Reduction of THD in Single Phase PAF with PSD Method for Reference Current Generation

A. Jeraldine Viji, M. Sudhakaran

Abstract:- In this paper Single phase parallel active filter (PAF) with a control algorithm of power synchronous detection method for reference current generation is proposed .The current waveform injected by the active filter is able to compensate the reactive power and the load current harmonics and to balance asymmetrical loads. The active filter designed in PSIM software and control of active filter is done in Simulink environment. PSIM and MATLAB software is linked by Sim coupler.The capacitor voltage is maintained constant by using PI controller. Simulation results with PSIM software show that the designed active filter is very effective in improvement of quality of power.

Keywords:- Active filter, Hysteresis Band controller, Power Synchronous detection (PSD), current harmonics, Pulse Width Modulation, PSIM software

I. INTRODUCTION

The increase of nonlinear loads due to the use of power electronic equipment causes power quality problem in the power system . Harmonic current which are drawn from a supply by the nonlinear load results in the distortion of the supply voltage, current waveform at the point of common coupling (PCC) due to the source impedance. Both distorted current and voltage may cause end-user equipment especially sensitive equipment to malfunction, Conductors to overheat and may reduce the efficiency and life expectancy of the equipment connected at the PCC. Usually a passive power filter is used to eliminate current harmonics when it is connected in parallel with the load.[1]. But the usage of this passive filter has some disadvantage such as the compensation characteristics heavily depend on the system impedance because the filter impedance has to be smaller than the source impedance in order to eliminate source current harmonics. Overloads can happen in the passive filter due to the circulation of harmonics coming from nonlinear loads connected near the connection point of the passive filter. They are not suitable for variable loads, since, on one hand, they are designed for a specific reactive power, and on the other hand, the variation of the load impedance can detune the filter and make harmonic resonance.[2]-[4].In literature different topologies applied to compensate the harmonics such as filtering like passive, active, and hybrid with shunt, series for two-wire single phase, three-wire three-phase and four-wire three-phase systems [5]. As well known, the parallel active filters are controlled to generate in real time the harmonic currents produced by the non-linear loads [6]. The performances of an active filter mainly depend on the reference current generation strategy. Several papers studied and compared the performances of filter with different reference current generation technique. Generally the reference current generation technique is classified in to two major classifications that is frequency domain method and time domain method. In this frequency domain method Fourier transform, DFT, FFT, RDFT are used for extracting harmonic component from polluted voltage and current signals. There are many types available in Time domain method such as P-Q theory, Instantaneous reactive power theory, Synchronous reference frame theory ,P-Q-R theory, among all models power synchronous detection is simplest one for calculation and it reduce the complexity for calculation of extraction of current harmonics. [8]. In this paper power synchronous detection (PSD) method is used for reference current generation and hysteresis band current controller is used for gate pulse generation. The principle of APF is injects a current equal in magnitude but in phase opposition to harmonic current.Fig.1shows the active filter principle.

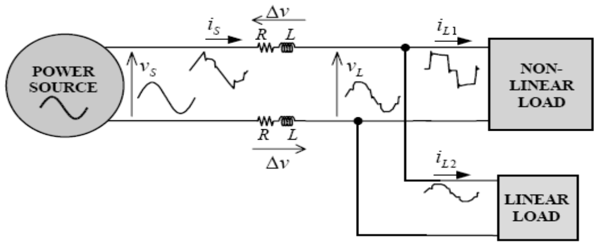

Fig.1 Principle of Active filter

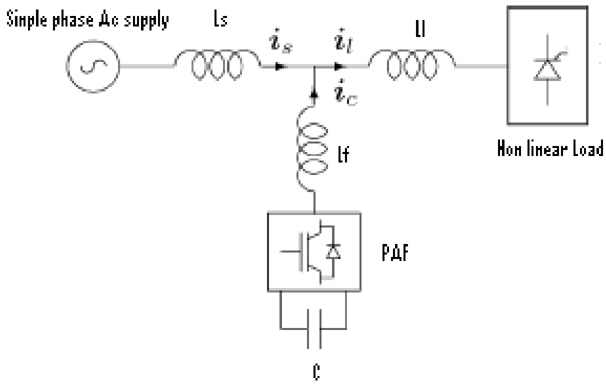

Fig.2. Diagram of PAF connected to load

Manuscript Received on June 22, 2012.
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II. CONFIGURATION OF SHUNT ACTIVE FILTER

