MODELING AND SIMULATION OF POWER QUALITY IMPROVEMENT IN THREE PHASE SYSTEM BY USING SAF WITH PLL AND DQ METHODS

Miss. Priyanka M. Deogade[1], Prof. Umesh G. Bonde [2],

[1]*Department of Electrical Engineering, Shri Sai College of Engineering & Technology, Bhadrawati, Maharashtra, India*
[2] *Professor, 1Department of Electrical Engineering, Shri Sai College of Engineering & Technology, Bhadrawati, Maharashtra, India*

ABSTRACT

The oversupply of electronic devices in the distribution system has turned into a power quality problem. Arc awards, Variable Frequency Drives (VFD), Computer power play a major role in the deterioration of quality energy by injecting harmonics into the service delivery source. This paper represents an effective solution for an effective energy filter to eliminate harmonics to maintain the quality of the power supply. On the proposed screen the active filter acts as a current source and eliminates harmonics by injecting equal but opposite parts of the common junction. The simulation of an active shunt filter based on the concept of active energy efficiency was performed using the MATLAB-Simulink Toolbox. To prove the flexibility and effectiveness of the proposed system two types of loads have been considered and the results of simulation have been obtained.

Keyword: - *Power Quality, Shunt Active Power Filter, Instantaneous reactive power theory, Hysteresis current control.*

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1. Introduction

There are basically two ways to reduce energy quality problems. The first method is load preparation, which ensures that the load is physically harmonious. The devices are made less sensitive to harmonious and power disturbances, which is less likely. Another solution is electrical repairs. In this method the layout of the insertion lines is placed in a common junction (PCC) that compresses or reverses the negative effect produced by loads that produce non-linear harmonic.

Traditionally filters were used to deal with harmonic power generation problems and functional power disturbance problems. But they were facing major issues such as volume problems, large size, constant compensation features, the effect of source impedance on performance etc. After that the concept of energy filtering introduced by Sasaki and Machida in 1971. Active power filters provide an effective solution compared to standard performance filters to reduce the problems of associated power outages.

2. ACTIVE POWER FILTERS

Active power filters are a device that produces the same amount of harmonic as in load but the 180o phase has shifted. Therefore, when these harmonics are placed in a line where the normal mixing the current harmonics of the load are eliminated and the service delivery becomes sinusoidal. There are two types of active filters: Active series filters and active shunt filter.

Fig. 1 shows the basic scheme of shunt active power filter which compensate load current harmonics by injecting equal but opposite harmonic compensating current.

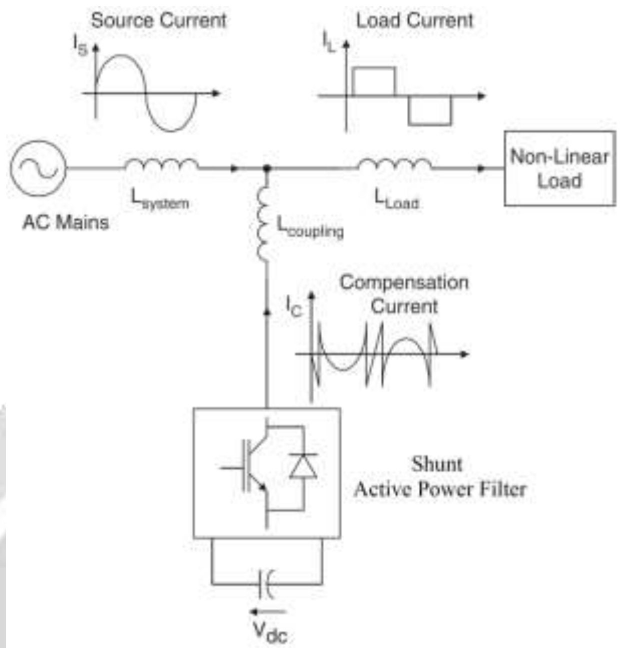

Fig -1: Basic scheme of shunt active power filter

The basic energy filter acts as the current source injects the harmonic components produced by the load but the phase is rotated 180 °. As shown in Fig. 2 active power filters serve primarily as a voltage regulator and as a harmonic separator between a line that does not match the line and the source of consumption

