CURRENT CONTROLLED VOLTAGE SOURCE INVERTER BASED THREE PHASE SHUNT ACTIVE POWER FILTER

[1]NageswaraRao G., [2] Dr. Chandra Sekhar K [3]Dr. Sangameswararaju P.,

Abstract

In this paper 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. The 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

Keywords: Active power filter, Harmonics

I. 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 $L_2$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. 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.

The method considered the instantaneous power delay caused by the current regulators and DC-link voltage feedback circuit and presented a load power estimation method to improve the dynamic response of input power regulatioSn. In this paper, besides considering the current regulator delay and the DC-link voltage feedback delay, the low pass filter delay is also discussed. In addition, the design of the cutoff frequency for the low pass filter, current regulators and DC-link voltage regulator are also given. The control strategies of the active power filter focus on the controller design for both the line current regulators of the active power filter and the DC-link voltage regulator. **A** simplified analytical model of the active power filter system is proposed. Using the derived analytical model, analyses of DC-link voltage response and current tracking capability for the active power filter will be easier. Applying the proposed control strategy, the current harmonics of a nonlinear load can be compensated quickly and the fluctuations of DC-link voltage during transient and steady states are effectively suppressed. The exclusive features of this paper are summarised as follows:

II. ACTIVE POWER FILTER CONTROL

2.1 Introduction

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.

2.2 Principle of Operation

The proposed three-phase active power filter is shown in Fig. 3.1. 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, the reference frame transformation method will be used.

2.3 Compensating Current Calaulations

Consider Fig 1 where e_a, e_b, e_c and v_{af}, v_{bf}, v_{cf} represent the phase voltages of a power system and the input voltages of a power converter, i_{af}, i_{bf}, i_{cf} and v_{dc2} denote the input currents of the active power filter and the DC-link voltage, respectively. Neglecting the reactors L_S of the input power system, the differential equations of the three-phase active Power filter in Fig.1 can be described as follows.

$$L_2 \frac{d}{dt} i_{af} = e_a - R_2 i_{af} - v_{af} \quad \text{... (1)}$$

$$L_2 \frac{d}{dt} i_{bf} = e_b - R_2 i_{bf} - v_{bf} \quad \text{... (2)}$$

$$L_2 \frac{d}{dt} i_{cf} = e_c - R_2 i_{cf} - v_{cf} \quad \text{... (3)}$$

$$C_2 \frac{d}{dt} v_{dc2} = f_a i_{af} + f_b i_{bf} + f_c i_{cf} \quad \text{... (4)}$$

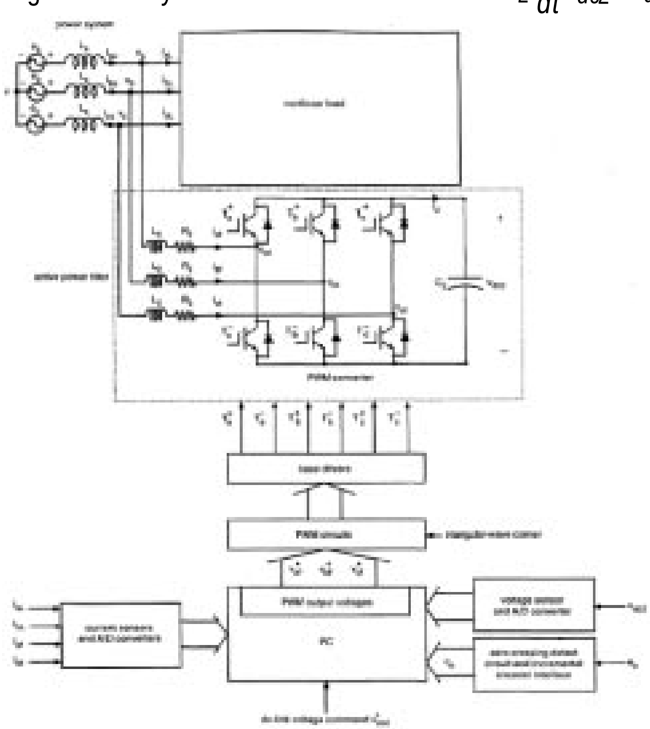


Fig. 1. Configuration of active power filter

Where C_2 is the capacitance of the DC-link capacitor, R_2 and L_2 are the resistance and inductance of the active power filter line reactors, respectively, f_a, f_b, f_c are Switching functions, and the possible values are $0, \pm\frac{1}{3}$ and $\pm\frac{2}{3}$. For model analysis and controller design, the three-phase voltages, currents and switching functions can be transformed to a *d-q-o* rotating frame. This yields,

