

Active shunt Power filter using PI and FUZZY logic Controller for Power Quality Improvement

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Abstract- In This paper we use PI and FUZZY logic controllers for improve the power quality using shunt active power filter. And PWM pattern generation is based on carrier less hysteresis based current control to obtain the switching signals to the voltage sourced PWM converter. Make a simulation of shunt active power filter in MATLAB.

Keywords- Active shunt power filter, PI controller, FUZZY logic controller, Hysteresis current controller, Power Quality, Harmonics.

I. INTRODUCTION

The application of power electronics devices such as arc furnaces, adjustable speed drives, Computer power supplies etc. are some typical non-linear characteristic loads used in most of the industrial applications and are increasing rapidly due to technical improvements of semiconductor devices, digital controller and flexibility in controlling the power usage. The use of the above power electronic devices in power distribution system gives rise to harmonics and reactive power disturbances.

The harmonics and reactive power cause a number of undesirable effects like heating, equipment damage and Electromagnetic Interference effects in the power system. The conventional method to mitigate the harmonics and reactive power compensation is by using passive LC filters but this method has drawbacks like large size, resonance problem and fixed compensation behaviour. The solution of these problem is the active power filter (APF) comes in to the picture, which gives promising solution to compensate for the above adverse effects of harmonics and reactive power simultaneously by using suitable control algorithms.

This report contains issues related with electrical system about power quality and available solutions to mitigate those issues.

II. POWER QUALITY ISSUE

The PQ issue is defined as “any occurrence manifested in voltage, current, or frequency deviations that results in damage, upset, failure, or misprision of end-use

equipment.” Almost all PQ issues are closely related with PE in almost every aspect of commercial, domestic, and industrial application. Equipment using power electronic devise are residential appliances like TVs, PCs etc. business and office equipment like copiers, printers etc. industrial equipment like programmable logic controllers (PLCs), adjustable speed drives (ASDs), rectifiers, inverters, CNC tools and so on [5]. The Power Quality (PQ) problem can be detected from one of the following several symptoms depending on the type of issue involved.

- Lamp flicker
- Frequent blackouts
- Sensitive-equipment frequent dropouts
- Voltage to ground in unexpected
- Locations
- Communications interference
- Overheated elements and equipment

III. SOLUTION OF POWER QUALITY PROBLEM

There are two approaches to the mitigation of power quality problems. The first approach is called load conditioning, which ensures that the equipment is made less sensitive to power disturbances, allowing the operation even under significant voltage distortion. The other solution is to install line-conditioning systems that suppress or counteract the power system disturbances. Passive filters have been most commonly used to limit the flow of harmonic currents in distribution systems. They are usually custom designed for the application. However, their performance is limited to a few harmonics, and they can introduce resonance in the power system. Among the different new technical options available to improve power quality, active power filters have proved to be an important and flexible alternative to compensate for current and voltage disturbances in power distribution systems. The idea of active filters is relatively old, but their practical development was made possible with the new improvements in power electronics and microcomputer control strategies as well as with cost reduction in electronic components. Active power filters are becoming a viable alternative to passive filters and are gaining market share speedily as their cost becomes competitive with the passive

variety. Through power electronics, the active filter introduces current or voltage components, which cancel the harmonic components of the nonlinear loads or supply lines, respectively. Different active power filters topologies have been introduced and many of them are already available in the market.

IV. POWER FILTER TOPOLOGIES

Depending on the particular application or electrical problem to be solved, active power filters can be implemented as shunt type, series type, or a combination of shunt and series active filters (shunt-series type). These filters can also be combined with passive filters to create hybrid power filters [3].

The shunt-connected active power filter, with a self-controlled dc bus, has a topology similar to that of a static compensator (STATCOM) used for reactive power compensation in power transmission systems. Shunt active power filters compensate load current harmonics by injecting equal-but opposite harmonic compensating current. In this case the shunt active power filter operates as a current source injecting the harmonic components generated by the load but phase-shifted by 180° [2].

