ISSN: 2454-7875
VOLUME 2, ISSUE 6, June -2016

DEVELOPMENT OF 3 PHASE 3 WIRE SHUNT ACTIVE POWER FILTER FOR HARMONIC REDUCTION

B. R. Babar, S.G. Kanade
Department of Electrical Engineering
TSSMs, Bhivarabai Sawant College of Engineering, & Research
Narhe, Pune.411043 India

ABSTRACT:

This paper shows the method of improving the power quality as well as power factor using shunt active power filter in the power system, which is caused by nonlinear loads. The Shunt Active Power Filter (SAPF) injects a suitable compensating current at a point of common coupling (PCC) so that the harmonics present in the line are cancelled out and the sinusoidal nature of voltage and current waveforms are restored. The proposed method consist of Bang Bang current control for reference current generation and Hysteresis band current control (HBCC) technique for the generation of firing pulses to the inverter. This system is simulated using MATLAB/Simulink and the results are presented.

INDEX TERMS: active power filter, Bang -Bang current Controller, Hysteresis current controller, harmonic mitigation, reactive power compensation

I. INTRODUCTION:

Shunt technology has brought drastic increase in the use of power electronic equipments which results in the increase of harmonics in source current. Large use of power converters, various non linear loads and increasing use of office equipment like computers, printers, faxes and laptops are reasons for the increasing harmonics which results in degradation of source current and source voltage. Harmonics causes very serious damage in powers system. Causes like, low power factor, overheating of neutral wire, damaging microprocessor based equipment, resonance etc. Traditionally, L-C passive filters were used to solve the problem of harmonics to filter out current harmonics to get sinusoidal supply current. Passive filters are classified as single tune filter and high pass filter. Passive filters have following disadvantages a) Resonance with the source impedance, b) Fixed compensation, and large configuration size.

To overcome the problems of passive filters, active filters were developed and used to solve the problem of harmonics [1]. This technology of the active filter has improved a lot thereby giving very good results to reduce the problem of harmonics. The power semiconductor devices improved the active filters a lot. Active filters solve the problem of harmonic in industrial area as well as utility Power distribution. The active power filter working performance is based on the techniques used for the generation of reference current. With the development various technologies results the lowering of harmonics below 5% as specifies by IEEE. In this paper Bang Bang Reference current generation method has been used [2]. We have many current control technologies for active power filter, but the Hysteresis current controller is proved to be very efficient in terms of fast current controllability and it also very easy to apply when compared to other method like sinusoidal PWM. We can detect harmonics in two ways or two main forms first in time domain and second in the frequency domain the paper deals with Fast Fourier Transform (FFT) to find harmonics in frequency domain. Other frequency domain techniques are discrete Fourier transform (DFT); recursive discrete Fourier transform (RDFT). Our main target is to reduce THD of supply current with the help of hysteresis band current controller. There are two type of hysteresis Current controller namely, adaptive hysteresis current controller and fixed band current controller. This paper deals with the use of fixed band hysteresis current controller [2]. The model of shunt active power filter using hysteresis current controller has been used in mat lab/Simulink. Results have been successfully retrieved from model and followed by conclusion.

ISSN: 2454-7875
VOLUME 2, ISSUE 6, June -2016

The proposed Shunt Active Power control scheme is used for power quality improvement and it has following objectives [7-8-9].

- Unity power factor at the source side.
- To mitigate the harmonics.
- To discuss effect of harmonics arising due to nonlinear load
- To simulate 3 Phase 3 Wire Shunt APF in MATLAB/SIMULINK
- Design Bang Bang Reference current Generation and to achieve fast dynamic response
- Design of hysteresis current controller
- Experimental validation of simulation work

This paper is organized as fallows. The Section II introduces the power quality issues and its consequences. The Section III describes the working of shunt Active Power Filter. The Sections IV, V, VI describes the control scheme, system performance, Results and conclusion.

II. POWER QUALITY ISSUES AND ITS CONSEQUENCES:

A. Voltage Variation:

The voltage variation is directly related to real and reactive power variations.