$$\begin{bmatrix} x_d \\ x_q \\ x_n \end{bmatrix} = \frac{2}{3} \begin{bmatrix} \sin\theta_c & \sin\left(\theta_c - \frac{2\pi}{3}\right) & \sin\left(\theta_c + \frac{2\pi}{3}\right) \\ \cos\theta_c & \cos\left(\theta_c - \frac{2\pi}{3}\right) & \cos\left(\theta_c + \frac{2\pi}{3}\right) \\ \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \end{bmatrix} \begin{bmatrix} x_a \\ x_b \\ x_c \end{bmatrix} \quad \text{... (5)}$$

Where θ_c is the transformation angle of the rotating frame and x denotes currents, voltages or switching functions. From equations (3.1) – (3.5), the state model in the rotating frame Can be written as.

$$L_2 \frac{d}{dt} i_{df} = e_d - R_2 i_{df} + \omega_e L_2 i_{qf} - v_{df} \quad \text{... (6)}$$

$$L_2 \frac{d}{dt} i_{qf} = e_q - R_2 i_{qf} - \omega_e L_2 i_{df} - v_{df} \quad \text{... (7)}$$

$$C_2 \frac{d}{dt} v_{dc}2 = \frac{3}{2} (f_d i_{df} + f_q i_{qf}) \quad \text{... (8)}$$

where

$$v_{df} = f_d \, v_{dc2} \quad \text{... (9)}$$

$$v_{qf} = f_q \, v_{dc2} \quad \text{... (10)}$$

ω_e is the frequency of the power system and the subscripts '*d*' and '*q*' are used to denote the components of the *d*- and *q*-axis in the rotating frame, respectively. Equations. (3.6) – (3.8) will be used to derive the block diagram of the active power fitter and calculate the input voltage commands of power converter.

Let transformation angle θ_e be equal to the angle of phase voltage. Assume that the three-phase voltages are balanced. This yields the voltage components:

$$e_d = V_m \quad \text{... (11)}$$

$$e_q = 0 \quad \text{... (12)}$$

Where V_m is the peak value of the phase voltage of the input power system. Under the above balanced three-phase voltage condition, the instantaneous real power p_L and reactive power q_L on the load side can be expressed as:

$$P_L = \frac{3}{2} V_m \, i_{dL} \quad \text{... (13)}$$

$$q_L = 0 \quad \text{... (14)}$$

Equations. (3.13) and (3.14) are suitable for both balanced and unbalanced loads. When the phase voltages of power system are balanced, p_L and q_L depend only on i_{dL} and i_{qL}, respectively. For a fully harmonic-current compensated active power filter system, the instantaneous real power p_s and reactive power q_s from the power system can be expressed as:

$$p\,s = \frac{3}{2} V_m \, i_1 \quad \text{... (15)}$$

$$q_s = 0 \quad \text{... (16)}$$

Where the fundamental component of the load current i_1 can be obtained from the *d*-axis current i_{dL} by means of a low pass filter. The corresponding reference currents, i^*_{df} and i^*_{qf} of the active power filter in the rotating filter are.

$$i^*_{df} = i_1 - i_{dl} \quad \text{... (17)}$$

$$i_{qf} = -\, i_{ql} \quad \text{... (18)}$$

Equations (3.17) and (3.18) are obtained from the proposed novel calculation method for reference currents of the active power filter by using the load current feedback, reference frame transformation and a digital low pass filter. It is noted that the reference currents can be obtained simply by subtracting the fundamental component from the measured load currents regardless of whether the load is balanced or not.

