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POWER QUALITY CONTROL ON NON LINEAR LOAD USING SLC CONVERTER

[1]Garima Goswami, [2]Pankaj kumar Goswami

[1, 2] Jaipur National University, Jaipur (RAJ) India
Email : grmsinha@gmail.com

Abstract
This paper presents a power electronic system for improving the power quality of the unbalanced non linear load. An electronic converter (synchronous link converter) along with PI controller is proposed to correct the system unbalance and harmonics so as to deal with the power quality problems. A carrier less hysteresis current controller is employed over the reference and sensed supply currents to generate gating pulses for the IGBTs of SLC. The operation and control of the converter are described. The smaller THD, the harmonic pollution in the power system will be reduced and the power quality will be increased. The proposed approach has been tested and validated using Matlab/Simulink software. The simulation results are shown to demonstrate the advantages of the proposed scheme and enhance the system power quality.

Keywords: *PI controller, matlab/simulink, Active Filter, Hysteresis current control.*

INTRODUCTION

Active filtering of electric power has now become a mature technology for harmonic and reactive power compensation in two-wire (single phase), three-wire (three phase without neutral), and four-wire (three phase with neutral) ac power networks with nonlinear loads. This paper presents a comprehensive review of active filter (AF) configurations, control strategies, selection of components, other related economic and technical considerations, and their selection for specific applications. It is aimed at providing a broad perspective on the status of AF technology to researchers and application engineers dealing with power quality issues. Solid state control of ac power using thyristors and other semiconductor switches is widely employed to feed controlled electric power to electrical loads, such as adjustable speed drives (ASD's), furnaces, computer power supplies, etc. Such controllers are also used in HV dc systems and renewable electrical power generation. The use of power converters, electronics equipments and other nonlinear loads are rapidly increasing in industry and also by consumers. These equipments draw nonlinear currents from the AC mains as compare to traditional loads such as motors and resistive heating elements. This leads to the distortion of power system voltage and other problems. In general industry and consumers both are responsible for the increasing deterioration of the power system voltage and current waveforms. Fig.1 presents a power system with sinusoidal source voltage (vs) operating with linear and nonlinear loads. The non linear load current (iL1) contains harmonics and is non sinusoidal. The resulting harmonics in the source-current (is) produces a nonlinear voltage drop (Δv) in the line impedance, which distorts the load voltage (vL). Since load voltage is distorted, even the current at the linear load (iL2) becomes non sinusoidal. The presence of harmonics in power lines result in low Power factor, low efficiency, increased power losses in the distribution system and interference problems in communication systems. Sometime this leads to the failures of electronic equipments, which are very sensitive to voltage and current distortions. Passive filters can be used to compensate these power quality problems to some extent, but they have limited operation range and solve/reduce the problem for the specific frequencies they are tuned for. Besides, passive filters have large size, more losses, fixed compensation characteristics and problem of resonance. Therefore, they do not provide the complete solution. This document is a template. An electronic copy can be downloaded from the conference website. For questions on paper guidelines, please contact the conference publications committee as indicated on the conference website. Information about final paper submission is available from the conference website.Fig1

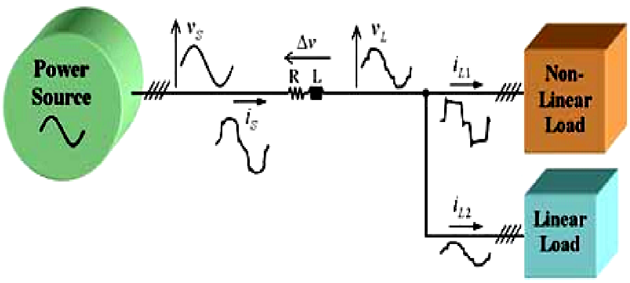


FIGURE 1 A POWER SYSTEM NETWORK WITH LINEAR AND NON LINEAR LOAD

HYSTERESIS CURRENT CONTROL

The hysteresis current control (HCC) scheme is based on a nonlinear control as shown in Fig.2The compensating currents are compared with the reference currents by using hysteresis comparators to generate the switching pulse. These pulses are used to control the IGBTs to turn on and turn off. The basic concept of the hysteresis current control is shown in Fig.2 According to Fig.2; hysteresis band (HB) is the possible boundary of the compensating current. This current swings between upper and lower hysteresis limits.