The voltage variation is commonly classified as under:

- Voltage Sag/Voltage Dips.
- Voltage Swells.
- Short Interruptions.
- Long duration voltage variation.

The voltage flicker issue describes dynamic variations in the network caused by varying loads [3]. The amplitude of voltage fluctuation depends on grid strength, network impedance, and phase-angle and power factor.

B. Harmonics:

The harmonic results due to the operation of power electronic converters. The harmonic voltage and current should be limited to the acceptable level at the point of common coupling. To ensure the harmonic voltage within limit, each source of harmonic current can allow only a limited contribution. The rapid switching gives a large reduction in lower order harmonic current compared to the line commutated converter, but the output current will have high frequency current and can be easily filter-out.

C. Consequences of the Issues:

The voltage variation, flicker, harmonics causes the malfunction of equipments namely microprocessor based control system, programmable logic controller; adjustable speed drives, flickering of light and screen. It may leads to tripping of contractors, tripping of protection devices, stoppage of sensitive equipments like personal computer, programmable logic control system and may stop the process and even can damage of sensitive equipments. Thus it degrades the power quality in the grid.

III. WORKING OF SHUNT APF:

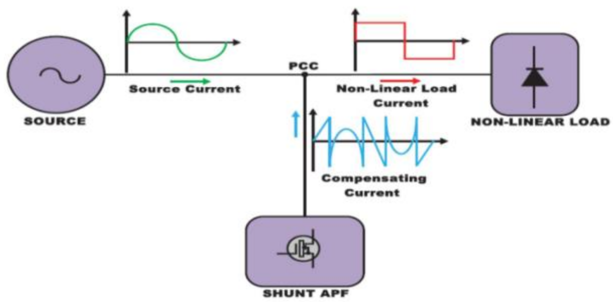

Fig. 1: Basic Scheme of shunt active filter

To overcome these disadvantages, active power filters are introduced which compensate for the current harmonics and reduces the total harmonic distortion. The SAPF is connected in parallel with the line through a coupling inductor. Its main power circuit consists of a three phase three-leg current controlled voltage source inverter with a DC link capacitor. An active power filter operates by generating a compensating current with 180 degree phase opposition and injects it back to the line so as to cancel out the current harmonics introduced by the nonlinear load. This will thus suppress the harmonic content present in the line and make the current waveform sinusoidal. So the process comprises of detecting the harmonic component present in the line current, generating the reference current, producing the switching pulses for the power circuit, generating a compensating current and injecting it back to the line as shown in fig.1

IV. CONTROL SCHEME:

The control scheme approach is based on injecting the currents into the grid using "bang-bang controller." The controller uses a hysteresis current controlled technique. Using such technique, the controller keeps the control system variable between boundaries of hysteresis area and gives correct switching signals for Shunt APF operation. The control system scheme for generating the switching signals to the Shunt APF is shown in Fig. 2. The control algorithm needs the measurements of several variables such as three-phase source current i_{sabc}, DC voltage V_{dc}, inverter current i_{iabc} with the help of sensor. The current control block, receives an input of reference current i^*_{sabc} and actual current i_{sabc} are subtracted so as to activate the operation of Shunt APF in current control mode [2].

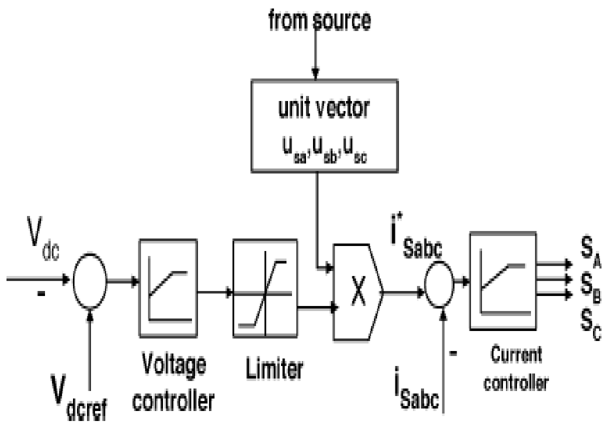

Fig. 2: Control system scheme.