2.4 Power Converter Control:

To reduce the DC-link capacitor fluctuation voltages and compensate the system loss, a proportional-integral controller $G_{DC}(S)$ is used in the DC-link voltage control loop. As a result, the d-axis reference current of the active power filter has to be modified to:

$$I_{df}^{*} = I_1 - I_{dl} + I_{dc} \quad \text{... (19)}$$

$$I_{dc} = G_{dc}(S)\,(V_{dc2}^{*} - V_{dc2}') \quad \text{... (20)}$$

Where I_{dc} is the current command of the DC-link voltage regulator, V_{dc2}^{*} and V_{dc2}^{*} are the command and feedback of the DC-link voltage, respectively. The variables in capitals represent the Laplace transforms of the corresponding variables in the time domain. The block diagram of d-and q-axis reference currents of an active power filter are shown in Fig. 3.2, where the voltage detection represents the Dclink voltage detecting circuits.

The input voltage commands, V_{df}^{*} and V_{af}^{*} of the power converter can be obtained by using equations. This yields: $nV_{df}^{*} = V_m - R_2 I_{df} + \omega_e L_2 I_{af} - U_{df}$ ... (21)

$$V_{df}^{*} = R_2 I_{qf} - \omega_e L_2 I_{df} - U_{qf} \quad \text{... (22)}$$

Where U_{df} and U_{qf} are the voltage commands of current regulators of an active power filter

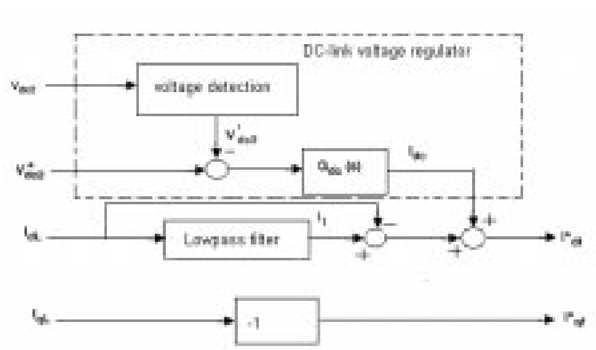


Fig. 2 Block diagram of d- and q-axis reference current of active power filter.

It is seen from equations. (3.21) and (3.22) that the cross coupling terms $\omega_e L_2 I_{df}$, and $\omega_e L_2 I_{qf}$ exist in the d-q current control loops. To decouple the d-q current loops and simplify the control scheme, the voltage de couplers can be designed as follows:

$$U_{df} = G_{df}(S)\,(I_{df}^{*} - I_{df}) \quad \text{... (23)}$$

$$U_{qf} = G_{af}(S)\,(I_{qf}^{*} - I_{qf}) \quad \text{... (24)}$$

Where G_{df} and G_{qf} are the proportional-integral controllers' gain of d- and q-axis current control loops of the active power filter, respectively. The block diagram of the d-q current control loops can be derived from equations. (3.6)-(3.8) and (3.21)-(3.24) as shown in Fig 3.3. Applying the inverse transformation of the rotating frame, the three-phase input voltage commands and of the power converter can be obtained as

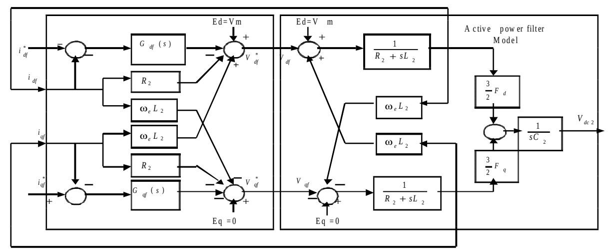


Fig. 3 Control block diagram of $d-$ and $q-$ axis current controllers of active Power filter.

$$\begin{bmatrix} v_{af}^{*} \\ v_{bf}^{*} \\ v_{cf}^{*} \end{bmatrix} = \frac{2}{3} \begin{bmatrix} \sin\theta_e & \cos\theta_e & 1 \\ \sin\left(\theta_e - \frac{2\pi}{3}\right) & \cos\left(\theta_e - \frac{2\pi}{3}\right) & 1 \\ \sin\left(\theta_e + \frac{2\pi}{3}\right) & \cos\left(\theta_e + \frac{2\pi}{3}\right) & 1 \end{bmatrix} \begin{bmatrix} v_{df}^{*} \\ v_{qf}^{*} \\ 0 \end{bmatrix} \quad (25)$$