According to configuration the Active filter classified into Series, shunt, hybrid active filter .Among all configuration shunt active filter is superior for reduction of current harmonics present in the system [9].Fig. 2 presents the shunt active filter topology based on a single phase voltage source inverter, using IGBT switches, connected in parallel with the AC single phase system through inductors LF. The capacitor C is used in the DC side to smooth the DC terminal voltage. The non-linear load is a single-phase diode rectifier supplying a RL load. This load generates harmonic currents in the supply system.

III. CONTROL STRATERGY

The first part of control strategy has reference current generation.The second part is the current control of the power converter. The controller generates the suited switching pattern to drive the IGBTs of the inverter.

A. Reference current Generation

The critical problem of Shunt active filter is to find the methodology to pick accurate harmonic current. There are many algorithms in time domain and frequency domain, generally frequency domain algorithm requires large computational delay compare to time domain. However traditional controllers in time domain include many disadvantages such as fixed compensation, bulkiness, and electromagnetic interference, possible resonance etc. develop. So that simple method of power synchronous detection (PSD) method for reference current generation. It requires lesser number of sensor count and computational delay. The algorithm is explained in the following Fig.3.1. The main part of the APF system is the IGBT based Voltage Source Inverter (VSI). A dc capacitor is used to deliver power for the VSI. For the good operation of APF, capacitor voltage should be at least 150% of maximum Line-line supply voltage. The source is connected to a diode bridge rectifier (non-linear) load. This nonlinear load current contains fundamental component and higher order of harmonic components. For this system, the instantaneous Voltage and load current. The input voltage and load current is measured by voltage and current sensor in the input and output side.

$$p(t)=[Vs(t)][\, I_l(t)] \qquad (1)$$

Whereas vs(t), is the instantaneous Values of supply voltages and $I_l(t)$, are the instantaneous values of load currents. The average value Pdc is determined by applying P(t) to a low pass filter.

$$i_s(t) = \frac{2\ Vs(t)\ Pa}{(Vsma\,)^2} \qquad (2)$$

B. Control scheme of shunt Active Power Filter

Linear current controller with pulse width modulation technique having constant switching frequency but its dynamic property is limited. Compared with other controllers, non-linear based on hysteresis strategies allows faster dynamic response and better robustness with respect to the variation of the non-linear load [10]. Nevertheless, with non-linear current controllers, the switching frequency is not constant and this technique generates a large side harmonics band around the switching frequency. Number of solution is there, to control switching frequency; one among them is using a variable hysteresis bandwidth [10]. Here, we implemented a non-linear current controller for generation of gate pulse to IGBTS. The carrier frequency is chosen equal to the desired switching frequency for the voltage inverter. The resulting signal (H)constitutes then the new reference of a classical hysteresis controller with a bandwidth of 2Bh. The outputs of the hysteresis block are the switching pattern. Fig 3 shows the hysteresis current controller. To control the active filter at fixed switching frequency, the triangular signal amplitude Atrand the hysteresis bandwidth Bhfor the modulated hysteresis current controller must be carefully selected.[9].

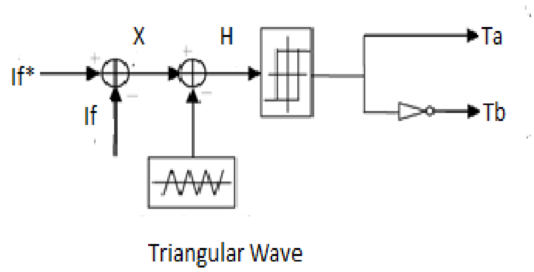

Fig. 3.the hysteresis current controller

IV. SIMULATION RESULTS

Table 1 .Power system parameters.