Series active power filters were introduced by the end of the 1980s and operate mainly as a voltage regulator and as a harmonic isolator between the nonlinear load and the utility system. The series-connected filter protects the consumer from an inadequate supply-voltage quality. This type of approach is especially recommended for compensation of voltage unbalances and voltage sags from the ac supply and for low-power applications and represents an economically attractive alternative to UPS, since no energy storage (battery) is necessary and the overall rating of the components is smaller. The series active filter injects a voltage component in series with the supply voltage and therefore can be regarded as a controlled voltage source, compensating voltage sags and swells on the load side. In many cases, series active filters work as hybrid topologies with passive LC filters. If passive LC filters are connected in parallel to the load, the series active power filter operates as a harmonic isolator, forcing the load current harmonics to circulate mainly through the passive filter rather than the power distribution system. The main advantage of this scheme is that the rated power of the series active filter is a small fraction of the load kVA rating, typically 5%. However, the apparent power rating of the series active power filter may increase in case of voltage compensation [1].

V. BASIC COMPENSATION PRINCIPLE OF SHUNT ACTIVE POWER FILTER

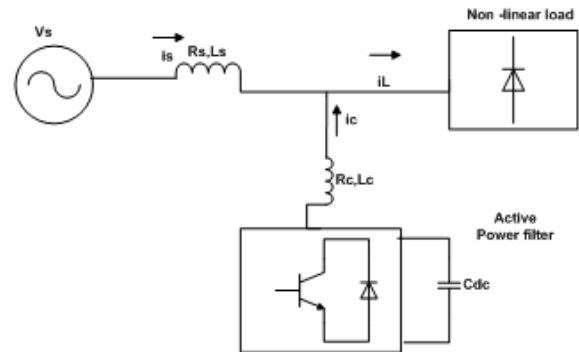


Fig 1. Shunt active power filters Basic compensation principle

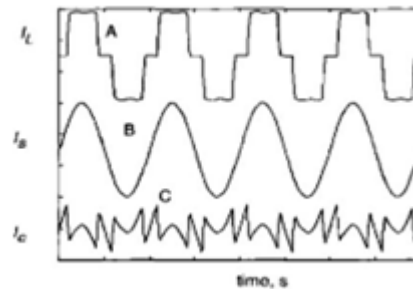


Figure 2 Shunt active power filter-Shapes of load, source and desired filter current wave forms

Figure 1 shows the basic compensation principle of a shunt active power filter. It is controlled to draw/supply a compensating current i_c from / to the utility, so that it cancels current harmonics on the AC side, and makes the source current in phase with the source voltage. Figure.2. shows the different waveforms. Curve A is the load current waveform and curve B is the desired mains current. Curve C shows the compensating current injected by the active filter containing all the harmonics, to make mains current sinusoidal [6].

VI. PI CONTROL SCHEME

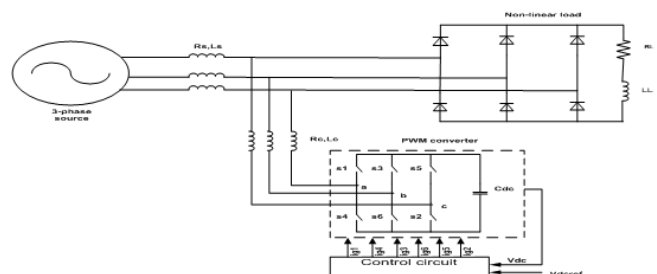


Figure 3. Schematic diagram of shunt active filter.

The complete schematic diagram of the shunt active power filter is shown in figure 3 gives the control scheme realization. The actual capacitor voltage is compared with a set reference value.

