Simulation Study of PWM Techniques for Voltage Source Converters

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Abstract: *In this project we study the simulation of Different types PWM technique for Voltage Source Converters. PWM techniques for VSC are discussed in this Paper. Ramp Comparator current control technique Explained with their corresponding advantages and disadvantages and it is explained that the ramp comparator current control technique is more efficient in providing switching pulses than the hysteresis current control technique.*

Keywords: Power Quality, Shunt active filter, uninterrupted power supply, adjustable speed drives, PWM Techniques

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. A Hysterisis PWM current controller is employed over the reference and sensed supply currents to generate gating pulses of IGBT's of the Active filter. But hysteresis current control having disadvantage like the switching frequency varied during fundamental period, this may be results in increased switching losses and phase angle errors. To overcome problems in the Hysterisis current control, a Ramp-comparator current controller is used. Results of both Hysterisis current control method and Ramp- comparator current control method are compared, which shows the Ramp-comparator current control method is better than Hysterisis current control method for harmonic reductions. In this paper, the simulation model of Different types PWM technique for voltage Source converters. PWM techniques for VSC are discussed in this. Hysterisis current control technique and ramp comparator current control technique is present.

2. Active Power Filters

Fig. 2.1 shows the components of a typical active-power-filter system and their interconnections. The information regarding the harmonic current, generated by a nonlinear load, for example, is supplied to the reference current/voltage estimator together with information about other system variables. The reference single from the current estimator, as well as other signals, drives the overall system controller.
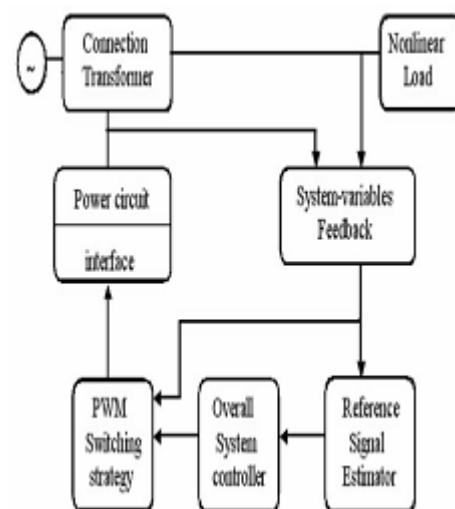

Figure 2.1: Generalized block diagram for Active power filter

2.1 Classification of Active Power Filters:

Active power filters can be classified using the following criteria.

(a) Classification based on the Converter type
(b) Classification based on the supply system
(c) Power-circuit configuration and connections
(d) System parameters to be compensated

2.2 Three Phase Active Filtering System
The active filtering system is based on a philosophy that addresses the load current distortion from a time domain rather than a frequency domain approach. The most effective way to improve the distortion power factor in a non-sinusoidal situation is to use a nonlinear active device that directly compensates for the load current distortion. The performance of these active filters is based on three basic design criteria.

1. The design of the power inverter (semiconductor switches, inductances, Capacitors, dc voltage)
2. Control method

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3. Method used to obtain the current reference or the control strategy used to generate the reference template.
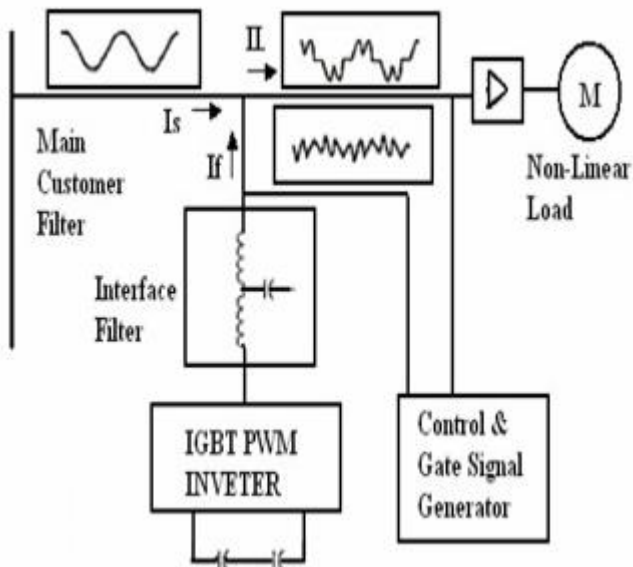

