SHUNT ACTIVE POWER FILTER

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Abstract - Now days the extensive use of Power electronic devices in distribution and power systems has evolved the power quality. There are various devices like variable frequency drive, Arc furnace etc. which are responsible for the deterioration of power quality by injection of harmonics. So importance is given to the development of Active power filter to improve the power quality among which shut Active power filter is used to eliminate voltage and load current Harmonics. The shunt active power filters have been made on the basis control strategies like instantaneous active and reactive power compensation scheme (p-q control) and instantaneous active and reactive current scheme (Id-Iq control).

Key Words: Active power filter, p-q theorem, Power Quality.

1. INTRODUCTION

Harmonics is defined as "a sinusoidal component of a periodic wave or quantity having a frequency that is an integral multiple of the fundamental frequency". Harmonic is mix of several of frequency current or voltage multiply by fundamental voltage or current in the provided system. Previous technique used to compensate load current harmonics is L-C passive filter; as a result the filter cannot adapt to the various range of load current and sometimes produce undesired resonance.

The presence of harmonics, when power lines are considered leads to even greater power losses in distributing, causing noise troubles in the communication systems and, every so often, causing breakdown of functioning of electronic apparatus, which have superior sensitivity for the reason that the addition of microelectronic control systems plus these systems lead to devices with low power and therefore a minute noise can be noteworthy. These become the reasons that put together the power quality issue as one of the most apprehensive issues as far as the final user is concerned.

International standards concerning electrical energy consumption impose that electrical equipment should not produce harmonic contents greater than specified values. Meanwhile it is a must to solve the harmonic problems caused by those devices which have already been installed. Use of the passive filters is one of the classic solutions to solve harmonic current problems, but they present several disadvantages, namely: they only filter the frequencies they were previously tuned for; their operation cannot be limited to a certain load; resonances can occur because of the interaction between the passive filter and other loads, with unpredictable results. As a result, conventional solutions that rely on passive filters to perform a harmonic reduction are ineffective. Under these conditions it has been proved that the most effective solutions are active filters which are able to compensate not only harmonics but also asymmetric currents caused by nonlinear and unbalanced loads. Due to the remarkable progress in the last two decades in the field of power electronics devices with forced commutation, active filters have been extensively studied and a large number of works have been published. This paper

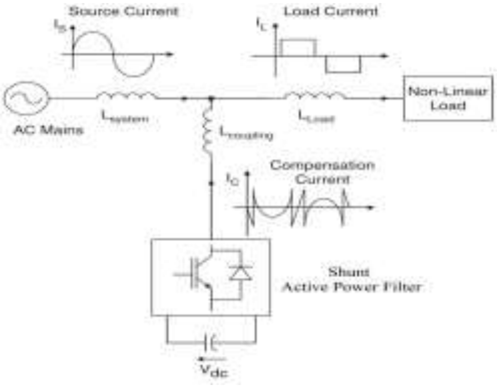
1.1 ACTIVE POWER FILTWR

Active power filter is a device that produces the exact amount of harmonics which is generated by a load which is 180 phase shift. As these lines injects harmonics in the lines at a point of common coupling so that the load harmonics are eliminated and our utilization supply will became sinusoidal. There are two types of filter: series active filter and shunt active filter.

Figure 1 give the basic design of shunt active power filter that compensate the load current Harmonics by injection of equal and opposite harmonics compensating current.

The shunt active power filter basically is a current source for injection of harmonic components produced by the load but are shifted by angle of 180 degree. As given in figure 2 the series active power filter mainly operated as voltage regulator and a harmonic isolator.

The series active power filter basically inject a voltage components in series with supply voltage and eliminates the harmonic components in voltage source waveform and can be considered as a controlled voltage source.



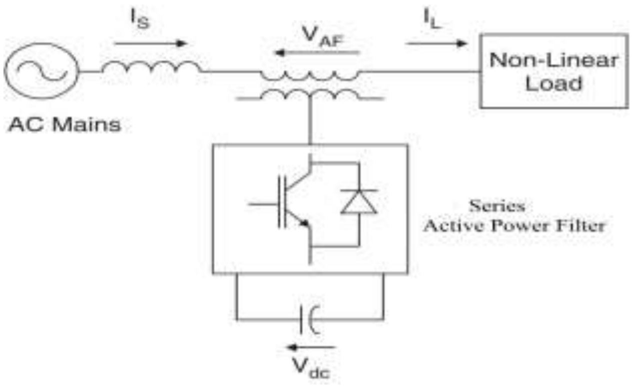


Fig.1 Basic scheme of shunt active power filter. Fig. 2 Basic scheme of series active power filter

In accordance to the mark McGranaghan, the major problem on designing active filter is to finding out the active filter, which is essential to compensate harmonics for a particular kind of load. He chose a parallel connected device that is active filter due for Harmonics cancellation and it's size according to achieve a desired level of cancellation. Figure 3 illustrate a shunt connected active filter cancelling the harmonic of a Allowable stress design load.

