PI &Fuzzy Logic Controller for Power Quality Control on Nonlinear Industrial Applications

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Abstract--The industry revolution requires many attributes to enhance productivity and reduces the production costs. In same series, the product quality follows the feature rules of smart industry systems. The quality is the prime concern among many; therefore, this paper elicits the design strategy of a controller system to improve power quality under industrial revolution 4.0. This helps in harmonic reduction and power quality (PQ) improvement at nonlinear load conditions in industrial applications. A design is modelled and evaluated for common converter application to compensate the harmonics for Single phase AC to DC bridge rectifier. Generally, it works as main converter in unregulated mode for most of the device application in automatic industry applications. The work describes the scheme where an auxiliary Synchronous Link Converter (SLC) is used for current compensation though shunt connection with the main converter unit.The adequate control on phase excitation results in elimination of harmonic components from the supply current and hence significant improvement in power quality. The turn on and turn off time is measured by an adequate signaling byPI/Fuzzylogic controller. This action results in advance filtering technique for nonlinear load applications in industrial system to avoid failure and faulty performance.

Keywords: **SAPF, APF, PI, FLC, PQ, Harmonics, MATLAB/Simulation.**

1.Introduction

The non-linear loads are seen in large industrial devices like arc furnaces, variable frequency drives (VFD and high voltage rating rectifiers. The harmonics produced by them are typically confined and only observed by somearea experts only. But nowthe times have changed. The problems related to harmonics are now common in not only automation but in domestic world as well.As the no. of connected nonlinear loads is increased the overall sum of harmonics is also increasedwhich can destroy components like circuit breakers and fuses and records wrong measurements in utility meters. We use the nonlinear loads in our daily life as well as in industries also, that can produce harmonic distortions. These may be electronic lighting ballasts, PLCs, printers, fax machines, TVs, refrigerators and computers. Passive Filters can be used while working with a non-sinusoidal system to compensate the power quality problem but on account of their tuning for some frequencies they have limitations in their operating range. In this paper we have worked with active filter for harmonic reduction in line current.

2. Shunt Converter Scheme

The phenomenal attributes of Active Power Filter (APF) current compensation scheme is shown in figure 1, it contains parallel processing scheme of converters which is castoff for power quality improvement of uncontrolled nonlinear loads, which is the main objective of this paper. The main contribution of this paper is to design a shunt APF scheme to compensate the harmonic current in the line current. It is connected in shunt with the main dc converter unit with a resistive load along and a dc capacitor. Both the converters (main and auxiliary) are linked in parallel at both input and output terminals. The SLC is controlled by an appropriate controller, made by switching device like IGBT. The gate pulse controls the turn on/off of IGBT in such a manner that the greater part of active power is diverted to the main converter. While, distorted power current component is produced by the core converter. This flows through the ancillary or secondary converter (SLC).

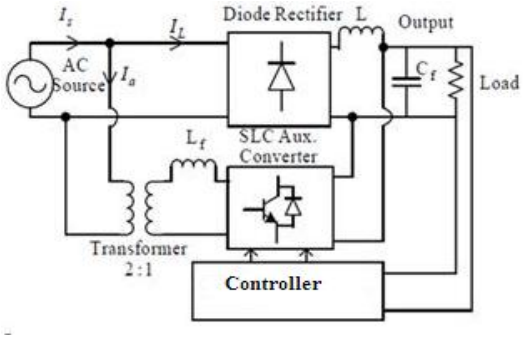

Fig.1 APF model

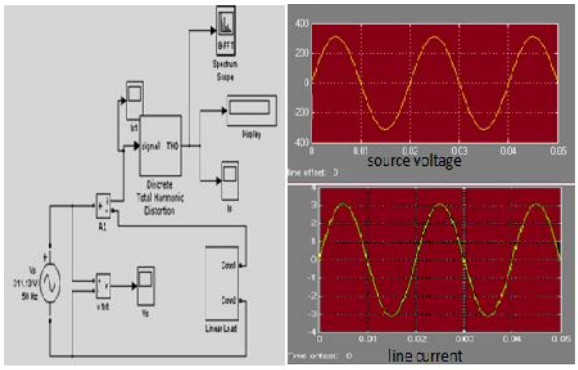

Fig.2 Model and results of linear load

We have also focused on the strategy to create and verify the control of converter's parallel power processing scheme using MATLAB/Simulation. As soon as the angle amid the source current and voltage reaches to zero, it will cause the improvement of overall power factor and thus the power quality is also improved.Thus, the combination of auxiliary converter (SLC) and nonlinear load can be considered as a pure resistive circuit. The controlling of auxiliary converter should beresultant of input current of auxiliary converter and main converter. The controller we have used here is PI controller first and then fuzzy logic controller and after that compare the results of both.

3. Linear load Application: Analysis of Power Quality

In application of many devices where linear components are the prime entities, there such kind of models are generated, and it is found that a linear load exhibits a phase synchronization with sinusoidal wave outcomes as shown in fig.2.

4. Application of Non Linear load :Analysis of Power Quality

The same supply is linked to nonlinear load the main current will contain harmonics and the power quality becomes poor.