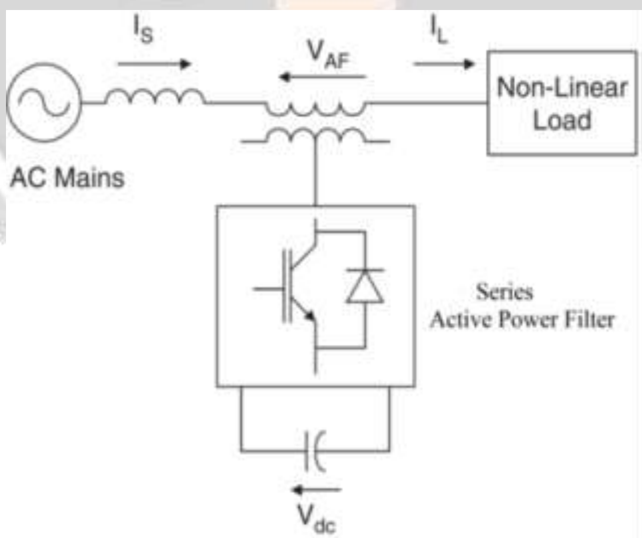

Fig -2: Basic scheme of series active power filter

The series active filter injects a voltage component in series with the supply voltage and removes harmonic components in voltage waveforms and therefore can be regarded as a controlled voltage source, compensating voltage sags and swells on the load side. Practically shunt active power filter are more effective and cheaper compared to series active power filters because most of the nonlinear loads produce current harmonics. Moreover series active power filter requires adequate protection scheme. The combined series and shunt active filter is called as Unified Power Quality Conditioner (UPQC).

3. HYSTERESIS CURRENT CONTROL TECHNIQUE

Hysteresis Current Control (HCC) technique is basically an instantaneous feedback current control method of PWM, where the actual current continually tracks the command current within a hysteresis band. Basic working principle of the HCC technique is shown in Fig. 3.

Hysteresis band (HB) is the possible boundary of the compensating current. This current deviates between upper and lower hysteresis limits. For example in phase a, if ica is equal or over than the upper hysteresis limit (i * + HB/2) then the comparator output is 0 (S1=0, S2=1). On the other hand, if ica is equal or less than the lower hysteresis limit (i * - HB/2) then the comparator output is 1 (S1=0, S2=1). From this operating, the ica can deviate inside the hysteresis band following the reference current i *. The main advantage of hysteresis current control method is excellent dynamic response, easy implementation and low cost.

Fig.4 shows the basic scheme of generation of six pulses to drive the six switches of inverter of shunt active power fitter. In this method the actual output current generated by inverter is compared with reference current generated using instantaneous reactive power theory. Hysteresis current controller will generate pulses in such a manner that inverter output current will follow the reference current.