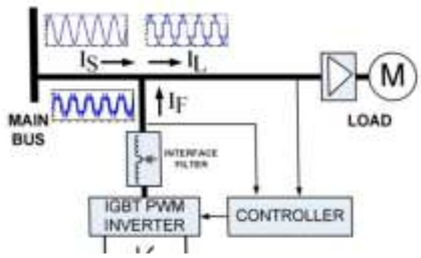


Fig. 3 Diagram illustrating components of shunt connected active power filter with the waveform showing cancellation of harmonics

1.2 INSTANTANEOUS POWER THEORY

The instantaneous power theory or also known as p-q theory is given by Akagi in 1983. In this method we use Clarke transform for three phase current and voltage. We convert three phase voltage and current in alpa-beta using equation 3 and 4, where iabc are three phase line current and vabc are three phase line voltage.

According to the p-q theory, active and reactive power of a three phase system is give by equation 5 and 6

$$p = v_\alpha i_\alpha + v_\beta i_\beta + v_o i_o \quad (5)$$

$$q = v_\alpha i_\beta - v_\beta i_\alpha \quad (6)$$

$$\begin{bmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \end{bmatrix} \quad (3)$$

$$v_{\alpha\beta o} = \sqrt{\frac{2}{3}} \begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \end{bmatrix} v_{abc} \quad (4)$$

For the system without neutral the zero sequence components will not exist so for that we can represent mathematical equations in matrix form as shown in equation 7

$$\begin{bmatrix} p \\ q \end{bmatrix} = \begin{bmatrix} v_\alpha & v_\beta \\ -v_\beta & v_\alpha \end{bmatrix} \begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix} \quad (7)$$

We can separate AC and DC part in two components as shown in equation 8 and 9. And to get the DC part active and reactive power the signal is filtered out using a low pass filter.

$$p = \overline{p} + \widetilde{p} \quad (8)$$

$$q = \overline{q} + \widetilde{q} \quad (9)$$

Then according to p-q theory the active power can be represented by DC part of alpha-beta reference current, we is shown in equation 10

$$i_{\alpha\beta}^{*} = \frac{1}{v_\alpha^2 + v_\beta^2} \begin{bmatrix} v_\alpha & v_\beta \\ v_\beta & -v_\alpha \end{bmatrix} \begin{bmatrix} p \\ q \end{bmatrix} \quad (10)$$

So the actual three phase reference current for active filter is given by equation 11

$$i_{abc}^{*} = \sqrt{\frac{2}{3}} \begin{bmatrix} 1 & 0 \\ -1/2 & \sqrt{3}/2 \\ -1/2 & -\sqrt{3}/2 \end{bmatrix} i_{\alpha\beta}^{*} \quad (11)$$

2. SIMULATION RESULTS

We can check the performance of shunt active power filter through MATLAB software for control strategy shown in below figure 4

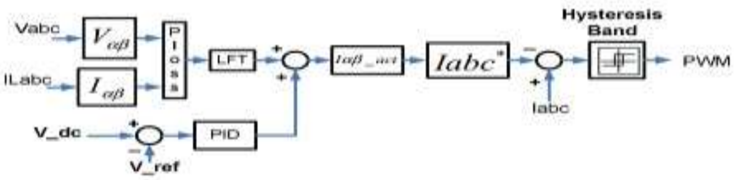


Fig. 4. Control strategy

The given three phase line voltage is shown in figure 5. And we are performing simulation on three phase balance non-linear load which is a three phase diode rectifier supplying a DC voltage to purely resistive load. The results of three phase load current will be shown in figure 6. And for three phase line current will be almost sinusoidal in figure 7. The active power filter current is given in figure 8

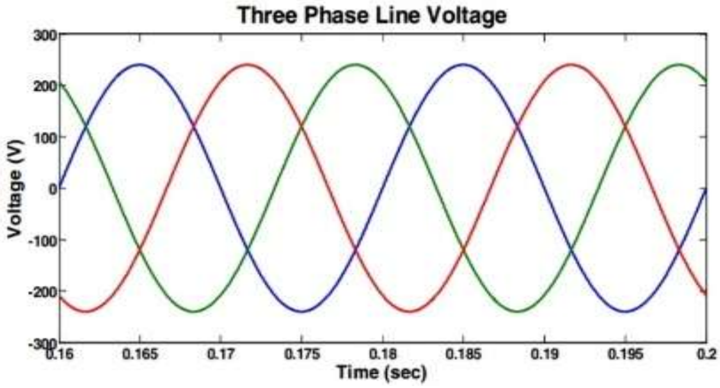


Fig. 5.

