

Shunt Active Filter Algorithms for a Three Phase System

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Abstract: This paper project we study the simulation of Shunt Active Power filter by using Indirect current control technique. This control techniques are working under both balanced and unbalanced three phase voltage source conditions and it is feeding to aadjustable speed drive the torque speed characteristics of a motor is presented. Indirect current control technique is implemented under dynamic load condition and load balanced condition. The equal current distribution method of synchronous detection theory is used here to calculate the three phase compensating currents to be provided by the active filter.

Keywords: Power Quality, Shunt active filter, indirect current control,

1. Introduction

The wide use of non-linear loads such as uninterrupted power supplies (UPS), adjustable speed drives (ASD), furnaces, and single phase computer power supplies etc cause power quality problems such as harmonic currents, poor power factor and voltage sag/swell increase in reactive power. There are several shunt active filtering algorithms developed. This paper presents the latest advanced techniques indirect current control technique of the Active filter; the three-phase reference supply currents are obtained using a closed loop PI controller. A Hysteresis PWM current controller is employed over the reference and sensed supply currents to generate gating pulses of IGBT's of the Active filter. The control algorithm used in this is synchronous detection theory based on Equal current distribution, but this theory, in its original form, will not work under the condition of voltage distortion. In this paper, simulation results of indirect current control technique are present.

2. Indirect Current Control

There are different control techniques available for obtaining the reference currents for active filter circuit. Those are;

- Instantaneous reactive power theory
- Indirect current control technique
- Power balance theory
- Synchronous frame based controller
- Sliding mode controller and Flux based controller.

The fig: 2.1 shows the basic control scheme of the AF using indirect current control. Three-phase voltages at PCC along with dc bus voltage of the AF are used for implementation of control scheme.

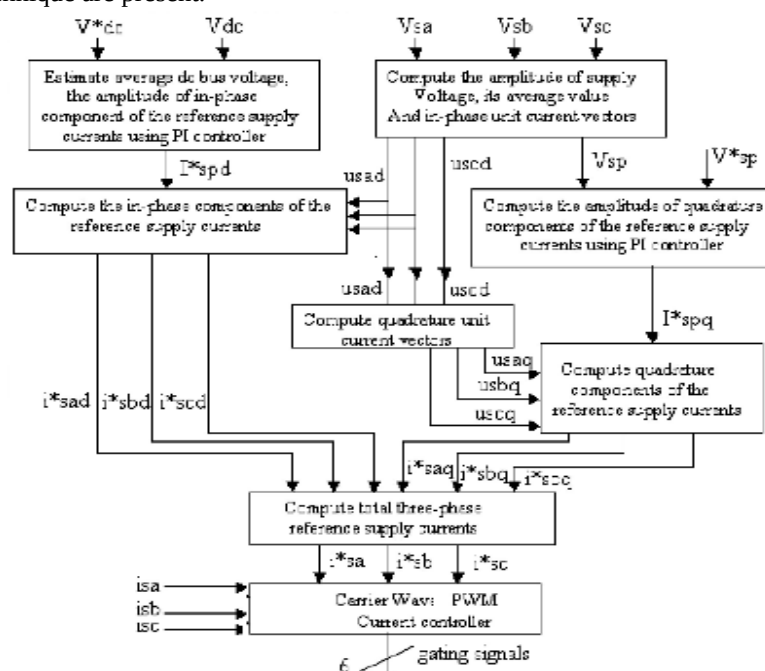


Figure 2.1: the basic control scheme of the AF using indirect current control

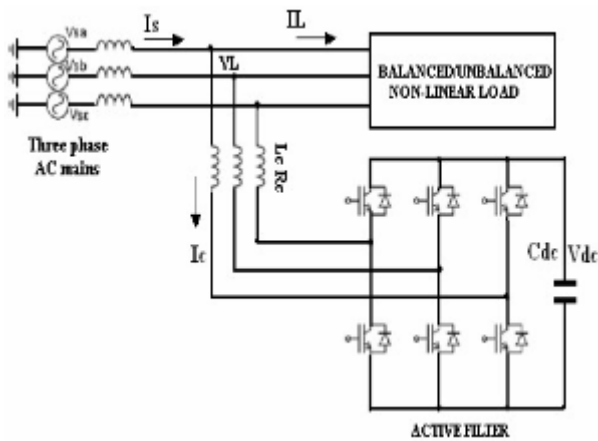


Figure 2.2: Configuration of three-phase shunt active power filter

2.1 Hysteresis Based Current Controller

A Hysteresis current controller is used over reference supply currents and sensed supply currents to generate gating signals to the IGBT's used in the VSI Bridge working as the AF. In response to gating pulses to the AF, eliminates harmonics, correct the power-factor at PCC to nearly unity and balances the unbalanced nonlinear load while maintaining a self-supporting dc bus of the AF. The actual current is forced to track the sine reference within the hysteresis band by back and forth (or bang-bang) switching of the upper and lower switches. The inverter then essentially becomes a current source with peak-to-peak current ripple, which is controlled within the hysteresis band, which makes the source current to be sinusoidal.