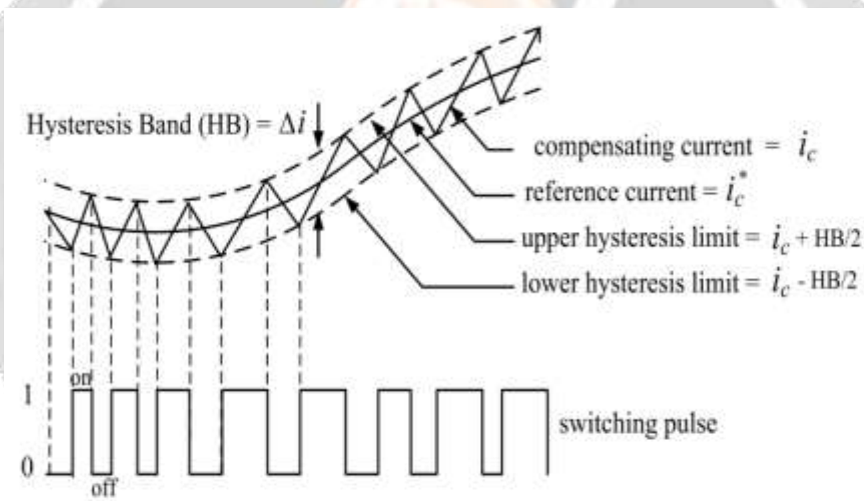

Fig -3: Principle of hysteresis current control technique

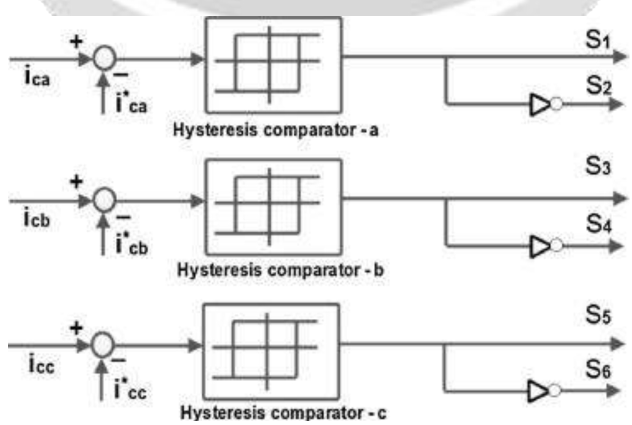

Fig -4: Pulse generation using hysteresis current control technique

4. INSTANTANEOUS REACTIVE POWER THEORY

The p-q theory was proposed by Akagi et al. in 1983. The p-q theory is based on conversion of a-b-c coordinate into α-β- 0 coordinates and α-β-0 coordinates into a-b-c coordinates, popularly known as Clark transformation and inverse transformation respectively. Basic block diagram of p-q theory is shown in Fig. 8. Generated compensating current will be:

$$I_{comp} = I_{source} - I_{load} \quad (1)$$

Where,

I_{comp} = Compensating current

I_{source} = Source current

I_{load} = Load Current

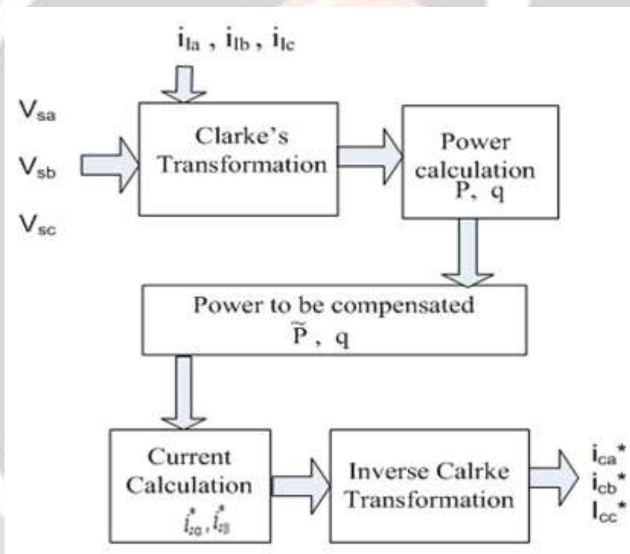

Fig -5: Basic block diagram of p-q theory

In this method three phase source voltage and load current are converted into α-β-0 stationary reference frame.

$$\begin{bmatrix} V_0 \\ V_\alpha \\ V_\beta \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ 1 & \frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} V_{sa} \\ V_{sb} \\ V_{sc} \end{bmatrix} \quad (2)$$

$$\begin{bmatrix} I_0 \\ I_\alpha \\ I_\beta \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ 1 & \frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} I_{sa} \\ I_{sb} \\ I_{sc} \end{bmatrix} \quad (3)$$

From this transformed quantities, instantaneous real and reactive power of the load is calculated which consists of average and oscillating component.