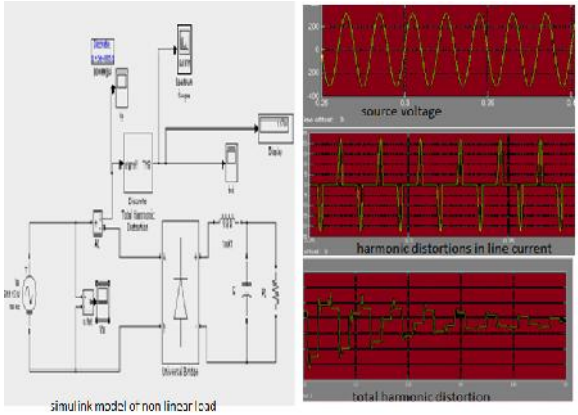

Fig.3 simulink model and simulation results of nonlinear load

5. Nonlinear Load Using PI Controller with SLC: Power Quality Improvement

The main schemes depict the implementation of auxiliary or secondary converter (SLC) in shunt with the nonlinear load as primary converter. This controls the turn on/off time of SLC is controlled using PI controller the harmonics are reduced and the line current becomes sinusoidal again thus the power quality is improved.fig.4 isshowing the simulation diagram and simulation results of nonlinear load using PI controller.

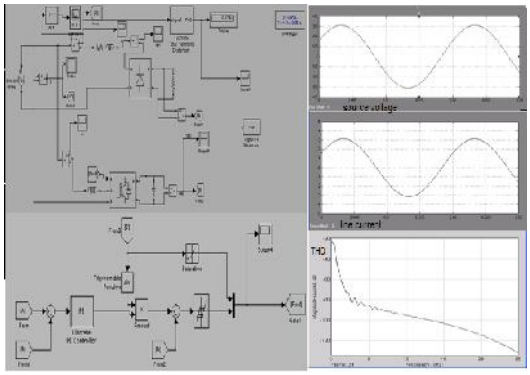

Fig.4simulink model and simulation results of nonlinear load with PI controller

6. Nonlinear Load Using Fuzzy Controller with SLC:Power Quality Improvement

The FLC is implemented to control the gate pulse of SLC, this retrieves the signal shapes of sinusoidalsource voltage and reduces the THD by5%, which can be depicted by fig.4, it shows fuzzy logic controller implementation on non-linear load.

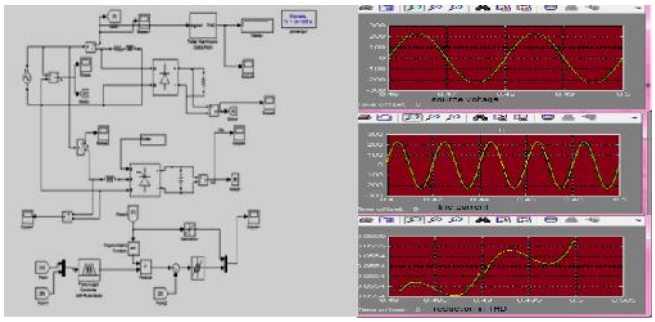

Fig.4 fuzzy controller

Conclusion

In this paper, a model is developed to diminish harmonics and enhances the quality of power on nonlinear load using SLC (synchronous link converter) for a common industrial solution. An implementation for PI control and fuzzy logic control has been done in the digital environment by using of MATLAB/Simulink. The different model shows sinusoidal waveform on linear applications but as soon as the non-linear device is applied main current signal became inaccurate thus power quality becomes poor. With the application of SLC in association with PI/Fuzzy controller to control adequate firing by gate signaling of IGBT andafter the simulation of designed model using MATLAB it has been found that the source current waveform became again sinusoidal with reduced distortions thus, we got the improved power quality.Table1 presents the analogous study of power quality control to compare the distortions in the four different cases.

Table 1: Analytical Observations

Type Load	Mains (V)	Current through Main Converter (A)
nonlinear	320	3.0 A Distortion less
nonlinear	320	3.0 A THD (117%)
nonlinear using SLC and PI controller	320	3.0 A THD (12%)
nonlinear using SLC and fuzzy logic controller	320	3.0 A THD (5 %)

Bibliography

[1]. Senthilk umar A.,Poongothai K.,SelvakumarS.,Silambarasan M. P.Ajay-d-Vimalraj“Mitigation Of Harmonic Distortion In Microgrid System Using Adaptive Neural Learning Algorithm Based Shunt Active Power Filter” published by Elsevier,2015, energy procedia,pp147-154.

[2]. R.Belaidi,A. Haddouche, H.Guendouz "Fuzzy logic controller based three- phase shunt active power filter for compensating harmonics and reactive power under unbalanced mains voltage" published by Elsevier,2012, energy procedia,pp560-570.

[3]. Dr. R.K. Tripathi, Member, IEEE &Mr. ChandreshverPratapSingh "Power Quality Control of Unregulated Non-linear Loads", Power, Control and Embedded Systems (ICPCES), 2010 InternationalConference on Nov. 29 2010-Dec. 1 2010 , 1 - 6

[4]. SinghB., SinghB. N., ChandraA., Al-HaddadK.,PandeyA., and KothariD. P. ,"A Review of Single-Phase Improved Power Quality AC-DC Converters," IEEE Trans. Ind. Electronics, vol. 50, No. 4, 2003,pp. 410-417

[5]. Luis A. Morán Juan W. Dixon José R. Espinoza, Rogel R. Wallace, "Using Active power filters to improvepower quality".

[6]. J. Nastran, R. Cajhen, M. Seliger, and P. Jereb, "Active power filter for nonlinear AC loads," IEEE Trans. Power Electron.,vol. 9, pp. 92-96, Jan. 1994.

[7]. Goswami G., Goswami P.K., "Simulation of Power Quality Control of Non-Linear Load using Fuzzy Controller at MATLAB", International Journal for Research in Science and Advance Technology ,Vol.3, 2013, pp.114-119

[8]. M.T.Benchouia,I. Ghadbane,A. Golea,K.Srairi,M.H.Benbouzid"Design and implementation of sliding mode and PI controllers based control for three phase shunt active power filter" published by Elsevier,2014, energy procedia,pp504-511.