A. Grid Synchronization:

In three-phase balance system, the RMS voltage source amplitude is calculated at the sampling frequency from the source phase voltage (V_{Sa}, V_{Sb}, V_{Sc}) and is expressed, as sample template V_{sm}, sampled peak voltage, as in (1).

$$V_{sm} = \left\{\frac{2}{3}\left(V_{sa}^2 + V_{sb}^2 + V_{sc}^2\right)\right\}^{1/2} \quad (1)$$

The in-phase unit vectors are obtained from AC source phase voltage and the RMS value of unit vector u_{sa}, u_{sb}, u_{sc} as shown in equation (2)

$$u_{sa} = \frac{V_{sa}}{V_{sm}}, u_{sb} = \frac{V_{sb}}{V_{sm}}, u_{sc} = \frac{V_{sc}}{V_{sm}} \quad (2)$$

The in-phase generated reference currents are derived using in-phase unit voltage template as, in (3)

$$i^*_{sa} = I.u_{sa}, \; i^*_{sb} = I.u_{sb}, \; i^*_{sc} = I.u_{sc} \quad (3)$$

Where I is proportional to magnitude of filtered source voltage for respective phases. This ensures that the source current is controlled to be sinusoidal. The unit vectors implement the important function in the grid connection for the synchronization for Shunt APF. This method is simple, robust and favourable as compared with other methods [4].

B. Bang-Bang Current Controller

Bang-Bang current controller is implemented in the current control scheme. The reference current is generated as in (3) and actual current are detected by current sensors and are subtracted for obtaining a current error for a hysteresis based bang-bang controller. Thus the ON/OFF switching signals for MOSFET of Shunt APF are derived from hysteresis controller.

The switching function S_A for phase 'a' is expressed as (4).

$$i_{sa} < (i^*_{sa} - HB) \rightarrow S_a = 0$$

$$i_{sa} > (i^*_{sa} - HB) \rightarrow S_a = 1 \quad (4)$$

Where HB is a hysteresis current-band, similarly the switching function S_B, S_C, can be derived for phases "b" & "c".

V. SYSTEM PERFORMANCE AND RESULTS:

The proposed control scheme is simulated using SIMULINK in power system block set.

A. Voltage Source Current Control—Inverter Operation:

The three phase injected current into the grid from Shunt APF will cancel out the distortion caused by the nonlinear load. The MOSFET based three-phase inverter is connected to grid through the transformer. The generation of switching signals from reference current is simulated within hysteresis band. The choice of narrow hysteresis band switching in the system improves the current quality [5]-[6]-[7]. The choice of the current band depends on the operating voltage and the interfacing transformer impedance. The compensated current for the nonlinear load and demanded reactive power is provided by the inverter. The real power transfer from the batteries is also supported by the controller of this inverter.

It is observed that the source current on the grid is affected due to the effects of nonlinear load, thus purity of waveform may be lost on both sides in the system. The inverter output voltage under Shunt APF operation with load variation is shown in fig. 3. The dynamic load does affect the inverter output voltage. The source current with and without APF operation is shown in Fig. 3 and 4. This shows that the unity power factor is maintained for the source power when the APF is in operation. The current waveform before and after the APF operation was analysed

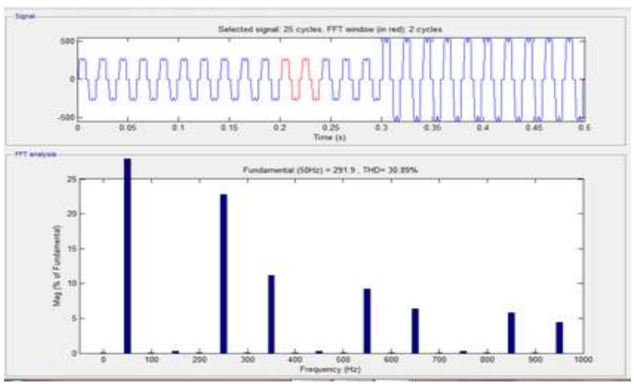

Fig. 3. THD spectrum without filter

NOVATEUR PUBLICATIONS
International Journal Of Research Publications In Engineering And Technology [IJRPET]
ISSN: 2454-7875
VOLUME 2, ISSUE 6, June -2016