The output for three-phase input voltage commands V_{af}^{*}, V_{bf}^{*} and V_{cf}^{*} can be_obtained through the input/output (o/p) interfaces of a personal computer. These commands are then compared with a 10khz triangular-wave carrier to produce the switching pattern for the IGBT devices.

III. MODEL ESTABLISHMENT AND STABILITY ANALYSIS:

The analytical model for the active power filter can be established as shown in Fig.4. It consists of a calculation circuit for the reference currents, a DC-link voltage regulator and a simplified model for the relation between reference and real currents of the active power filter. Based on the analytical model, the following design of the proportional-integral controller parameters, K_{Pdc} and K_{Idc} and of the DC-link voltage regulator and analysis of the DC-link voltage response are given. From Fig.4.5, the closed-loop transfer functions can be derived as:

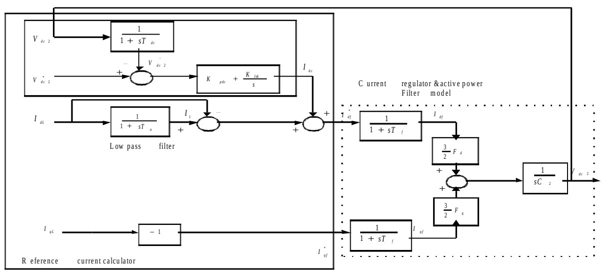


Fig. 4. Analytic model for active power filter

$$\frac{I_{df}(S)}{I_{dL}(S)} = \frac{-2\,(1+sT_{dc})\,C_2T_2s^2}{(1+sT_a)\,\Delta(S)} \quad \text{... (26)}$$

$$\frac{V_{dc2}(S)}{I_{dL}(S)} = \frac{-3\,(1+sT_{dc})\,F_dT_as^2}{(1+sT_a)\,\Delta(S)} \quad \text{... (27)}$$

$$I_{qf}(S) = \frac{-1}{1+sT_f} \quad \text{... (28)}$$

$$\frac{V_{dc2}(S)}{I_{qL}(S)} = \frac{-3\,(1+sI_{dc})\,F_qs}{\Delta(S)} \quad \text{... (29)}$$

Where F_d and F_q are the Laplace transforms of f_d and f_q respectively, while the symbol $\Delta(S)$ is the characteristic polynomial which can be expressed as

$$\Delta(s) = 2C_2T_fT_{dc}{}^{s^4} + 2C_2\,(T_f+T_{dc})\,s^3 +$$

$$2C_2s^2 + 3\,F_{d\,Pdc}{}^{s} + 3F_dK_{Idc} \quad \text{... (30)}$$

The DC-link voltage variation is imposed basically by i_{df} because the switching function in the d-axis component is much greater than that of the q-axis, i.e. $f_d >> fsubq$ in addition, since the voltage drop across the inductors L_2 of an active power filter is small as compared to the phase voltage magnitude V_m the inductor voltage of L_2 can be neglected. This yields $e_d = V_{df}$ and from equations. (3.9) and (3.11) F_d is obtained a

$$F_d = \frac{V_m}{V_{dc2}} \quad \text{... (31)}$$

Substitution of equation. (4.13) in to equations. (4.8), (4.9) and (4.12), the closed-loop transfer functions and the characteristic polynomial can be written, respectively, as

$$\frac{I_{df}(S)}{I_{dL}(S)} = \frac{-2\,(1+sT_{dc})\,C_2\,V_{dc2}T_aS^3}{(1+sT_a)\,\Delta(S)} \quad \text{... (32)}$$

$$\frac{V_{dc2}(S)}{I_{dl}(S)} = \frac{-3\,(1+sT_{dc})\,V_mT_aS^2}{(1+sT_a)\,\Delta(S)} \quad \text{... (33)}$$