$$\begin{bmatrix} P_0 \\ P \\ q \end{bmatrix} = \begin{bmatrix} V_0 & 0 & 0 \\ 0 & V_\alpha & V_\beta \\ 0 & -V_\beta & V_\alpha \end{bmatrix} \begin{bmatrix} I_0 \\ I_\alpha \\ I_\beta \end{bmatrix} \quad (4)$$

For three phase three wire systems I0= 0, so source power P0 also becomes zero. So power equation becomes as follows.

$$\begin{bmatrix} P \\ q \end{bmatrix} = \begin{bmatrix} V_\alpha & V_\beta \\ -V_\beta & V_\alpha \end{bmatrix} \begin{bmatrix} I_\alpha \\ I_\beta \end{bmatrix} \quad (5)$$

Instantaneous active and reactive power of load can be calculated as follows:

$$\begin{bmatrix} P_l \\ q_l \end{bmatrix} = \begin{bmatrix} V_\alpha & V_\beta \\ -V_\beta & V_\alpha \end{bmatrix} \begin{bmatrix} I_{l\alpha} \\ I_{l\beta} \end{bmatrix} \quad (6)$$

The real and actual energy can be broken down into two parts called oscillatory parts and normal parts. Considering the conditions of a completely limited supply and the state of sinusoidal the ratio of electrical energy represents the harmonic current of the positive sequence and the oscillatory components are related to all high-level harmonic components including the first harmonic negative sequence. The effective shunt filter must therefore compensate for the oscillatory power components, as a result of which the normal power components remain the same in the main supply.

$$\begin{bmatrix} I_{s\alpha} \\ I_{s\beta} \end{bmatrix} = \frac{1}{V_\alpha^2 + V_\beta^2} \begin{bmatrix} V_\alpha & -V_\beta \\ V_\beta & V_\alpha \end{bmatrix} \begin{bmatrix} \bar{p} \\ 0 \end{bmatrix} \quad (7)$$

The oscillating component is extracted using high-pass filter and taking inverse of α-β transformation compensating reference signals in terms of either currents or voltages are derived.

$$\begin{bmatrix} I_{ca}^{*} \\ I_{cb}^{*} \\ I_{cc}^{*} \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} 1 & 0 \\ -\frac{1}{2} & \frac{\sqrt{3}}{2} \\ -\frac{1}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} I_{s\alpha} \\ I_{s\beta} \end{bmatrix} \qquad (8)$$