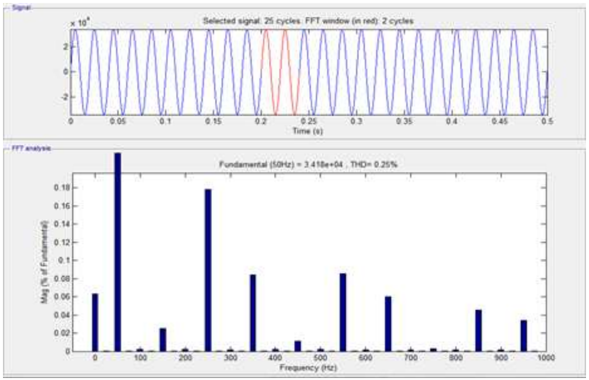

Fig. 4. THD spectrum with filter

The Fourier analysis of this waveform is expressed and the THD of this system at PCC without APF is 30.89%, as shown in Fig. 3. The power quality improvement is observed at point of common coupling, when APF is placed in the operation at 0.3 sec and source current waveform is shown in Fig. 4 with its FFT. It is shown that the THD has been improved considerably up to 0.25%. The above test with proposed scheme has not only improved power quality but it also has sustained capability to support the load with the energy storage through the batteries.

VI. CONCLUSION:

This paper presents the APF-based control scheme for power quality improvement in grid connected system and with non linear load. The operation of the control system developed for the Shunt APF in MATLAB/SIMULINK for maintaining the power quality is simulated. It has a capability to cancel out the harmonic parts of the load current. It maintains the source voltage and current in-phase and support the reactive power demand for the load at PCC in the grid system, thus it gives an opportunity to enhance the utilization factor of transmission line. The Shunt APF have shown the outstanding performance. Thus the proposed scheme in the grid connected system fulfils the power quality conditions.

REFERENCES:

[1] Pablo Acuna, Luis Moran,s *"Improved Active Power Filter Performance for Renewable Power Generation Systems,"* IEEE Trans. Power electronics, vol. 29, NO. 2, Feburary 2014

[2] Sharad W. Mohod, Mohan V. Aware. *"A STATCOM-Control Scheme for Grid Connected Wind Energy System for Power Quality Improvement,"* IEEE System journal, vol. 4, NO. 3, September 2010.

[3] Zainal Salam, Tan Perng Cheng and Awang Jusoh, *" Harmonics Mitigation Using Active Power Filter"* Vol. 8, No. 2, 2006.

[4] B. Singh, K. Al-Haddad, and A. Chandra, *"A review of active filters for power quality improvement,"* IEEE Trans. on Industrial Electronics, Vol. 59, No. 3, March 2012

[5] Yi Tang, Poh Chiang Loh, *"Generalized Design of High Performance Shunt Active Power Filter With Output LCL Filter,"* IEEE Trans. Power Electron., vol. 22, no. 1, pp. 229–236, Jan. 2007.

[6] Q.-N. Trinh and H.-H. Lee, *"An advanced current control strategy for three-phase shunt active power filters,"* IEEE Trans. Ind. Electron., vol. 60, no. 12, pp. 5400–5410, Dec. 2013.

[7] "Jinn-chang wu Member, Hsin-Hsing Hsaio, and Shun-Tain *"New Hybrid Power Conditioner for Suppressing Harmonics and Neutral-Line Current In Three-Phase Four-Wire Distribution Power System"*, IEEE transactions on power delivery, vol. 29, no. 4, AUGUST 2014

[9] Yi Tang, Poh chaing loh, & peng wang *"Generalised Design of High Performance Shunt Active Power Filter With Output LCL Filter,"* IEEE Trans. Ind. Electron., vol. 59, no. 3,pp. 1443-1452, march. 2012.