2.2 Ramp-comparator Current Controller

In this method the actual values of the three -phase load currents are measured and compared to the reference currents. The generated error signals are compared to a triangular waveform of fixed frequency and amplitude. The following fig2.3 shows the block diagram of the Ramp-comparator current controller.

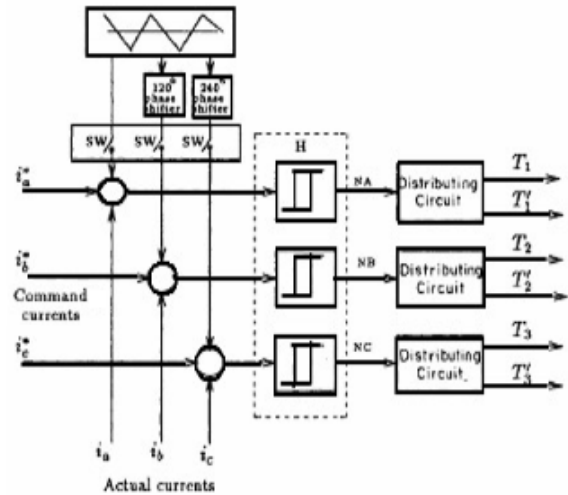


Figure 2.3: The block diagram of Ramp-comparator current Controller

2.3 PI Controller

Comparison of Average value of DC bus voltage (V_{dc}) and reference value of dc bus voltage (V_{dc}^*) of the AF results in a voltage error, which is fed to a PI controller as shown in figure.

$$V_{dc \text{ error}} = V_{dc}^* - V_{dc}$$

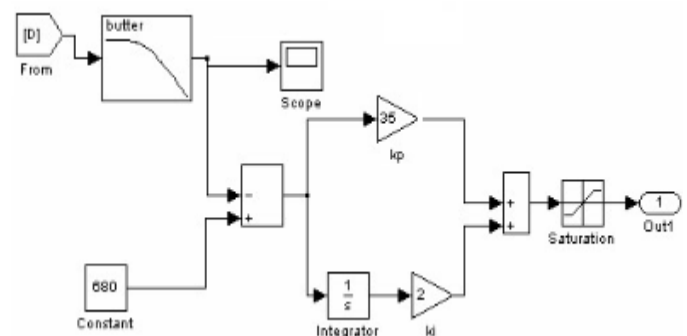


Figure 2.4: PI controller

Here, proportional (K_p) and integral gains (K_i) are so chosen, such that a suitable DC bus voltage response is achieved. The output of PI controller is taken as amplitude (I_{sp}^*) of the reference supply currents.

PI Controller Gain Constants:

Proportional controller gain value = 0.35.

Integral Controller gain value = 2.

The Capacitor Reference Voltage = 680 V.

Different current control techniques available for obtaining the reference currents for active filter circuit are discussed in this chapter. Indirect current control technique is used in this work, which is easy to implement, and requires less number of current sensors and transformations.

3. Simulation Model Result

The simulation model for the indirect current control is shown in fig: 2. Three phase supply is used under both balanced and unbalanced conditions. Unbalanced case fifth

and seventh harmonics are high. Third harmonic content was zero because of three phase.