5. WORK DONE

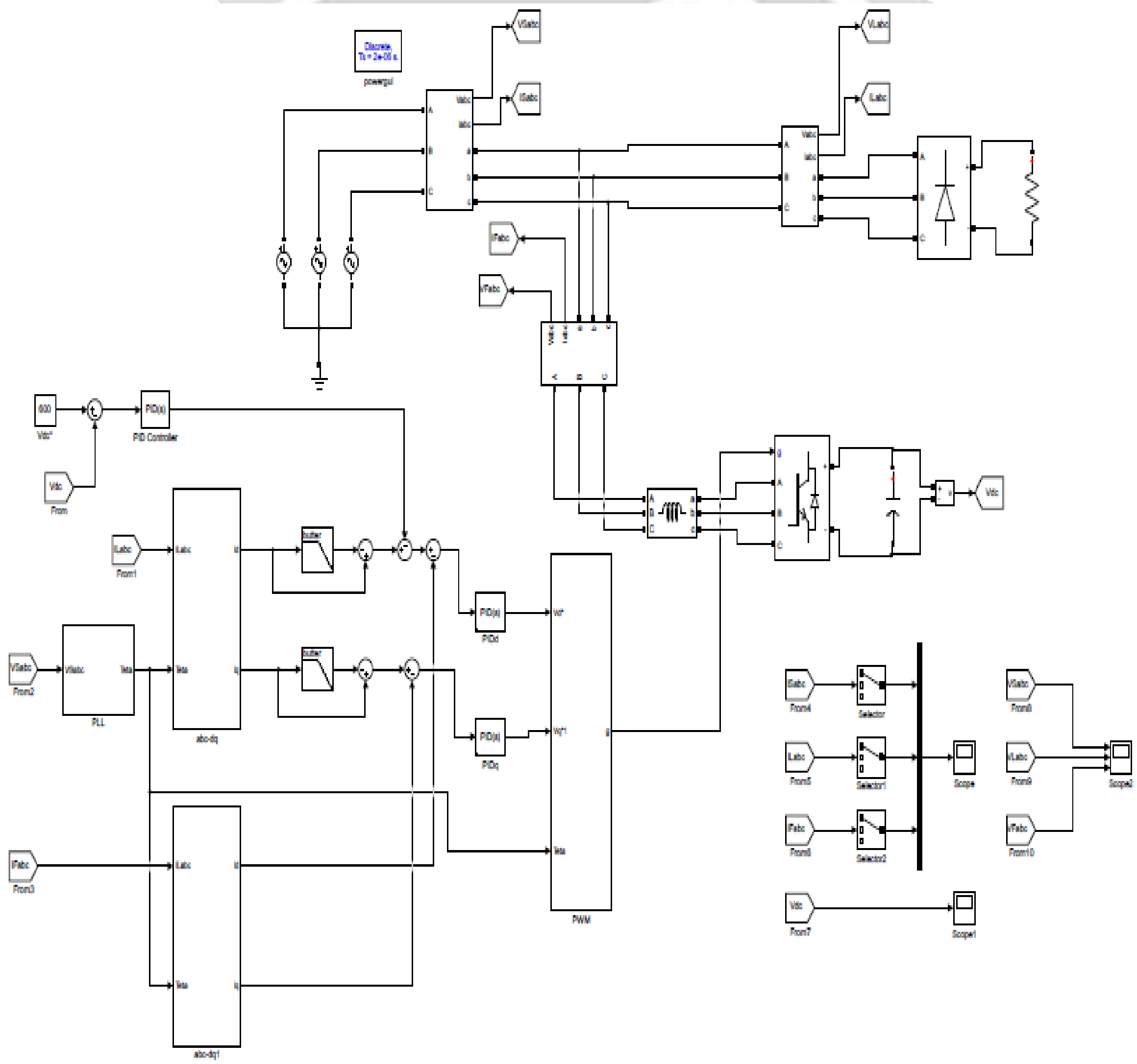

Fig -6: AF Control system based on id iq method

For supplying the compensation current to the line, a three phase IGBT based Voltage Source Inverter (VSI) is used. This makes the design simple, robust and has good dynamics in spite of some of its well-known disadvantages. The current controller used is composed of three independent two-level hysteresis comparators operating on a three leg VSI. This provides the compensation harmonic current to be injected and by the control circuit which consists of two units namely Harmonic Current Generator and DC Voltage Regulator (Fig. 2).

6. SIMULATION RESULTS AND ANALYSIS

Performance of shunt active power filter is checked with the use of MATLAB software. In the proposed scheme two types of loads have been considered as nonlinear loads: (i) Resistive rectifier load and (ii) Inductive rectifier load. Figure 6 and Fig. 11 shows the current source of the source wave before and after the installation of the active shunt power filter. From then on it is considered that until the active power filter is applied to the system, the current source is very distorted. But when an active power filter is in line the effective power filter for injection 180o phase shifted the current load of harmonics in line with the current source is very close to the correct sinusoidal form.