$$\Delta(S) = 2\,C_2V_{dc2}T_fT_{dc}s^4 + 2C_2\,V_{dc2}\,(T_f+T_{dc})\,s^3$$

$$+\,2C_2V_{dc2}s^2 + 3C_m\,K_{pdc}s + 32C_2V_mK_{Idc} \quad \text{... (34)}$$

Assume that the steady-state value of the DC-link voltage is equal to the DC-link voltage command, $V_{dc2} = V_{dc2}{'}$. By using Routh-Hurwitz criterion, it is easy to find that the DC-link voltage regulator parameters, an K_{Idc} must satisfy the following relations for stable operation.

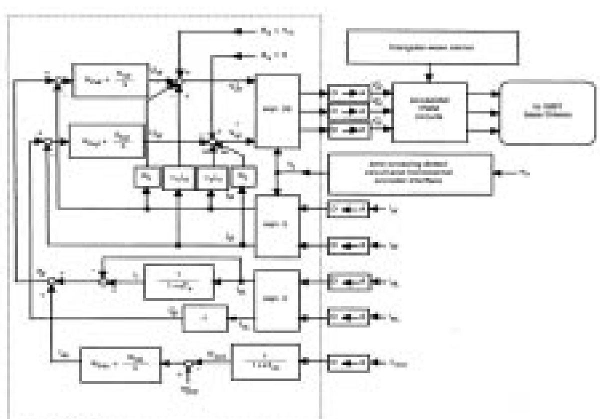


Fig. 5. Total control block of proposed system

$$K_{Pdc} < \frac{2C_2 V_{dc2}\,(T_g + T_{dc})}{3\,V_m\,(T_f\,T_{dc})} \qquad \text{... (35)}$$

$$0 < K_{Idc} < \left[\frac{2C_2 V_{dc2}\,(T_f + T_{dc}) - 3V_m K_{Pdc}\,(T_f\,T_{dc})}{2C_2 V_{dc2}\,(T_f + T_{dc})^2}\right] K_{Pdc} \qquad \text{... (36)}$$

Satisfaction of equations (35) and (36) will be assured during the determination of K_{Pdc} and K_{Idc} for the active power filter. Parameters of non linear load: $L_1 = 3$ mH $R = 0.03\,\Omega$ $R_1 = 8.67\,\Omega$ $C_0 = 3300$ Mf

IV. DESIGN OF LOW PASS FILTER FOR REFERENCE CURRENT CALUCLATION:

The block diagram of a low pass filter for reference current calculation is shown in Fig. 5. When ω_a is small, the current harmonics on the source side and the DC-link fluctuation voltages will decrease, while the settling time of the DC-link voltage and the compensation time of current harmonics will increase. Therefore, the design of the cutoff frequency ω_a will strikingly affect the active power filter compensation characteristics. For the sake of explanation in this paper, the three-phase nonlinear load is regarded as a balanced load, while when one phase of the three-phase nonlinear load is disconnected; it is defined as an unbalanced load. A general representation .for balanced and unbalanced load currents that include harmonic components can be expressed as follows: For balanced load.

$$i_{aL} = i_1 \sin(\theta_e - \varphi_1) + \sum_{n=2}^{\infty} i_n \sin(n\,\theta_e - \varphi_n) \qquad \text{... (37)}$$

$$i_{bL} = i_1 \sin\left(\theta_e - \frac{2\pi}{3} - \varphi_1\right) + \sum_{n=2}^{\infty} i_n \sin\left[n\left(\theta_e - \frac{2\pi}{3}\right) - \varphi_n\right] \qquad \text{... (38)}$$

$$i_{cL} = i_1 \sin\left(\theta_e + \frac{2\pi}{3} - \varphi_1\right) + \sum_{n=2}^{\infty} i_n \sin\left[n\left(\theta_e + \frac{2\pi}{3}\right) - \varphi_n\right] \qquad \text{... (39)}$$

