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Simulink Model of Shunt Active Power Filter Using Instantaneous Power Theory

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***Abstract* -** Active Power Filters (APFs) are the fine solution to power quality problems. Shunt active filters allow the compensation of current harmonics, unbalance, together with power factor correction, and can be much better solution than the conventional approach like passive filters. Harmonic reduction is the key word for the proper operation of APF.In this paper, Performance of Shunt active power filter (SAPF) is analyzed for non linear loads by three phase instantaneous power theory method. The system was tested and modelled in MATLAB/ Simulink simulation package with a shunt active power filter to compensate the harmonics current injected by the loads

***Keywords* -** *Harmonics, Instantaneous active power theory, Shunt active Filter, MATLAB.*

I. INTRODUCTION

The growing use of electronic equipment produces a large amount of harmonics in the power distribution systems because of non-sinusoidal currents consumed by non-linear loads. Due to this, the electric system is hard to measure and anticipate and the effects are harmful to other loads.

To cope with these disadvantages, recent efforts have been concentrated on the development of active power filters. In this paper the development of a shunt active filter is proposed, with a control system based on the p-q theory. With this filter it is possible to effectively compensate the harmonic currents and the reactive power.

In this the real and imaginary powers are calculated for DC and AC components. The DC component is extracted by means of conventional filters while the AC component is used to generate the reference template of the compensation currents.

II. INSTANTENEOUS POWER THEORY

The p-q theory, or "Instantaneous Power Theory", was developed by *Akagi et al* in 1983, with the objective of applying it to the control of active power filters.

Initially, it was developed only for three-phase systems without neutral wire, being later worked by *Watanabe* and *Aredes* , for three-phase four wires power systems.

This theory is based on time-domain, what makes it valid for operation in steady-state or transitory regime, as well as for generic voltage and current power system waveforms, allowing to control the active power filters in real-time. Another important characteristic of this theory is the simplicity of the calculations, which involves only algebraic calculation. The p-q theory performs a transformation (known as " Clarke Transformation") of a stationary reference system of coordinates *a –b - c* to a reference system of coordinates ± - ² - *0*, also stationary.

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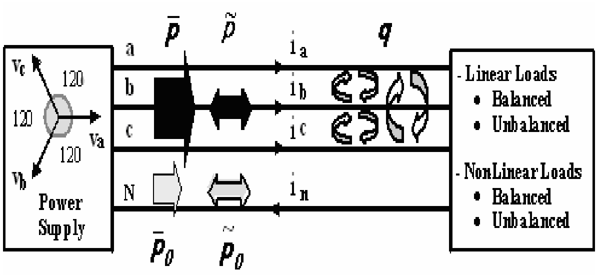


Fig. 2.1 P-q theory power components in a generic three-phase power system

It allows observing the components of the p-q theory in a generic power system. Each one of these power components has a meaning:

p - Medium value of the instantaneous real power

It corresponds to the transferred energy per time unit from the power source to the load, through the $a – b – c$ phases of the three-phase system.

p ~- Alternated value of the instantaneous real power

It corresponds to the energy per time unit that is exchanged between the power source and the load, through the $a – b – c$ phases.

p0 - Mean value of the instantaneous zero-sequence power

It corresponds to the transferred energy per time unit from the power source to the load ,through the neutral wire and one or more phases.

~p0- Alternated value of the instantaneous zero sequence power

It corresponds to the energy per time unit that is exchanged between the power source and the load, through the neutral wire and one or more phases.

q - Instantaneous imaginary power

It corresponds to the power that has to circulate between the phases $a – b – c$ of the three-phase power system (it does not contribute to any transference of energy from power source to load, but produces undesirable currents).

III. SIMULATION

The simulation diagram with shunt Active Power Filter is shown in Figure. The diagram consists of the source, non-linear load, shunt Active Power Filter and its control circuit.

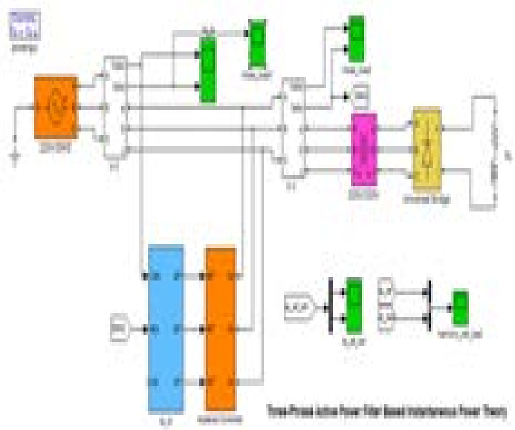


Fig. 3.1 Simulink Model of Instantaneous Power Theory

IV. SIMULATION RESULTS

The harmonic current compensation is implemented in a three-phase power system using a shunt active power filter. The rms value of source voltage of the system is set as 480V and a combination of three-phase universal bridge rectifier with an RLC load across it constitutes the nonlinear load which introduces the harmonics into the system.