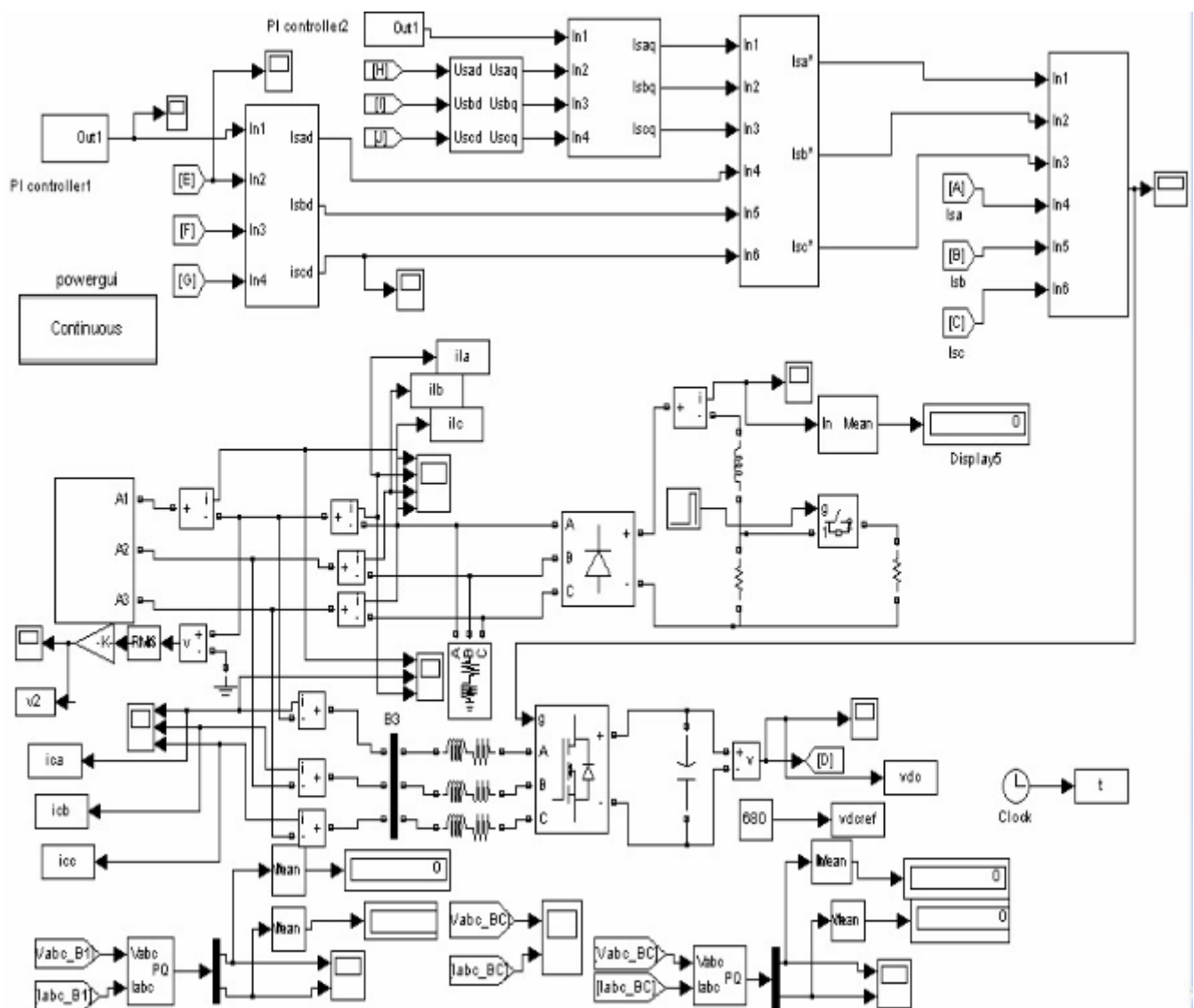
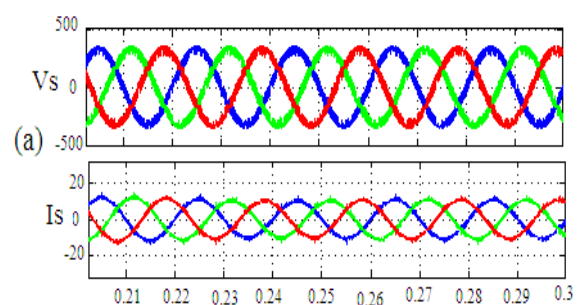


Figure 2.5: The Simulink Model for Voltage regulation

The simulation results of the shunt active power filter is carried in MATLAB/Sim Power Systems environment. The simulation results are shown below. As can be seen from the figure, the non-linear load is a three-phase bridge rectifier feeding an adjustable speed drive. The simulation is done for various source and load conditions for providing harmonic compensation, load balancing and reactive power compensation. It can be clearly seen that by using Synchronous detection technique THD value is less compared to indirect current control technique.