For an unbalanced load assume that non linear load of phase b is open i.e. $i_{bl} = 0$ and $i_{cL} = -i_{aL}$. ... (40)

$$\{i_{aL}' = i_1' \sin\left(\theta_e - \theta_1'\right) + \sum_{n=2}^{\infty} i_1' \sin(n\,\theta_e - \varphi_n') \qquad \text{... (41)}$$

$$i_{bL}' = 0 \qquad \text{... (42)}$$

$$i_{cL} = -i_{aL} = -i_1' \sin(\theta_e - \theta_1') - \sum_{n=2}^{\infty} i_n' \sin[n\,\theta_e - \varphi_n'] \qquad \text{... (43)}$$

Where i_n and i_n' represent the peak values of the n^{th} current harmonic for balanced and un balanced loads, ϕ_n and ϕ_n denote the power factor angle of the n^{th} harmonic component for balanced and unbalanced loads respectively.

V. DESIGN OF CURRENT REGULATORS

As mentioned earlier, the choice of cutoff frequency ω_f in the simplified analytical model will influence the line current tracking capability of the active power filter. To obtain a fast response and low overshoot for the current of an active power filter, a higher value of ω_f must be chosen. Unfortunately, the maximum value is limited by the maximum IGBT device switching frequency. In the proposed system, the IGBT's operating frequency is 1OkHz. Therefore, the cutoff frequency ω_f is designed to be $\frac{\omega_p}{5}$ (or) 12500 rad/sesc. The delay time constant T_f is equal to 0.08 ms.this yields, from equation (4.4) the proportional-integral controller parameters of current regulators, $K_{Pdf} = K_{Pqf} = 62.5$ and $K_{Idf} = K_{Idf} = 375$.

VI. DESIGN OF DC-LINK VOLTAGE REGULATOR:

For the sake of simplicity in the design of a DC-link voltage regulator, the cutoff frequency ω_{dc} of a low -pass filter in the voltage detection block of Fig. (4.4) is equal ω_a to this gives

$$\omega_{dc} = \omega_a = 100 \text{ rad/S} \qquad \text{... (44)}$$

Thus, the delay time constant T_{dc} is equal to 10 ms and equation (40) can be written as.

$$\frac{V_{dc2}(S)}{I_{dL}(S)} = \frac{-3V_m T_a S^2}{\Delta(S)} \quad \text{... (45)}$$

For design convenience of controller parameters, reduced-order operation is exercised for equation(4.7) to obtain the following standard second-order transfer function.

$$\frac{V_{dc2}(S)}{I_{dL}(S)} = \frac{-3\,V_m\,T_a s \quad \text{... (46)}}{2C_2\,V_{dc2}\,(T_f + T_{dc})\,(s^2 + 2\,\zeta\,\omega_n\,\theta + \omega_n^2)}$$

$$\omega_n = \sqrt{\frac{3\,V_m\,K_{Pdc}}{2C_2\,V_{dc2}\,(T_f + T_{dc})}} \quad \text{... (47)}$$

$$\zeta = \sqrt{\frac{C_2\,V_{dc2}}{6\,V_m\,V_{dc2}\,(T_f + T_{dc})}} \text{@RIGHT = ... (48)}$$

To obtain low overshoot for the DC-link voltage, the damping coefficient $= 0.707$ is chosen..TheFet Analysis For Souece Currents Without Apfc:

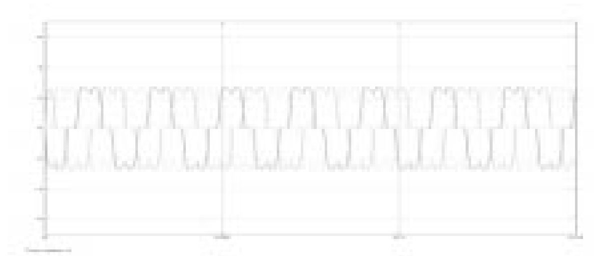
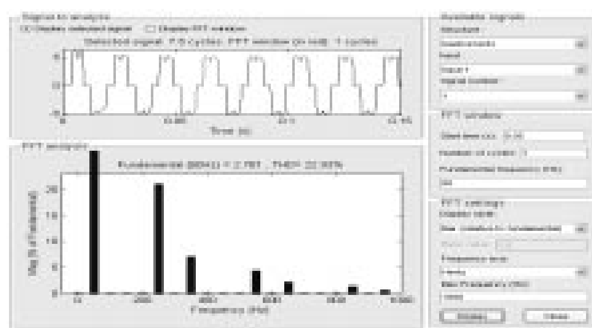
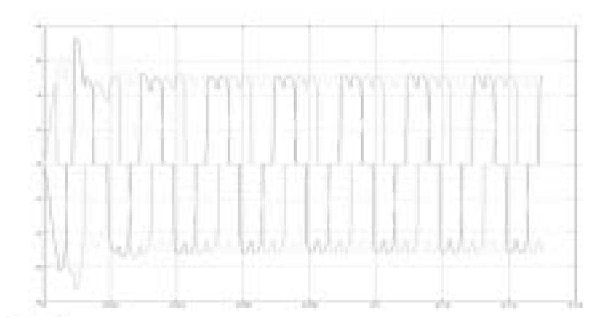
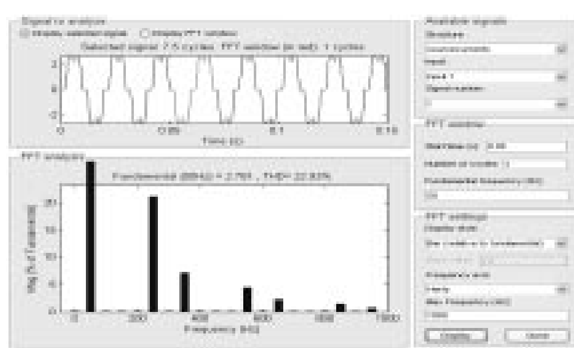


Fig. Waveform For Load Current Without Apfc:

Fig. Fet Analysis For Load Currents Without Apfc:







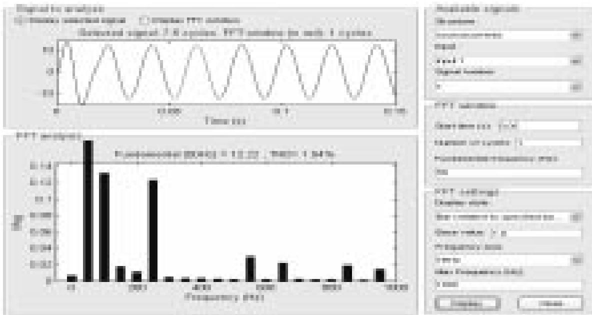


Fig. Thd Calculation For Source Current

Fig. Waveform For Source Current With Apfc

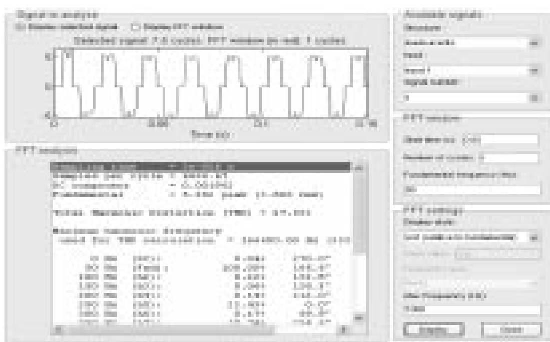


Fig. Thd Calculation For Load Current

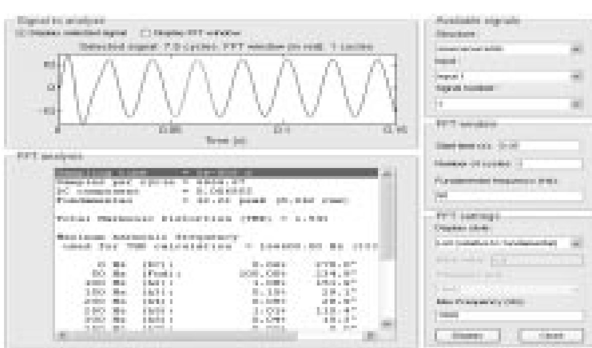


Fig. Thd Calculation For Source Current

Total Harmonic Distortion (THD)

