Improvement of Power Quality by using Active Filter based on Vectorial Power Theory Control Strategy on the MATLAB-Simulink Platform

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Abstract: Harmonic current drawn from a supply by the nonlinear load results in the distortion of the supply voltage waveform. Both distorted current and voltage may cause conductors to overheat and may reduce the efficiency and life expectancy of the equipment. So that reduction of harmonics is very important in day today life. For that purpose used filtersActive power filters are used to improve power quality by compensating harmonics and reactive power required by a non-linear load. In this paper a Series active and passive shunt filter is discussed. The control strategy based on vectorial theory of instantaneous reactive power, so that the voltage waveform injected by the active filter is able to compensate the reactive power.

Keywords –Active power filter, current harmonics, instantaneous reactive power, power filter, power quality

I. INTRODUCTION

In recent years both power engineers and consumers have been giving focus on the "electrical power quality" i.e. degradation of voltage and current due to harmonics, low power factor etc. A power quality problem exists if any voltage, current or frequency deviation results in a failure or in a bad operation of customer's equipment. So, for the better performance of the system it should be free from harmonics. For that purpose filters are used. There are so many types of filters such as active filter, passive filter, high pass filter, low pass filter etc. In that high-pass filters present disadvantages due to the resistance connected in parallel to the inductor, which increases the filter losses and reduces the filtering effectiveness at the tuned frequency. Conventionally, Passive LC filters were used to compensation of current harmonics. But, there are some limitations of using only passive filters such as fixed compensation, large size, bulkiness, occurring series and /or parallel resonance problem etc. To overcome these limitations combination of active and passive filters are used. In this paper a Series active with passive shunt filter is discussed. Series active with passive shunt filter topology is implemented with three phase PWM inverter connected in series with power lines and resonant LC passive filter are connected in parallel with power lines [1].

II. PROPOSED ALGORITHM

Power quality

Power quality means the physical characteristics of the electrical supply provided under normal operating conditions that do not disturb the customer's processes.

2.1 Power quality problems

Power quality problem exists if any voltage, current or frequency deviation results in a failure or in a bad operation of customer's equipment.One more problem is harmonics. Harmonics are produced due to non linear load

2.2 Solution to power quality problems

A flexible and versatile solution to power quality problems are offered by active power filters. There are also three types of active power filter such as series active power filter, shunt active power filter& hybrid active power filter. In that the cost of shunt active power filter is relatively high and they are not preferable for a large scale system. The series active power filters works as a kind of harmonic isolator rather than a harmonic voltage generator. Series active power filters are used to eliminate voltage harmonics, to balance and regulate the terminal voltage of the load or line. Also, it has been used to reduce negative-sequence voltage [2].A new control algorithm is hybrid filter, which is a combination of an active series filter and passive shunt filter is quite popular because of the solid-state devices are used in the active series part can be of reduced size and cost. Also the major part of the hybrid filter is made of the passive shunt LC filters are used to eliminate lower order harmonics [2]. It has the capability of reducing voltage and current harmonics at a reasonable cost, and allows the use of active power filters in high-power applications at a relatively low cost. Moreover, compensation characteristics of passive filters can be significantly improved by connecting a series active power filter at its terminals, giving more flexibility to the compensation scheme and avoid possibility of the generation of series and /or parallel resonance [3].

3.Series active filter and parallel passive filter

Series active filter and parallel passive filter topology shown in fig. 3,An active power filter is implemented with a three-phase pulse width modulation (PWM) voltage-source inverter operating at fixed switching frequency. When this equipment is connected in series to the ac sourceimpedance it is possible to improve the compensation characteristicsof the passive filters in parallel connection.In order to allow current harmonic compensation, a parallel LC filter must be connected between the nonlinear loads and the series transformers. It is well known that series active power filters compensate current system distortion caused by non-linear loads by imposing a high impedance path to the current harmonics which forces the high frequency currents to flow through the LC passive filter connected in parallel to the load. The high impedance imposed by the series active power filter is created by generating a voltage of the same frequency that the current harmonic component that needs to be eliminated. Current harmonic and voltage unbalance compensation are achieved by generating the appropriate voltage waveforms with the three phase PWM voltage-source inverter (Fig.3). Active power filter is used with passive filters to improve the compensation characteristic of passive filter, also it avoid the possibility of generation of series or parallel resonance [4].

4. Instantaneous reactive power theory- Vectorial

The instantaneous reactive power theory is the most widely used as a control strategy for the active power filter. There are five formulationsof the instantaneous reactive power theory: p-q original theory, d-q transformation, modified or cross product formulation, p-q-r reference frame and vectorial theory.From the five formulations, only the vectorial one allows balanced and sinusoidal source currents after compensation. The main difference between vectorial power theory and rest of the formulations is that, vectorial formulation need not do any kindof coordinates translation. It uses the same power variables as the original theor[5].