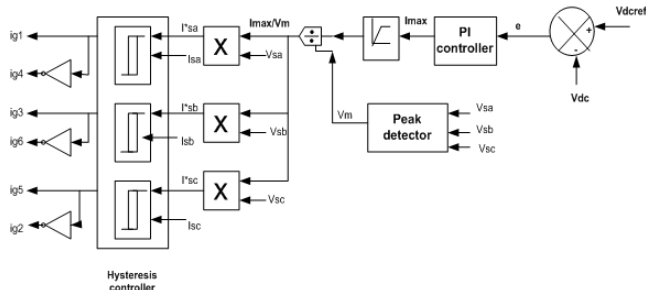


Figure 4. APF Control Scheme with PI Controller

The error signal is fed to PI controller. The output of PI controller has been considered as peak value of the reference current. It is further multiplied by the unit sine vectors (u_{sa} , u_{sb} , and u_{sc}) in phase with the source voltages to obtain the reference currents (i_{sa}^* , i_{sb}^* , and i_{sc}^*). These reference currents and actual currents are given to a hysteresis based, carrier less PWM current controller to generate switching signals of the PWM converter [2]. The difference of reference current template and actual current decides the operation of switches. To increase current of particular phase, the lower switch of the PWM converter of that particular phase is switched on, while to decrease the current the upper switch of the particular phase is switched on. These switching signals after proper isolation and amplification are given to the switching devices. Due to these switching actions current flows through the filter inductor L_c , to compensate the Harmonic current and reactive power of the load, so that only active power drawn from the source.

VII. SIMULATION SYSTEM AND PARAMETERS

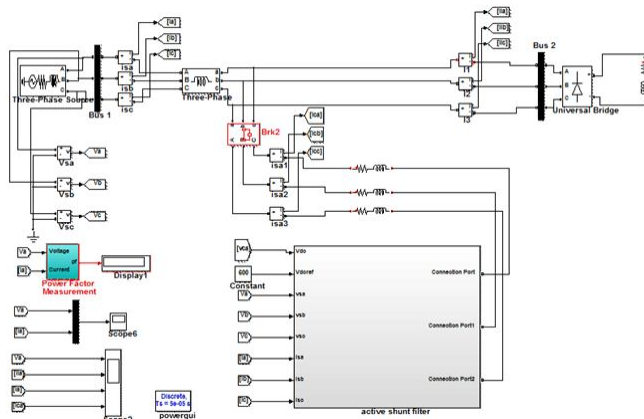


Figure 5: Simulation model using PI controller

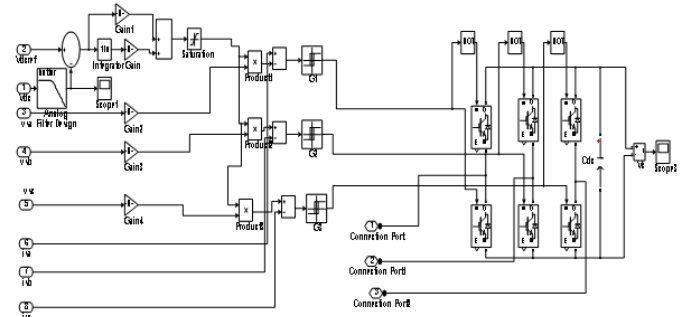


Figure 6. Control Block of SAPF Using PI Controller

Table 1 Simulation Parameter

System Parameters	Values
Source voltage(V_s)	415(peak)
System frequency(f)	50Hz
Source impedance(L_s)	0.15mH
Filter impedance(R_c, L_c)	0.4Ω,3mH
Load impedance(R_l, L_l)	6.7Ω,20mH
DC link capacitance	2000μF
Reference DC link voltage(V_{dcref})	600V