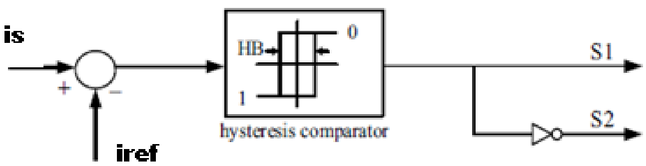


Figure 2 Hysteresis current control scheme

PROPOSED DESIGN OF PARALLEL CONVERTER SCHEME

A diode rectifier effects the ac/dc conversion, while the Controller operates the switch in such a way to properly shape the input current ig according to its reference. The output capacitor absorbs the input power pulsation, and allowing a small ripple of the output voltage V_L. The boost topology is very simple and allows low-distorted input currents and almost unity power factor with different control techniques. Moreover, the output capacitor is an efficient energy storage element (due to the high output voltage value) and the ground-connected switch simplifies the drive circuit.SLC is operated to improves the power quality of diode bridge rectifier non linear load by injecting a compensated current such that summation of input load current and auxiliary converter current makes the source current sinusoidal and in phase with the input source voltage.This principle can be used in variety of nonlinear loads which are considered as sources of harmonics. Moreover,with an appropriate control scheme, SLC not only compensates the harmonic component of source current but also takes care of reactive power demand of non linear load.As the source voltage and source current becomes in phase with each other, hence overall power factor is also improved. In this way the power distribution system sees the combination of nonlinear load and auxiliary converter (SLC) as an ideal resistor. The auxiliary converter is controlled in such a way that sum of main converter input current and auxiliary converter input currents are sinusoidal and in phase supply voltage. Reference input current of auxiliary converter is derived using a feedback of output dc voltage of SLC and main converter which are connected in parallel, comparison of rms values subsequently compared with the actual output dc voltage to drive the reference for the input source current.

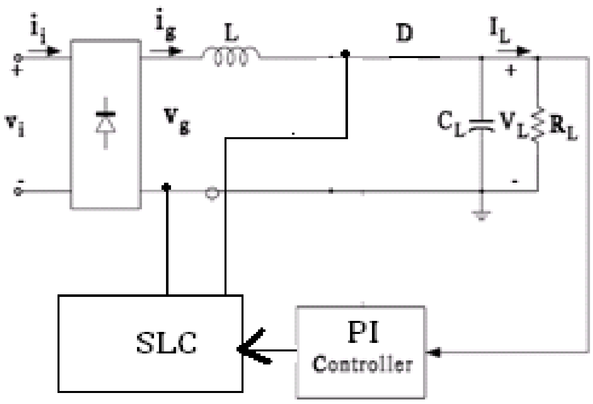


Figure 3 Proposed Converter Scheme

POWER QUALITY ANALYSIS WITH LINEAR LOAD APPLICATION

Simulink model is given to show power quality on linear load, theoretically **as** well as practical realization shows smooth current wave form, this result is basically provided to get a difference on power quality on non linear load application.

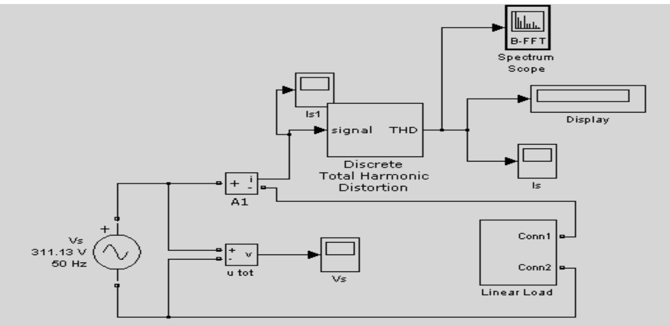


Figure 4 Simulink model at linear load

Simulation results at linear load

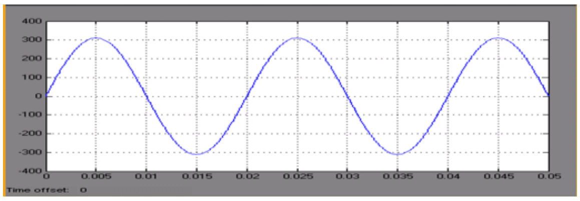


Figure 5 Source Voltage

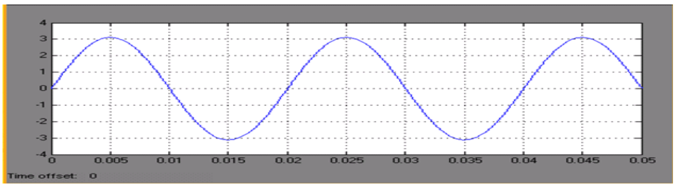


Figure 6 Line current

POWER QUALITY ANALYSIS WITH NON LINEAR LOAD APPLICATION

During the load application on power supply in its various applications the quality of power becomes poor due to effect of non linear load (like electronic appliances), here a Simulink model is given to show the effect of non linear load (power rectifier) on power quality in terms of its harmonic distortions. The distorted current wave form is being depicted to show problem issue on application of non linear load