Figure 2.2: Shunt Active Power Filtering

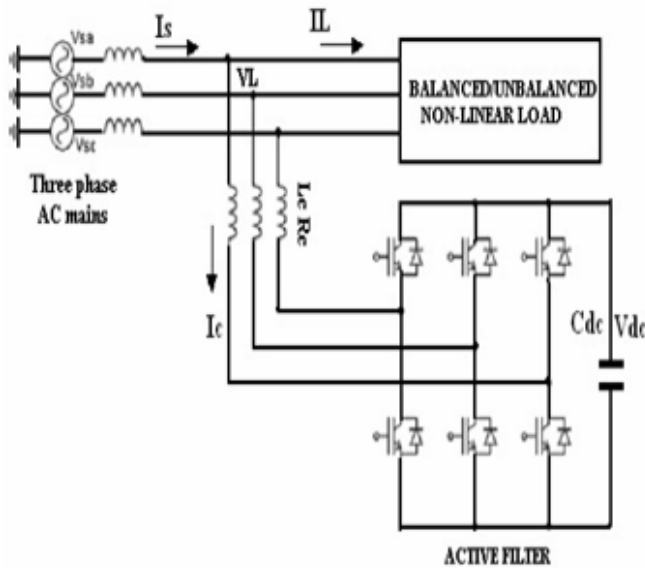## 2.3 Configuration of Three Phase Shunt Active Power Filter

Figure 2.3: Configuration of three-phase Shunt active power filter

The basic configuration of a three -phase three-wire active power filter is shown in Fig 2.3. The diode bridge rectifier is used as an ideal harmonic generator to study the performance of the Active filter. The current-controlled voltage-source inverter (VSI) is shown connected at the load end. This PWM inverter consists of six switches with anti- parallel diode across each switch. The voltage which must be supported by one switch is uni-polar and limited by the DC voltage Vdc.

2.4 Configuration of Reduced Switch Count Active Power Filter:

It uses the principle that in a balanced three-phase system if two-phase currents are controlled then the current in the third

leg is automatically controlled. Hence the inverter shown uses only two legs, but uses an additional capacitor to provide a zero voltage return point for the third winding
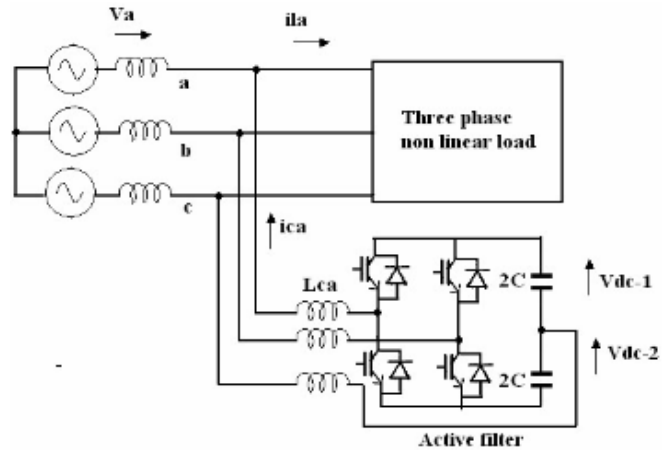

Figure 2.4: Reduced Switch APF

3. PWM Techniques for Voltage Source Converters

In many applications it is desirable to have a nearly sinusoidal output. In order to achieve sine wave output from square wave output waveform, large filters are required to filter out the low order harmonic contents from the square wave output. With PWM control it is possible to achieve sinusoidal outputs. In voltage source converters (VSC), variables to be controlled are the amplitude and frequency of the converter output voltage. PWM techniques enable the modulation of the controllable switches of the converter. By proper modulation of the controllable switches, a high frequency converter output voltage can be generated, Various PWM techniques are there for getting sinusoidal output, and they are;

1. Sine triangle PWM
2. Selective harmonic elimination method of PWM
3. Stair case PWM
4. Current control PWM
5. Space vector PWM

3.1. Hysteresis Based Current Controller

A Hysterisis 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 hysterisis band, which makes the source current to be sinusoidal.

3.2 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 allowing fig3.1 shows the block diagram of the Ramp-comparator current controller.
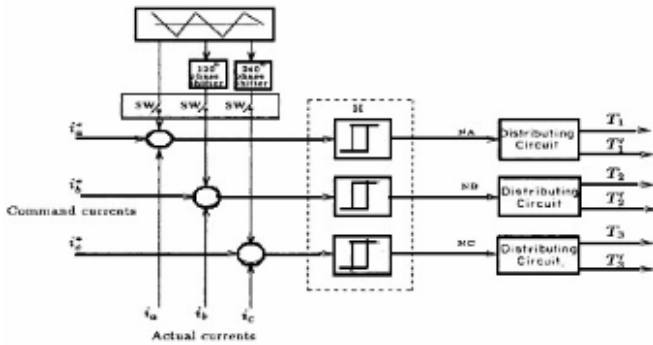

Figure 3.1: The block diagram of Ramp-comparator current Controller

4. Simulation Model Results

The simulation was performed on the MATLAB/SIMULINK package. Simulink is a software package for modeling, simulating and analyzing dynamic systems. It supports linear and nonlinear systems, modeled in continuous time,

Results with Ramp-comparator current control method:

The steady state response of the active filter for 10KW non-linear load with ramp comparator current controller is shown below.
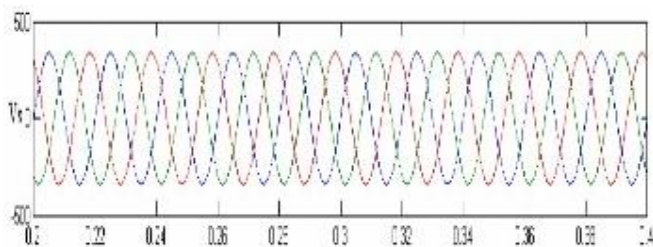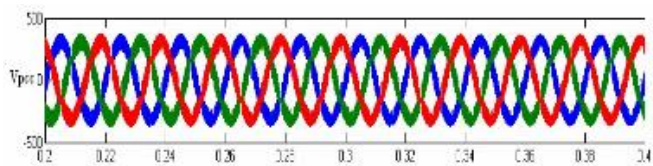

Figure 4.1: Source voltage

Figure 4.2: Voltage at the point of common coupling
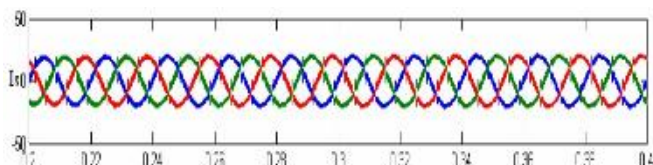

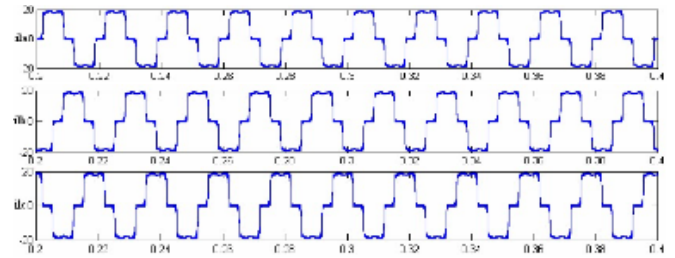**Figure 4.3:** Three phase source currents

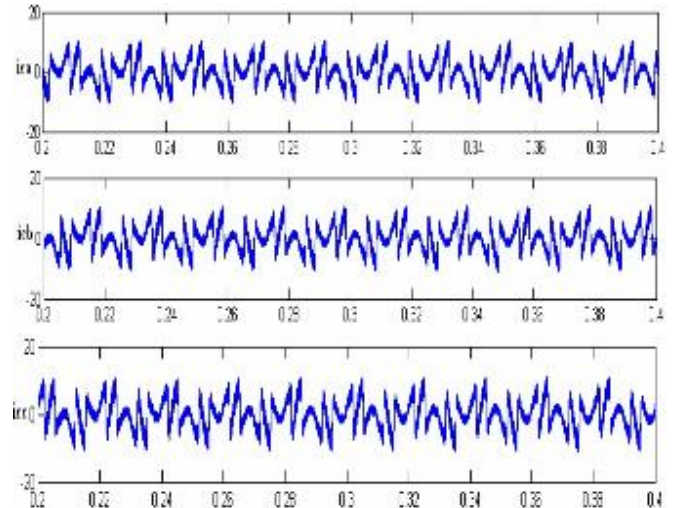**Figure 4.4:** Load currents Ila, Ilb, Ilc

Figure 4.5: Compensating currents Ica, Icb, Icc
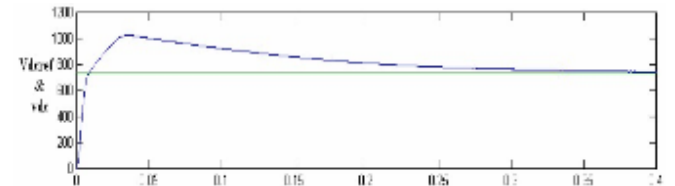

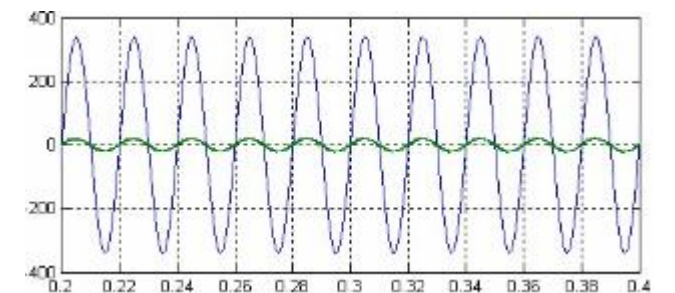**Figure 4.6:** Reference voltage and the actual Voltage of the capacitor

Figure 4.7: Phase A voltage and current showing the unity power factor operation

Figure 4.8: Simulation diagram of Ramp-comparator current controller

5. Conclusions

In this paper Ramp-comparator current controller are simulated in Simulink. It is observed that both the controllers have satisfactory performance. With both the controllers, the supply power factor is improved to unity, with the harmonics in the supply current being eliminated for different types of loading conditions. As the switching frequency is fixed in the case ramp comparator current control method it has better performance when compared with hysteresis current control method.

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