VIII. RESULT USING PI CONTROLLER

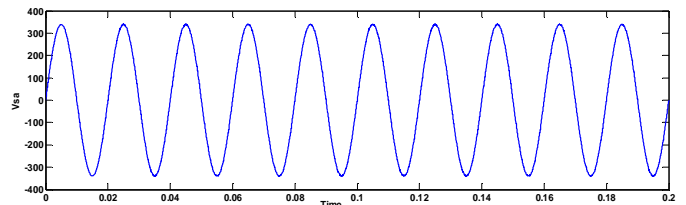


Figure 7 source voltage

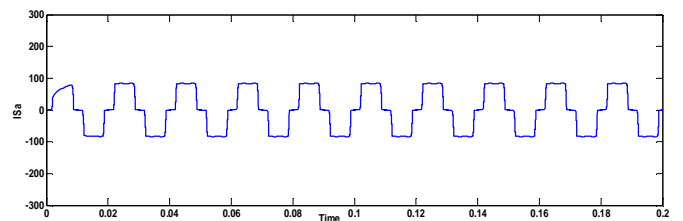


Figure 8: source current without SAPF

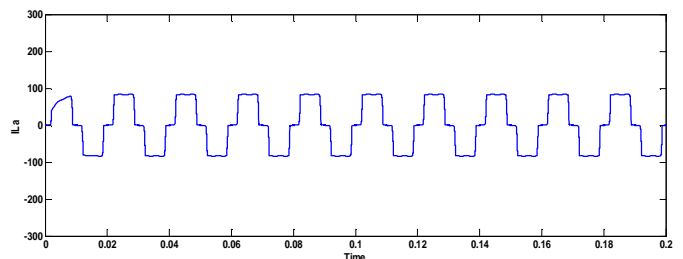


Figure 9: Load Current without SAPF

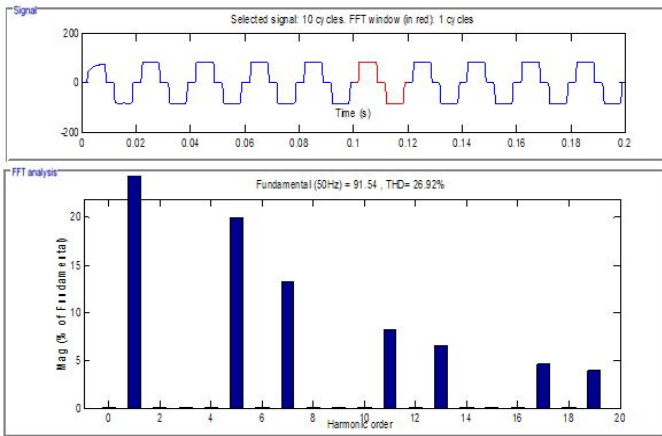


Figure 10. FFT analysis without SAPF

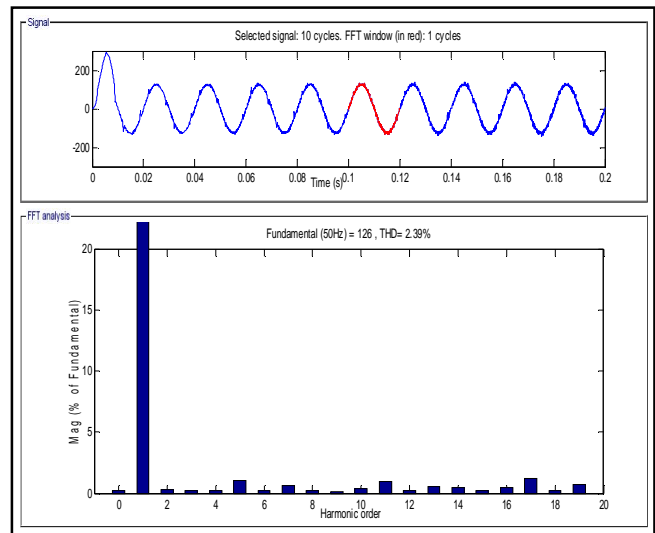


Figure 13. FFT analysis with SAPF using PI controller

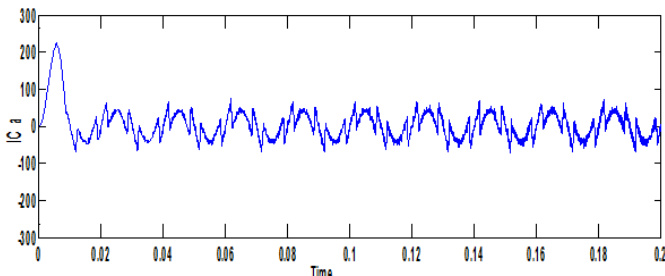


Figure 11: compensating current using pi controller

Using PI controller Shunt active power filter is implemented on a 415V distribution network in MATLAB. Simulation result with and without SAPF configuration are shown in figure. Total harmonic distortions in current for system without SAPF and with SAPF are compared as shown in figure. For 415 V distributions system a diode rectifier with R-L load is taken as non-linear load. THD of the system without SAPF is 26.92% and THD of the system with SAPF is 2.39%.from above analysis, it is found that implemented SAPF is capable to reduce current harmonics of the system.