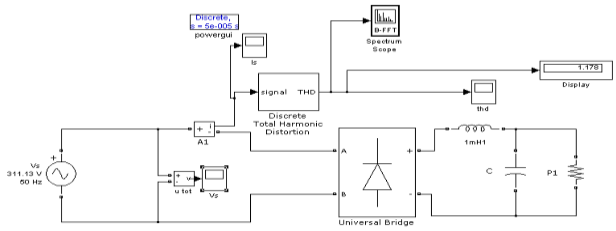


Figure 7 Simulink model of Power analysis on nonlinear load

Simulation results at non linear load

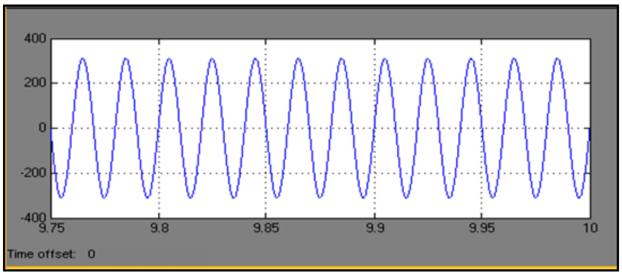


Figure 8 source voltage

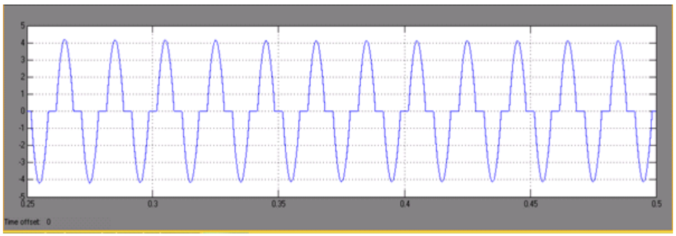
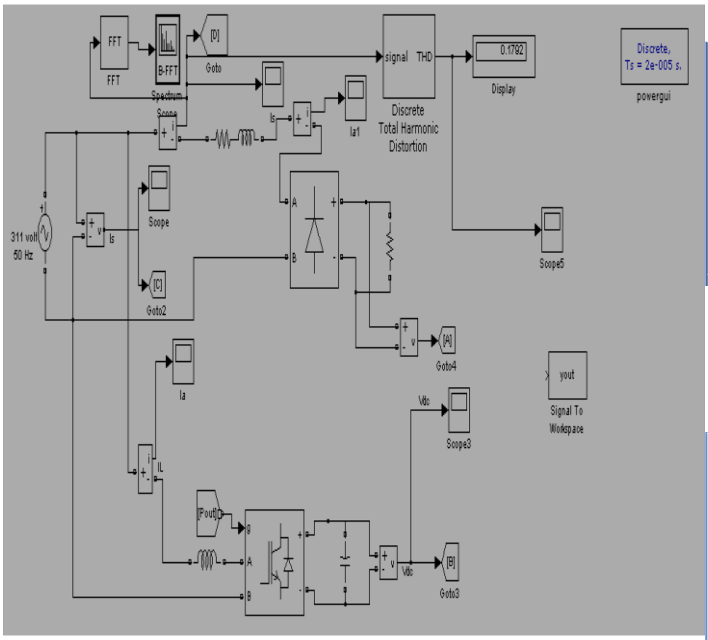


Figure 9 Harmonic distortion in line current at non linear load

POWER QUALITY IMPROVEMENT ON NONLINEAR LOAD USING SLC WITH PI CONTROLLER

As now it is clear from above analysis, the addition of non linear load produces a very high Level of distortion in power quality that is shown in terms of percent THD. Finally a Simulink based model is proposed to reduce these harmonics from input current and hence to provide significant improvement in overall THD



