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Shunt Active Power Filter with Hysteresis Current Control

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Abstract: The intensive use of various nonlinear loads like power electronics equipment create harmonics. These harmonics causes very serious damage in powers system such as resonance, overheating of neutral wire, low power factor, damage of microprocessor based equipment. In order to overcome this problem shunt active power filter is introduced. The proposed scheme is a combination of PI controller, active filter, hysteresis current control loop and a dc link capacitor. The switching signal generation for filter is from hysteresis current controller techniques. With all these element shunt active power filter reduce the total harmonic distortion. This paper presents the simulation and analysis of shunt active power filter to compensate harmonics .The proposed shunt active filter model uses balanced non-linear load. This scheme successfully lowers the THD within IEEE norms and satisfactorily works to compensate current harmonics. The model is made in MATLAB / SIMULINK and successfully reduces the harmonic in the source current.

Keywords: Shunt active power filter, reference current generation, hysteresis current control.

I. INTRODUCTION

Shunt technology has brought drastic increase in the use of power electronic equipments resulting in the increase of harmonics in source current or ac mains current. intensive use of power converters, various nonlinear loads and increasing use of office equipments like computers ,faxes ,printers are reasons for the increasing harmonics resulting in deterioration if sources current and source voltage.

Harmonics causes very serious damage in powers system. Problems like resonance; overheating of neutral wire, low power factor, damaging microprocessor based equipment. 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 are current resonance with the source impedance fixed compensation and large configuration size etc.

To overcome the problems of passive filters, active filters were developed and used to solve the problem of harmonics the 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. Efficient ways of generating reference current are p-q theory, synchronous reference current theory (SRF method).

In this paper SRF method has been used. 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. 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.

II. SHUNT ACTIVE POWER FILTER

The shunt-connected active power filter, with a self-controlled dc bus, has a topology similar to that of a static compensator (STATCOM)used for reactive power compensation in power transmission systems [1]. Shunt active power filters compensate load 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. Figure.2.2. Filter current IF generated to compensate load-current harmonics.

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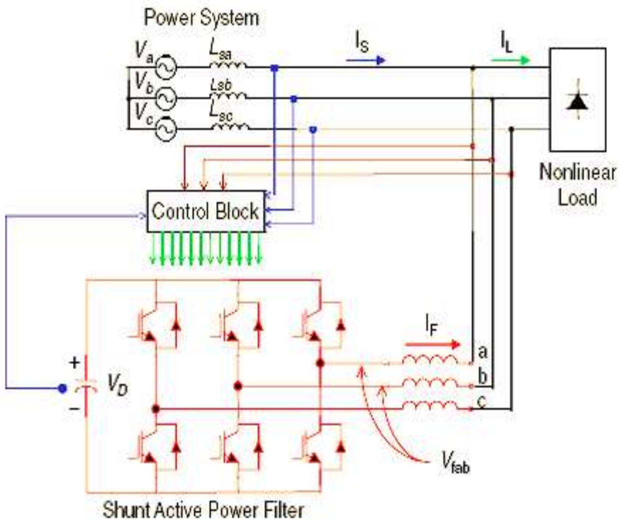

Fig 1.Shunt active power filter topology

III. CONTROL STRATEGY

A. Reference current generation

In Synchronous Reference Frame (SRF) theory the sensed load current has to be converted to rotating reference frame using 'sine and cosine' signals, with unity magnitude, generated by a PLL in-phase with the load voltage [2]. Hence the three phase load currents (a-b-c frame) are transformed into two phase stationary global reference (α-β) system, known as Clark's Transformation. This two phase global reference frame is transformed to rotating local reference (d-q-0) frame. This is called Park's transformation.

The SRF method is also known as I_d–I_q method. A set of voltages and currents can be transformed into α–β–0 axis using the following transformation.

$$\begin{bmatrix} i_0 \\ i_\alpha \\ i_\beta \end{bmatrix} = \sqrt{2/3}\begin{bmatrix} 1/\sqrt{2} & 1/\sqrt{2} & 1/\sqrt{2} \\ 1 & -1/2 & -1/2 \\ 0 & \sqrt{3}/2 & -\sqrt{3}/2 \end{bmatrix}\begin{bmatrix} i_a \\ i_b \\ i_c \end{bmatrix}$$

The reference d–q (d-direct axis, q-quadrature axis) frame is determined by the angle □ with respect to the α–β frame and the angle is obtained using a PLL.