The source current waveform without filter in a-phase is shown in Fig. 4.1 The compensating current waveform in a phase is illustrated in Figure 4.2. The source current after the injection of compensating current is shown in Fig. 4.3.

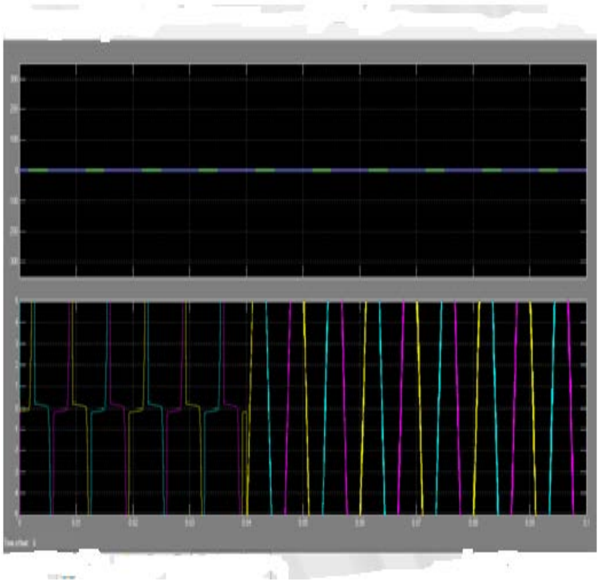


Fig 4.1 INPUT SOURCE VOLTAGE & CURRENT BEFORE APPLYING FILTER

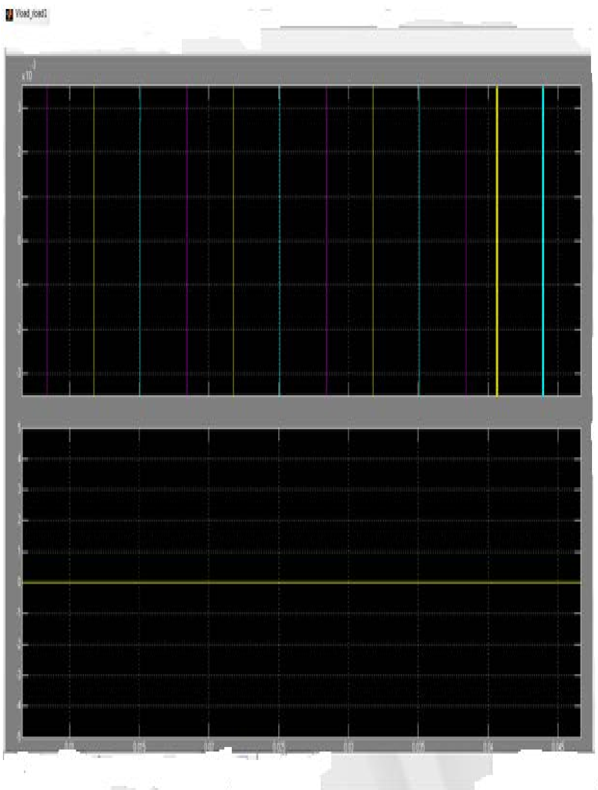
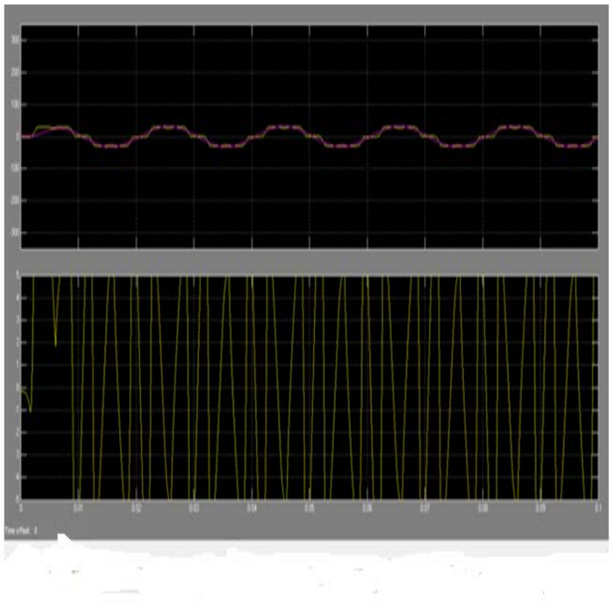


Fig.4.2 LOAD VOLTAGE & CURRENT BEFORE APPLYING FILTER



V. CONCLUSION

In this paper, it is shown through computer simulations, using *Matlab/Simulink*, that the p-q theory can be used with success in the implementation of shunt active power filters controllers. The following conclusions could be achieved regarding the studied active filter and its control system:

- It compensates dynamically the harmonic currents
- It corrects dynamically the power factor
- It balances and reduces the values of the currents supplied by the source to the load
- It turns the instantaneous three-phase power that source delivers to load into a constant value (the source only delivers conventional active power).

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