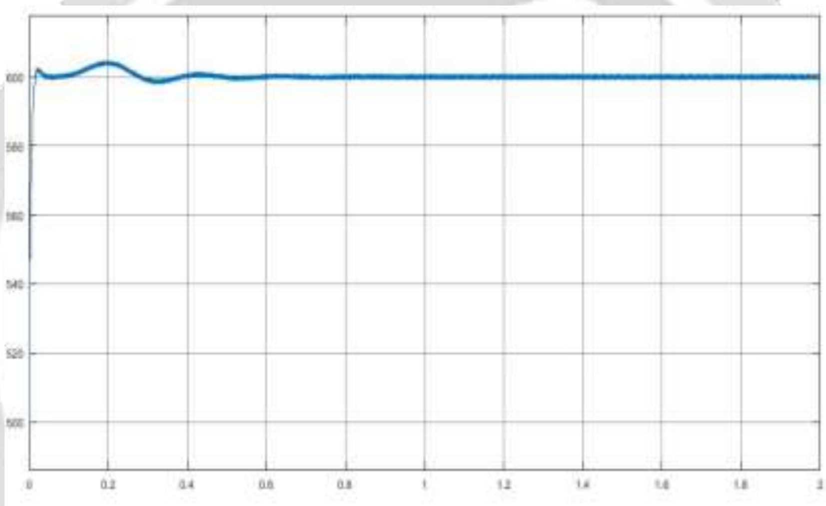

Fig -7: DC voltage output

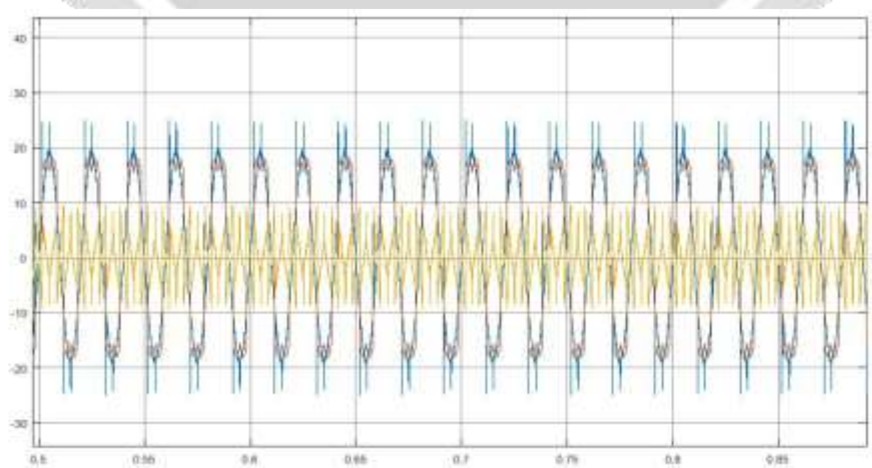

Fig -8: Three output current

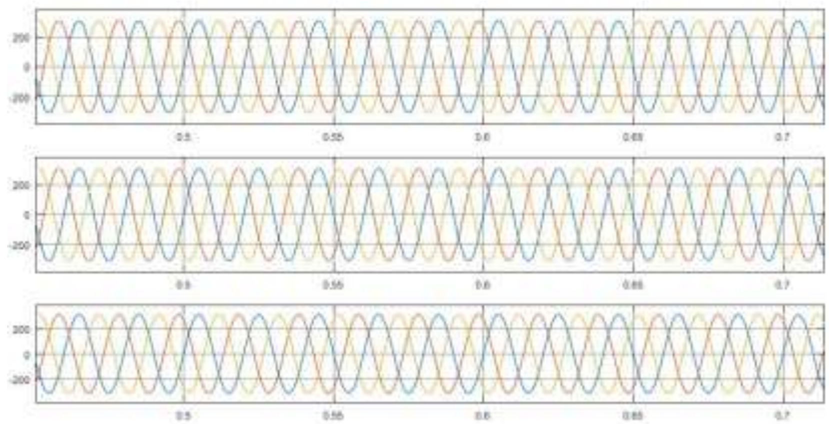

Fig -9: Three voltage output

6. CONCLUSION

In this paper an analysis of the performance of the active shunt energy filter using fast energy theory. Imitation results demonstrate the effectiveness of an effective power filter for harmonic dissipation in the current twisted source. Two types of loads are considered to determine the legitimacy and flexibility of the proposed system. In both cases the current source THD decreases from 27.17% to 1.02% and 25.82% to 2.46%, consistent with IEEE-519 standard harmonic control.

7. REFERENCES

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