The transformation from α–β–0 frame to d–q–0 frame is given by

$$\begin{bmatrix} i_0 \\ i_d \\ i_q \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\theta & \sin\theta \\ 0 & -\sin\theta & \cos\theta \end{bmatrix}\begin{bmatrix} i_0 \\ i_\alpha \\ i_\beta \end{bmatrix}$$

B. Hysteresis current control

The hysteresis band current control (HBCC) technique is used for pulse generation in current controlled VSIs [1]. The control method offers good stability, gives a very fast response, provides good accuracy and has got a simple operation. The HBCC technique employed in an active power filter for the control of line current is shown in Figure 3. It consists of a hysteresis band surrounding the generated error current. The current error is obtained by subtracting the actual filter current from the reference current. The reference current used here is obtained by the SRF method as represented by i_{ref}. The actual filter current is represented i_{act}. The error signal is then fed to the relay with the desired hysteresis band to obtain the switching pulses for the inverter.

IV. MATLAB MODELLING OF THE SYSTEM

A non-linear load is supplied by a three phase source. The load injects harmonics to the power system. In order to avoid the effect of these harmonics, we introduce a shunt active power filter which is connected parallel to the load, which is shown in the simulation diagram shown below

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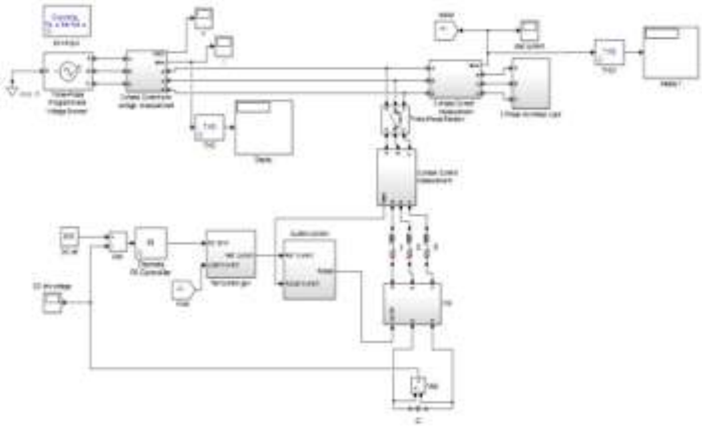

Fig 2.simultion model

V .SIMULATION RESULTS

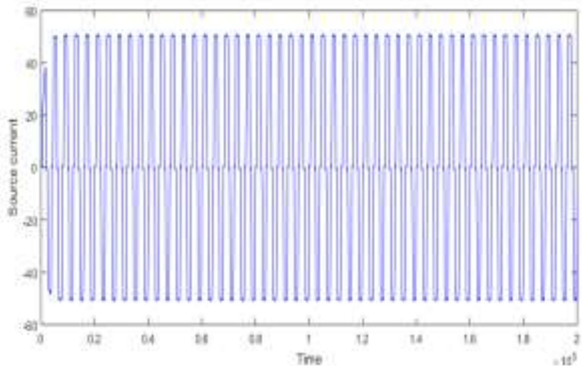

Fig 3. Source current before compensation

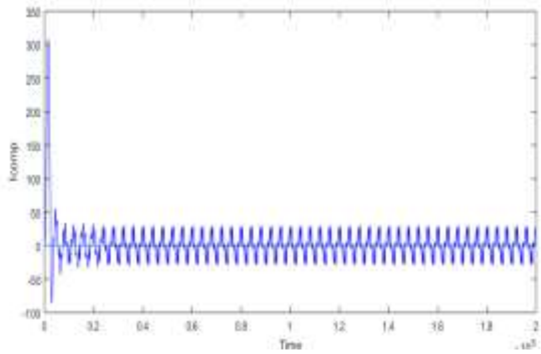

Fig 4. Compensation current

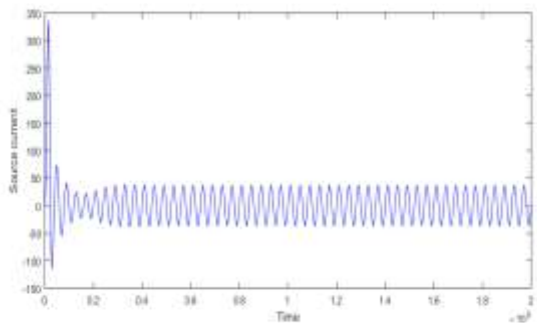

Fig 5 Source current after compensation

VI. CONCLUSION

In this paper, the working principle of three phase shunt active filter using dq0 theory and hysteresis current control. The harmonics injected by the load s are studied, simulated and analyzed the THD by means of FFT analysis by using MATLAB software. The harmonics in the power system are reduced to a great extent by using the shunt active filter and thus power quality is improved. It has been found that 90% percentage of the harmonics are eliminated.

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BIOGRAPHIES

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