Defining now the instantaneous real and imaginarypower in phase coordinates as follows:

$$p(t) = \vec{v} \cdot \vec{i} = v_1 i_1 + v_2 i_2 + v_3 i_3$$

$$q(t) = \vec{v}_q \vec{i} = \frac{1}{\sqrt{3}} \begin{bmatrix} v_2 - v_3 \\ v_3 - v_1 \\ v_1 - v_2 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix}$$

With

$$\vec{v}_q(t) = \frac{1}{\sqrt{3}} [v_{23} \quad v_{31} \quad v_{12}]^t$$

III. EXPERIMENT AND RESULT

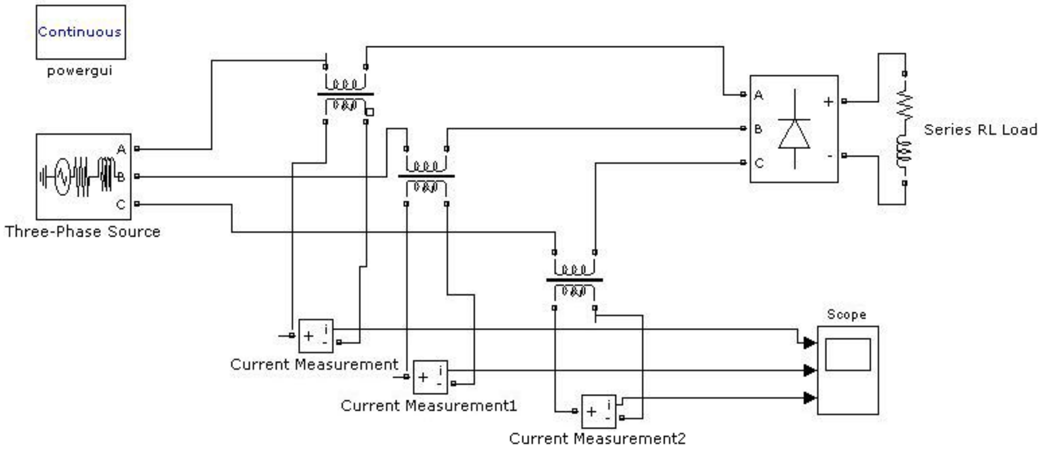

Fig.No.1 Three phase source before using filter

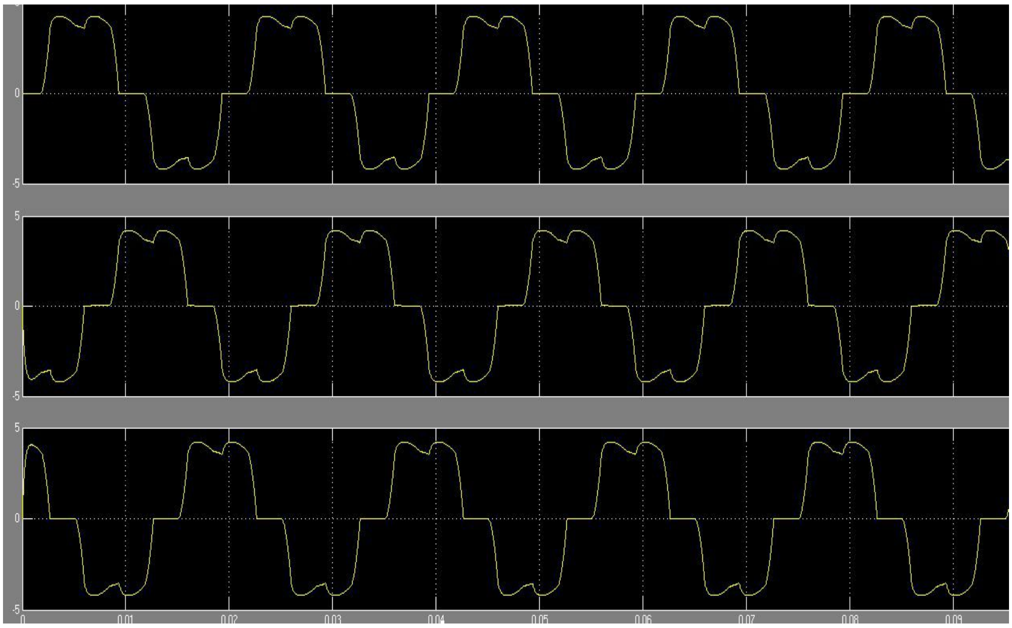

Fig.No.2 Current Waveform before using filter

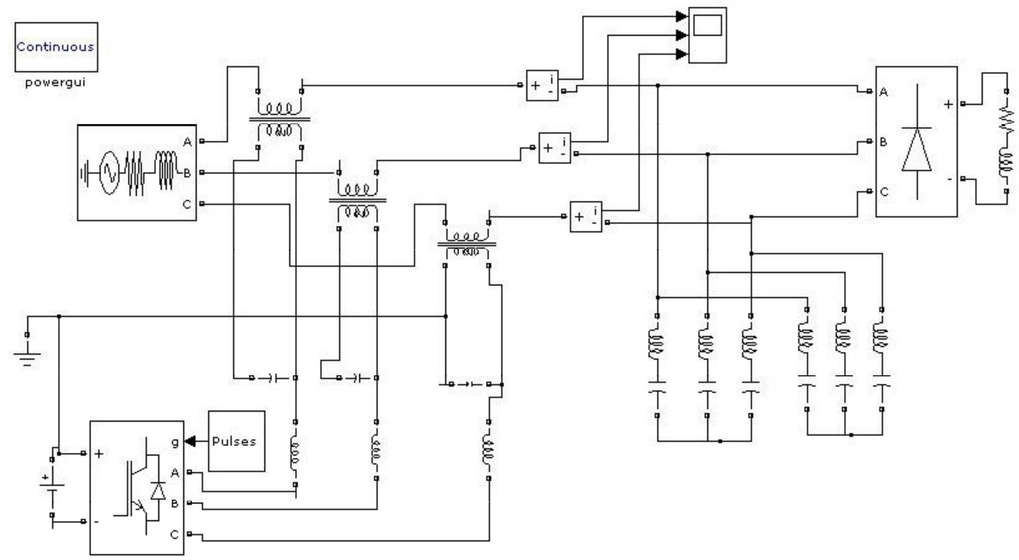

Fig. No. 3 Series active and shunt passive filter topology

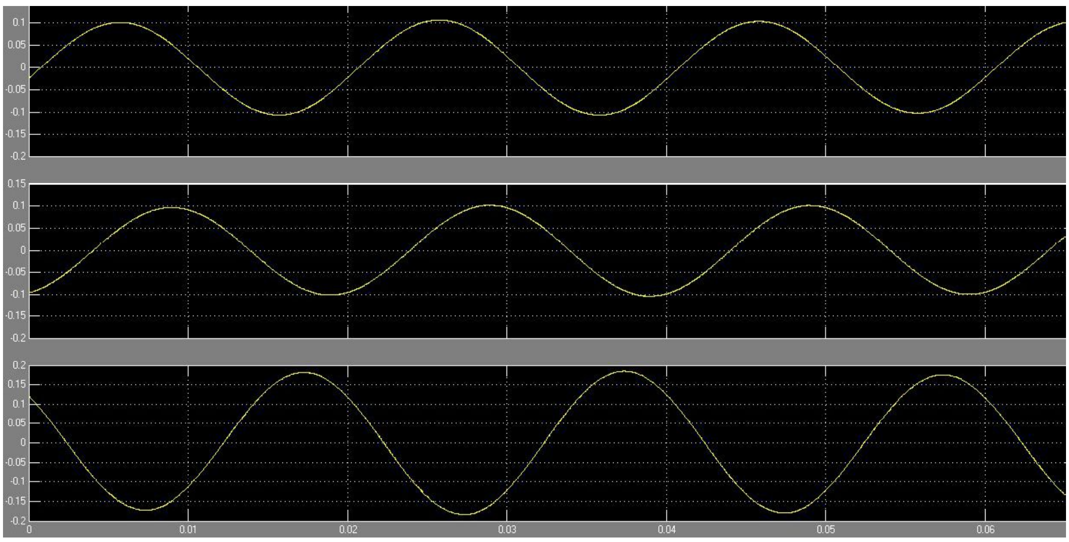

Fig.No.4 Current Waveform after using filter

The system shown in Fig. 1 & Fig.3 has been simulated in the Matlab-Simulink platform. Each powerdevice has been modeled using the SimPowerSystem toolbox library. Fig.1 shows the system without using filter.Fig.2 shows the current waveform without using filter. From distorted current waveform 5th& 7th order harmonics are found by using FFT analysis.Fig.3 shows the series active and shunt passive filter topology, in that the PWM voltage source inverter consists of an Insulated Gate Bipolar Transistor (IGBT) bridge. With 200V dc supply are connected. An LC filter has been included to eliminate the high frequency components at the output of the inverter. This set is connected to the power system by means of three single-phase transformers with a turn ratio of 1:1. Also passive LC filter are connected in parallel with load to eliminate the 5th& 7th order harmonics.

IV.CONCLUSION

Harmonic distortion is a main cause of power quality degradation. For elimination of harmonics active filters are used. Because there is are some disadvantages of passive filter. Improve the compensation characteristic of passive filter. It eliminates the problems of using only a shunt passive filter. Also it improve the behavior of passive filter.It allows the use of active power filter in high power application at relatively low cost.Compensation characteristic of series active and shunt passive filter do not depend upon system impedance. It is achieve due to using vectorial power theory.

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