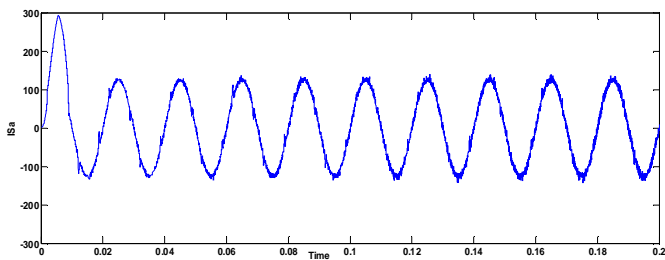


Figure 12: Source Current With SAPF

IX. FUZZY CONTROL SCHEME

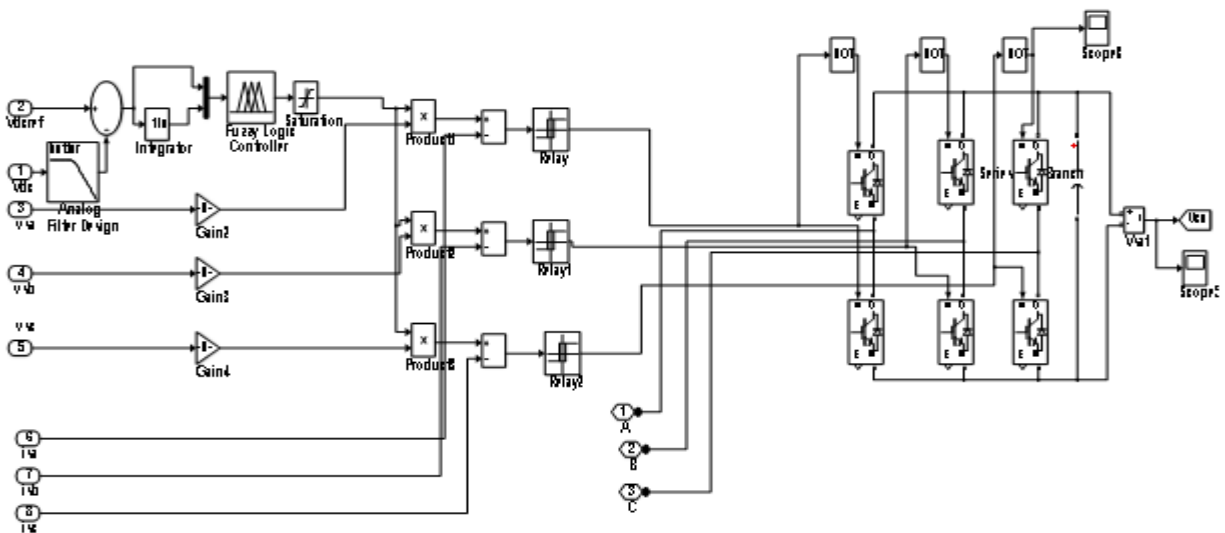


Figure 14. Control Block of SAPF Using FUZZY Controller

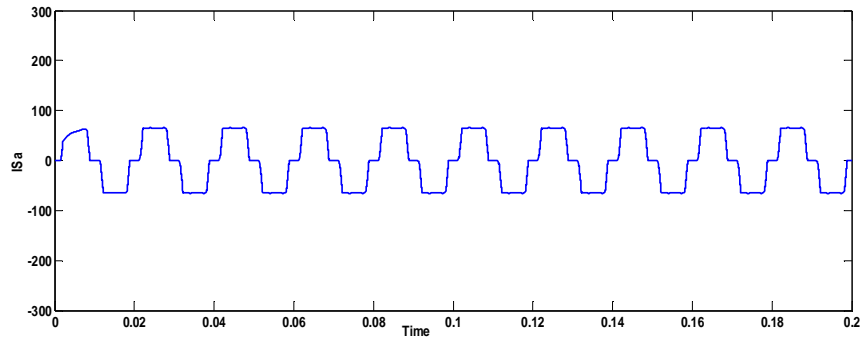


Figure 15. Source Side Current without SAPF

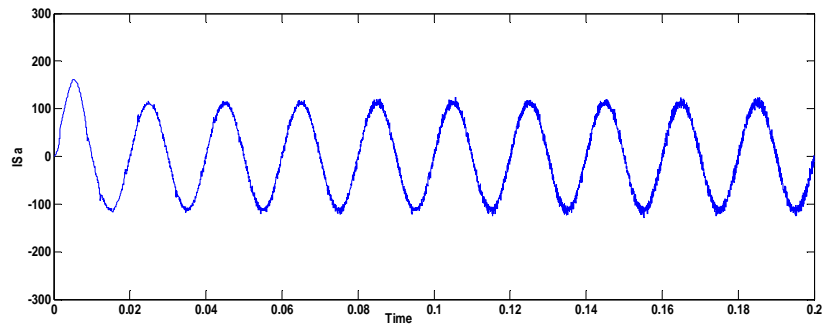