System Frequency	*50 Hz*
System Voltage	$110V_{max}$
System Resistance R_s	25 ohm
System Inductor : L_s	0.3mH
Load side Resistance R_l	10 ohm
Load side Inductor : L_l	0.1mH
Filter side Resistance R_f	20 ohm
Filter side Inductor : L_f	0.1mH
Load Resistance (single phase)R_d	50 ohm
Load Inductor(single phase) : L_d	40 mH
Load Resistance (single phase) : R_d	100 ohms
Load Capacitor (single phase) : L_d	100μF

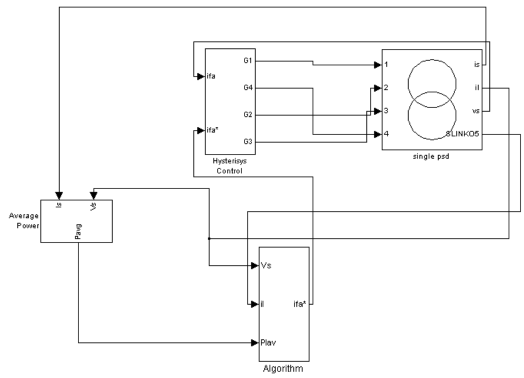

Fig.4.PSIM coupled Simulink diagram

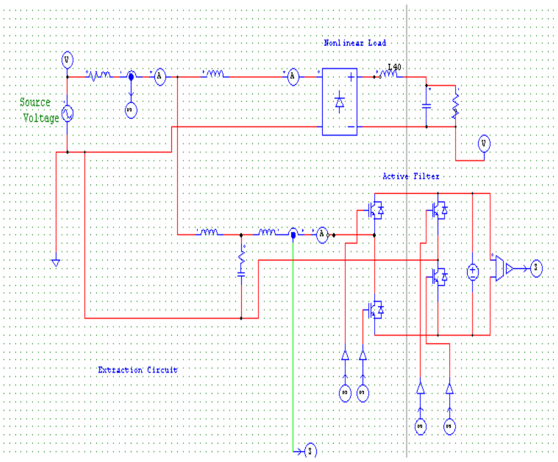

Fig.5. Simulation diagram of Active filter in PSIM

The proposed control algorithm was simulated with and without active filter and THD value are also shown in the following Figures.

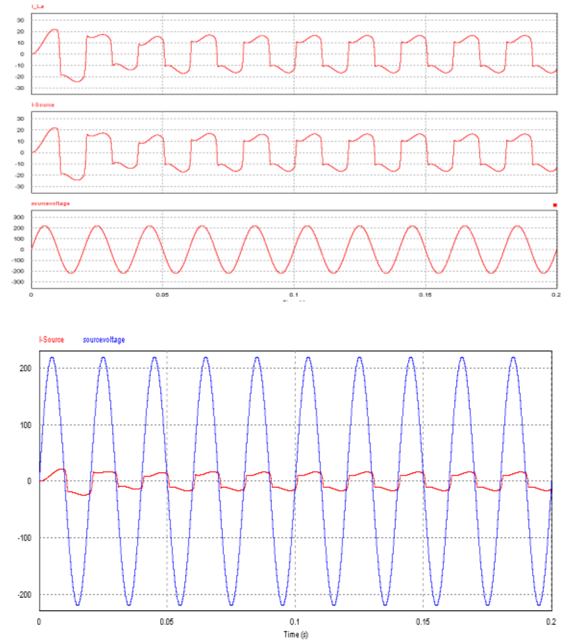

Fig .6. Source current ,load side current, source voltage ,combined source current and voltage before compensation

