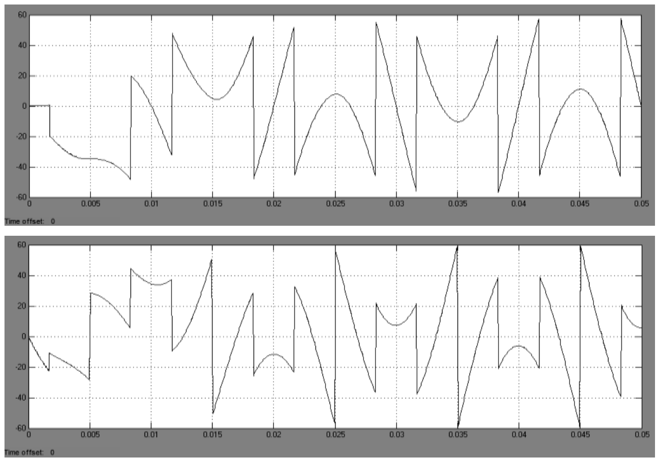


Fig.14 component of $\mathbf{i_{c\alpha}^*}$ & $\mathbf{i_{c\beta}^*}$

C. Wave form of $i_{c\alpha}^*$ & $i_{c\beta}^*$



D. Calculation of Compensating Current

To compare actual current to $i_{c\alpha}^*$ & $i_{c\beta}^*$ and show wave form of compensating current wave.

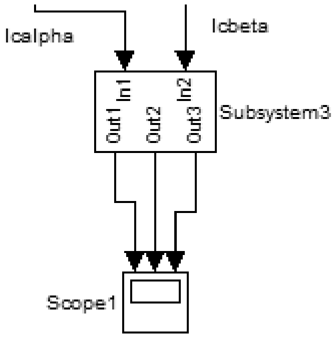
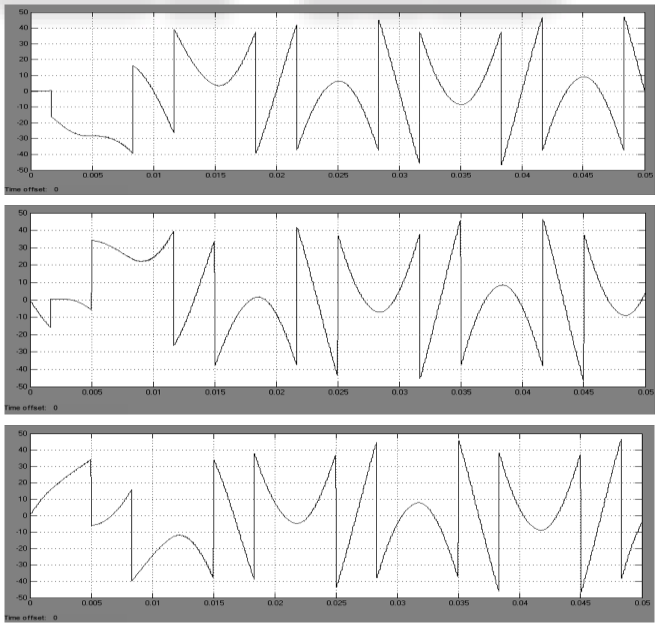


Fig.15 compensating current component

E. Wave form of compensating current i_{ca}^* & i_{cb}^* & i_{cc}^*



V. CONCLUSION

In conclusion we have presented the shunt active filter for reducing the current harmonics, increasing the power factor and voltage profile. Here the current reference required by the voltage source inverter is the use of the instantaneous power theory. By this method we take reference current and voltage and match with actual current and reduced the error by current controller then gives the opposite with same magnitude of current harmonics to the system.

REFERENCES

[1] Hirofumi Akagi " The Instantaneous power." Wiley Interscience. A jhon Inc. Publication 2007 by IEEE. Page No. 41 to 44.

[2] Emílio F. Couto, Júlio S. Martins, João L. Afonso "Simulation Results of a Shunt Active power filter using with control Based on P-Q theory." Department of Industrial Electronic University of Minho.

[3] [1]Rajesh Kr. Ahuja, [2]Aasha Chauhan, [3]Sachin Sharma, "HYSTERESIS CONTROL FOR CURRENT HARMONICS SUPPRESSION USING SHUNT ACTIVE FILTER." [1]Faculty, Electrical & Electronics Engineering Dept. YMCAUS&T, Faridabad, Haryana, [2]Student, Electrical & Electronics Engineering Dept. YMCAUS&T, Faridabad, Haryana, [3]Student, Electrical & Electronics Engineering Dept. YMCAUS&T, Faridabad, Haryana.

[4] Musa Yusup Lada, Ismadi Bugis and Md Hairul Nizam Talib "Simulation a Shunt Active Power Filter using MATLAB/Simulink." The 4thInternational Power Engineering and Optimization Conf. (PEOCO2010), Shah Alam, Selangor, MALAYSIA: 23-24 June 2010.