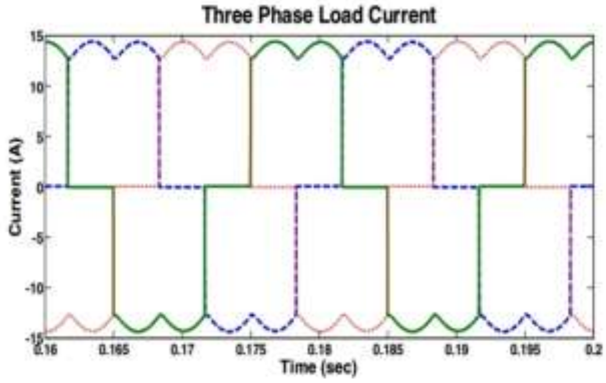


Fig.6.

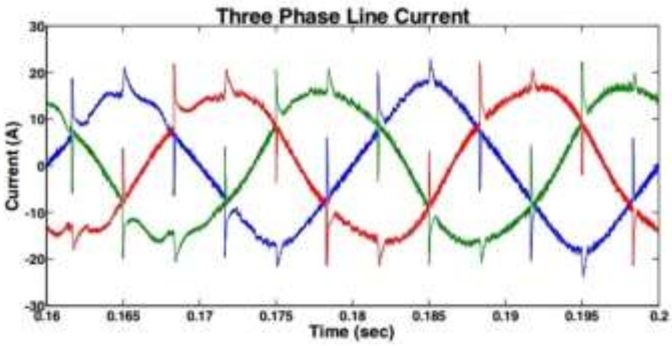


Fig. 7.

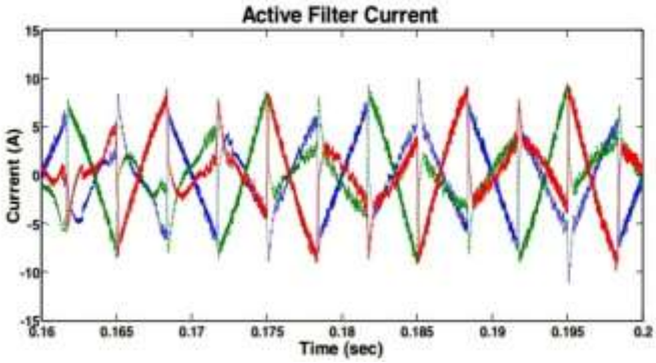


Fig. 8

Total harmonic distortion (THD) for line and load current is given in figure 9 and 10 and we can clearly see because of the use of active filters the harmonic components are compensated and THD is reduced from 30.76% to 12.68% which satisfies the IEEE-519 standard for THD.

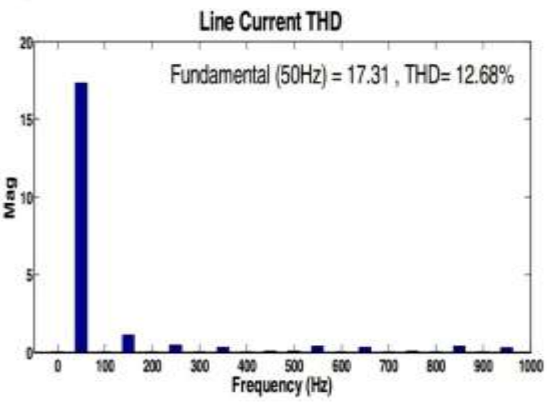


Fig. 9.

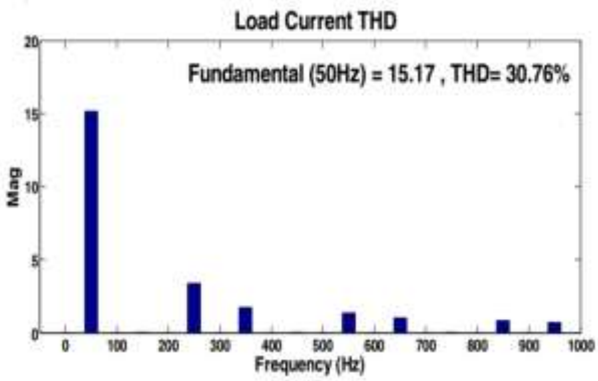


Fig. 10.

3. CONCLUSIONS

In this paper we discussed the performance analysis of shunt active power filter using instantaneous reactive theory or p-q theory. And the simulation results we got shows that how effective shunt active power filter is for the elimination of harmonics in distorted current source. So for the increasing usage of non-linear load in electrical power systems we can effectively use this method for harmonics mitigation and power factor correction. And the harmonic elimination carried out here also meet the standards of IEEE-519.

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