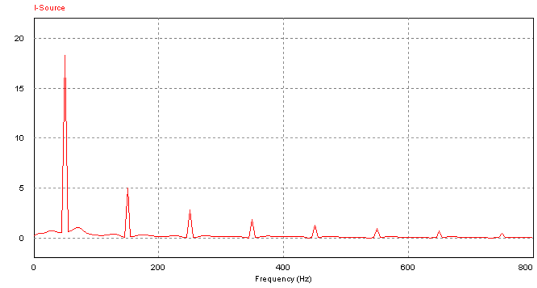

Fig.7. source current THD spectrum Before compensation

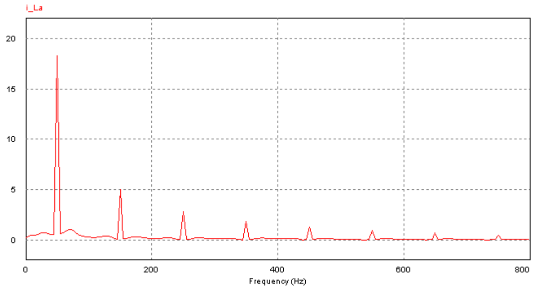

Fig .8.Load side current THD spectrum Before compensation.

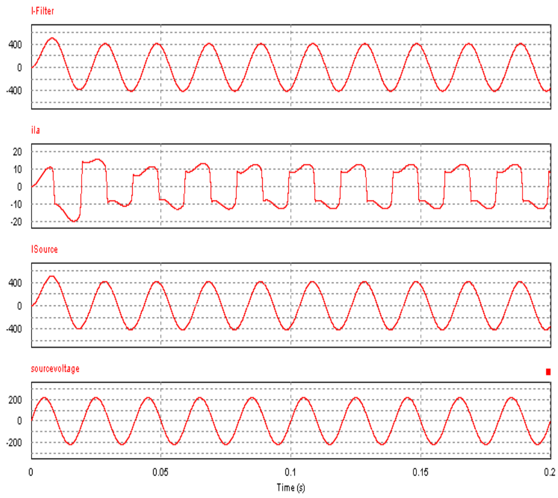

Fig .9. source current ,Load side current ,source voltage ,Filter current After compensation

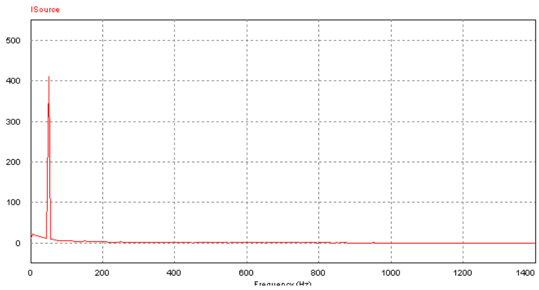

Fig .10. source current THD spectrum After compensation

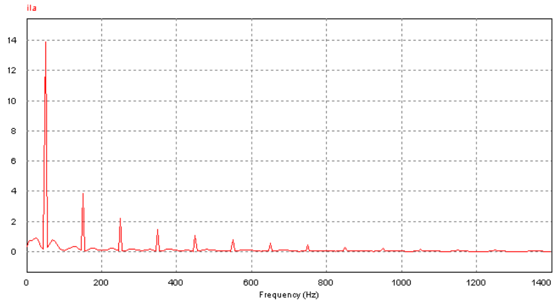

Fig 4.1.8 load current THD spectrum After compensation

V. CONCLUSION

This paper presents simple control method of Active filter with power synchronous detection topology for reference current generation and hysteresis Band controller for gate pulse generation to compensate current harmonics, Reactive power at PCC.The proper operation of the presented topology and control algorithms is validated through computer simulation results, developed with PSIM 9.1. software package. The performance of PAF in steady state condition is evaluated using FFT simulation with and without active filter. The control algorithm is developed in Simulink and active filter model developed in PSIM package. Both software packages are connected through simcopupler. The presented results show a good performance of the developed shunt active filter working in steady state conditions. The next step of this work is to construct a test workbench to assess the prototype in different control strategy, and also to evaluate the behavior of the active power filter in transient conditions.

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