The Total Harmonic Distortion (THD) in the source current of the proposed three phase system of non linear balanced and unbalanced load with and with out active power filter controller. Similarly from section 5.1 the Harmonic order and Total Harmonic Distortion (THD) in the source current of three phase system connected to unbalanced nonlinear load (Diode bridge rectifier)with ActivePower Filter Controller. Then the corresponding Harmonic order as follows

Thd	Without Apfc	With Apfc
INITIAL	22.93	22.93
FINAL	22.93	1.54

VIII RESULTS

Results for following foure cases of three-phase power system connected to non-linear load. For the design of active power filter controller, the proposed tree phase system parameter uses as follows

Peak value of the phase voltage $(V_m) = 98\ V.$, Frequency of the power system $(\omega_e) = 377$ rad/sec., DC-link voltage $(V_{dc2}) = 240$ V., Resistance and inductance of the line $(R_1, L_1) = 3.1$ mH, $0.03\ \Omega$

Resistance and capacitor of the nonlinear load$(R_0, C_0) = 8.67\ \Omega$, $3300\ \mu F$ DC-link capacitor $(C_2) = 4700\ \mu F$

Resistance and inductance of the active power filter $(R_2, L_2) = 0.03\ \Omega, 5m.$, DC-link voltage $(V_{dc2}) = 240$

IX. 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.

X. FUTURE WORK

The hardware implementation of active power filter can be done with DSP controller

REFERENCES

[1] A novel and analytical model for design and implementation of active power filter' IEE proc –electr., power appl.,vol.148,no.4,july 2001

[2] Nassar Mendalek and Kamal Al-Haddad Modeling and Nonlinear Control of Shunt Active Power Filter in the Synchronous Reference Frame. 2000 IEEE.

[3] FUJITA, H., and AKAGI, H.: 'A practical approach to harmonic compensation in power system-series connection of passive and series active filters', IEEE Trans. Ind. Appl., 1991, 27, (6), pp. 1020-1025.

[4] MORAN, L.A., DIXON, J.W., and WALLACE, R.R.: 'A three phase active power filter operating with fixed switching frequency for reactive power and current harmonic compensation', IEEE Truns Ind Electron., 1995, 42, (4), pp. 40240

G.N.Rao was born in Guntur, India, in 1975. He received the AMIE (electrical) degree from the Institute of Engineers (India) and the M.Tech degree from Nagarguna University, Nambur,AP,India., and currently pursuing his Ph.d from J.N.T.University Kakinada .Working as Sr. Asst .Prof & H.O.D ,electrical and electronics engineering in VIJAYA INSTITUTE OF TECHNOLOGY FOR WOMEN ,Vijayawada. His areas of interest are in power systems, electrical machines, electromagnetic fields. Mr.Rao is a Life Member of the Indian Society for Technical Education (ISTE) and Associate Member of the Institution of Engineers (India)[IE(I)]. Mail: gnrgudipudi@gmail.com

Dr. K.Chandra Sekhar received his B.Tech degree in Electrical & Electronics Engineering from V.R.Siddartha Engineering College, Vijayawada, India in 1991 and M.Tech with Electrical Machines & Industrial Drives from Regional Engineering College, Warangal, India in 1994, He Received the Ph.D , degree from J.N.T.U College of Engineering, Hyderabad-500072,India. From 1994 to 1995, he was the Design & Testing Engineer in Maitreya Electricals(P) Ltd, Vijayawada. From 1995 to 2000,he worked with Koneru Lakshmaiah College of Engineering as a Lecturer ,since 2000,he has been with R.V.R & J.C.College of Engineering as Prof & H.O.D ,electrical and electronics engineering. Mail: cskoritala@hotmail.com

Dr. P.Sangameswararaju did his Ph.D from S.V.University. Presently he is working as Associate Professor in the Department of Electrical Engineering ,S.V.University, Tirupathi, Andhra Predesh. He has about 20 publications in National and International Journals and Conferences to his credit. His areas of interest are in Distribution systems and power systems. Mail : Raju_ps_2000@