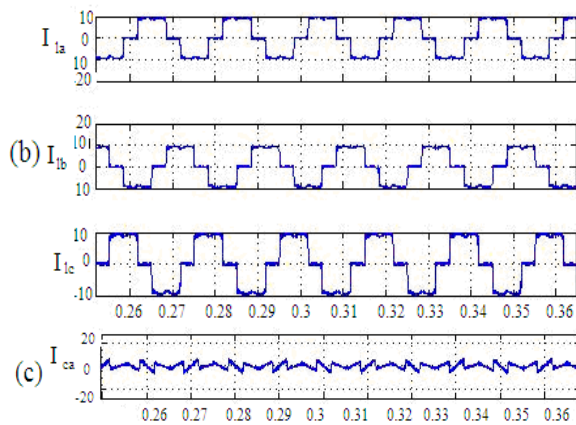


Figure 3.1: Indirect current control wave forms under balanced three phase (a) Supply voltage& current (b) load current (c) filter current

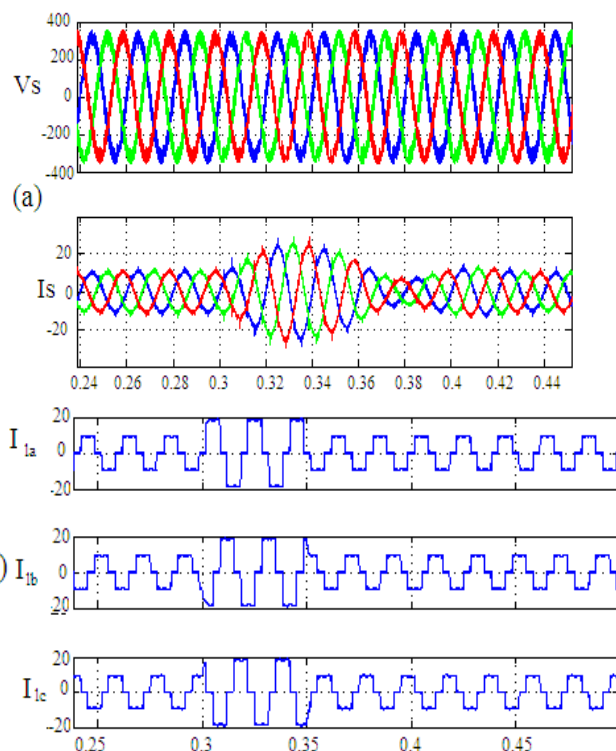


Figure 3.2: Indirect current control wave forms under dynamic Load condition load is changing from 5KW to 10KW to 5KW. Three phase (a) supply voltage& current (b) Load current

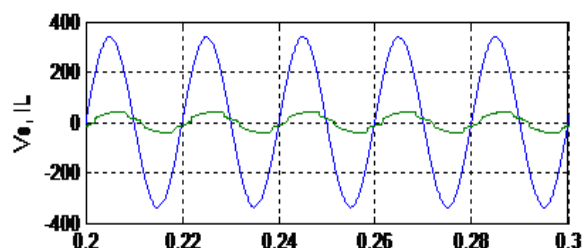


Figure 3.3: power factor is unity for supply voltage and current

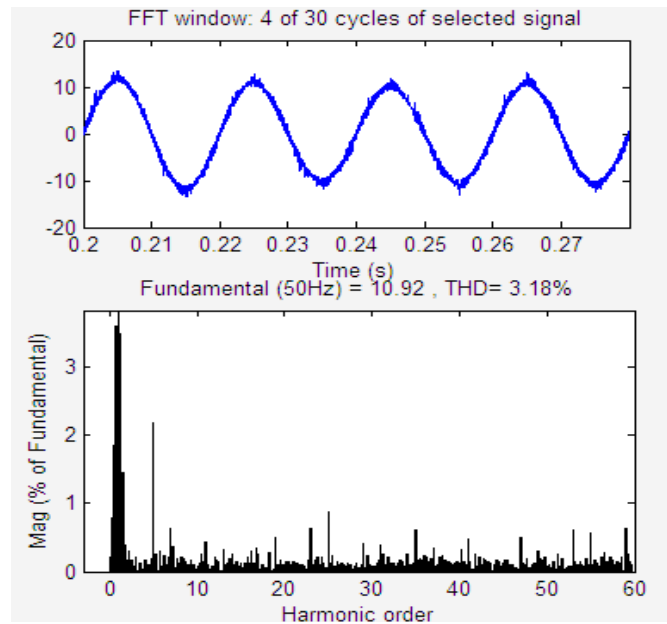


Figure 3.3: Indirect control FFT analysis for supply current

Table 1: shows that by using indirect current control the THD value

Control techniques	THD%
Indirect current control	3.18

4. Conclusion

In this paper, indirect current control method using equal current division technique have been applied to a shunt active power filter to compensate for reactive and harmonic currents under balanced and unbalanced source voltage conditions. The simulation has been carried out in MATLAB environment and power factor is unity for supply voltage, current.

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