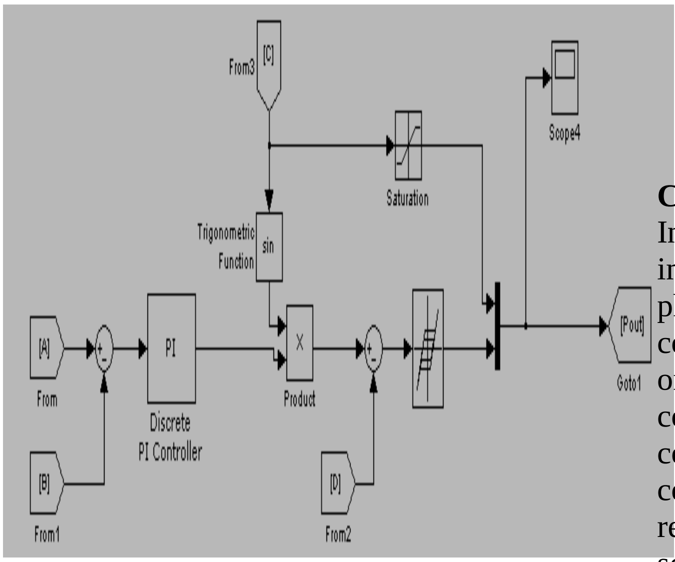


Figure 10 Simulink model of proposed control scheme

Simulation results at non linear load with proposed Scheme (SLC)

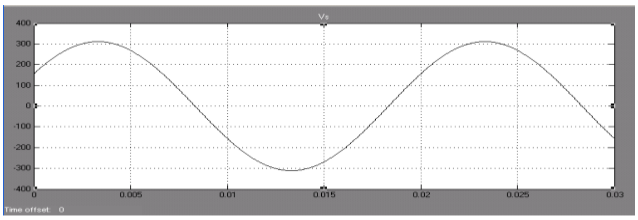


Figure 11 Source Voltage

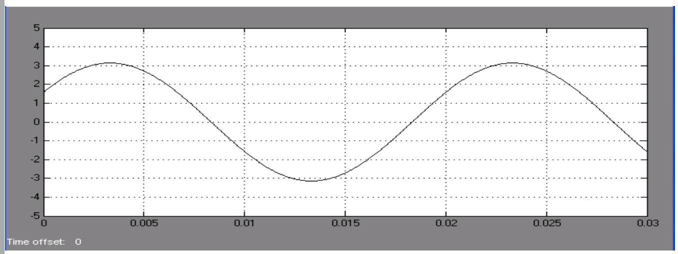


Figure 12 Line current with improved quality

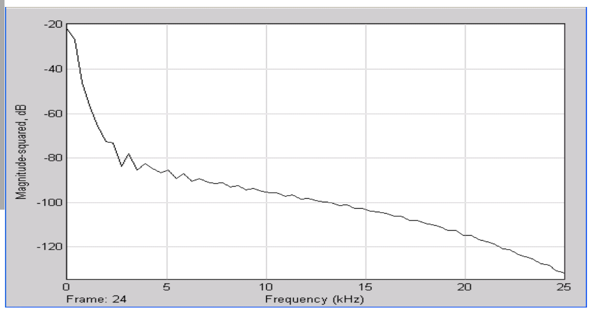


Figure 13 Reductions in THD of line current

CONCLUSION

In this work an effort has been made to develop and implement a harmonic compensator for single phase diode bridge rectifiers AC to DC unregulated converter (main converter). The principle is based on parallel power processing. An auxiliary converter which is basically a synchronous link converter is connected in parallel to the main converter in order to compensate the harmonic and reactive power of the main converter. The above scheme has been simulated using MATLAB simulation software. Various simulation results are presented for the comparisons.. This has the flexibility of PC based control. Using MATLAB software PI control is implemented in the digital environment. It is found that initially (with linear load) the waveform of source current was sinusoidal and in phase with source voltage thus having power factor unity. With the application of non linear load the waveform of source current became distorted having THD as 117% thus power quality becomes poor having power factor other than unity. As we apply SLC with PI controller and simulate the model with the help of MATLAB it was found that the waveform distortion of source current has been reduced to 12% thus the power quality is improved with power factor close to unity.

TABLE- I

COMPARATIVE ANALYSIS OF POWER QUALITY IMPROVEMENT

Load	Applied voltage (peak value) (Vs)	Source current (peak value) (Is)
With linear load	311.13v	3.2 A without distortion
With non linear load	311.13v	Appx 3.2 A with very high THD(appx 117 %)
With non linear load using SLC with PI controller	311.13v	3.2 A with very reduced THD (12 %)

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