Figure 16. Source Current with SAPF

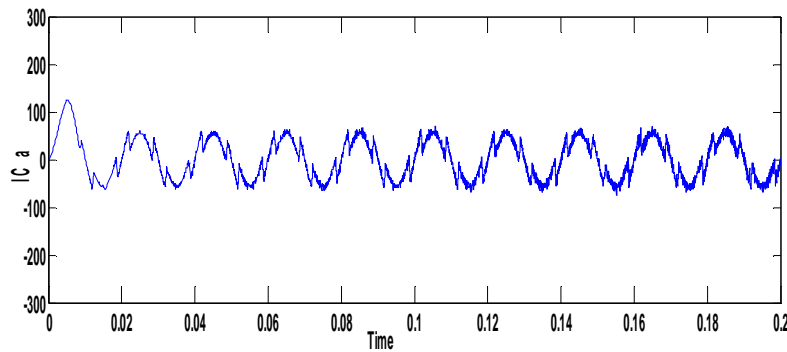


Figure 17. Compensating Current Generated by SAPF

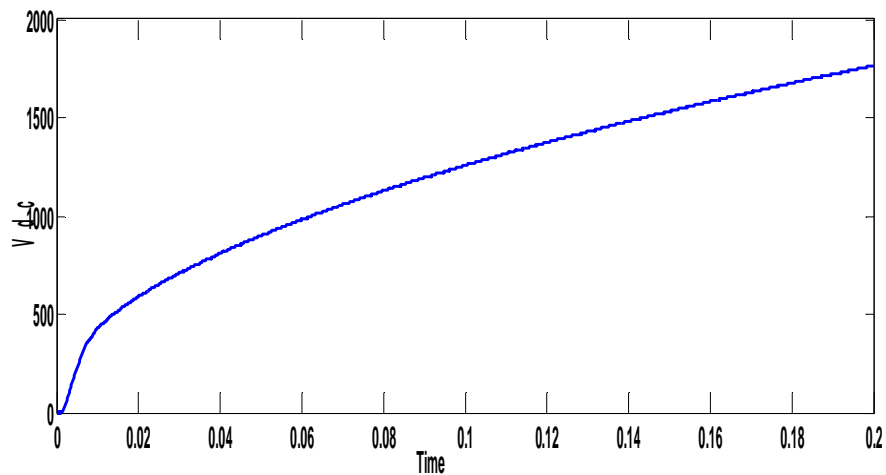


Figure 18. Capacitor Voltage

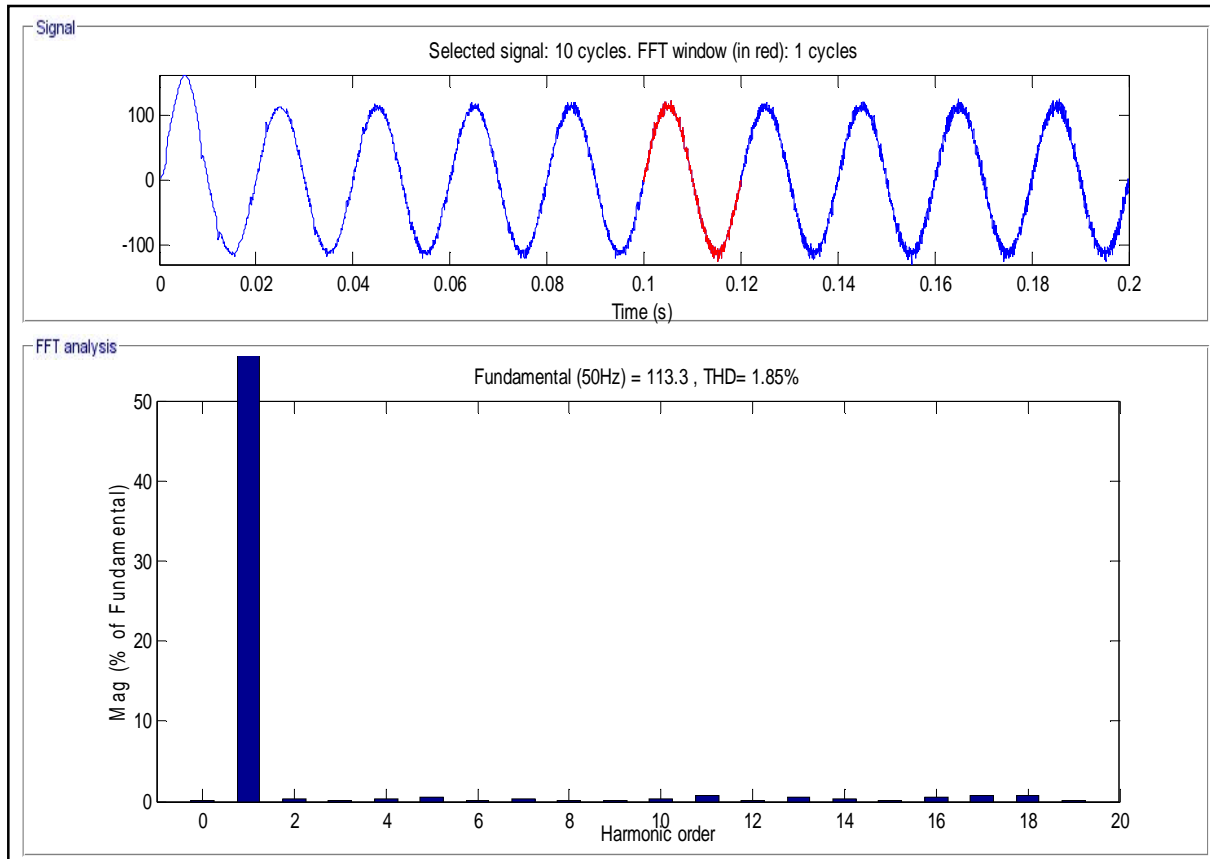


Figure 19. Source Current THD with SAPF

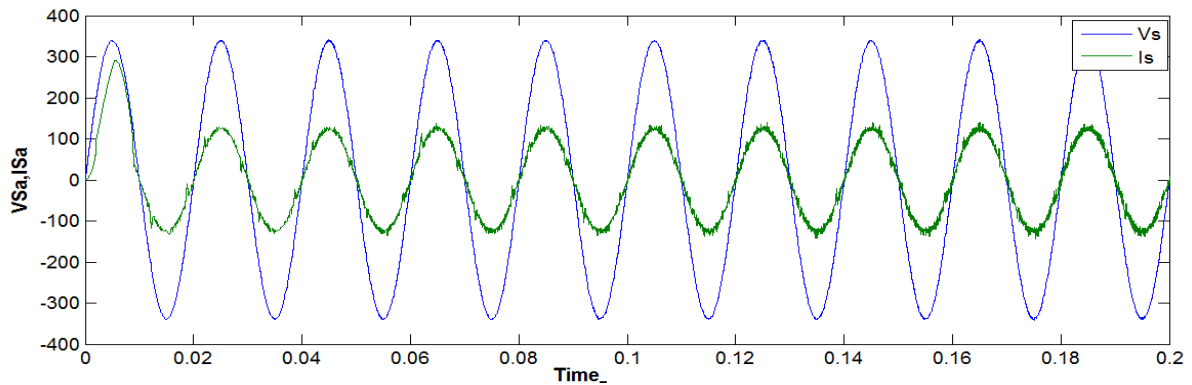


Figure 20. Voltage and Current Became a same phase after Harmonic Compensation

X. COMPARISONS BETWEEN PI AND FUZZY CONTROLLER

Table 2. Comparisons between PI and Fuzzy Controller

	% THD
Without SAPF	26.92
With PI controller SAPF	2.39

With Fuzzy Logic controller SAPF	1.85
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Fuzzy logic controller base SAPF is implemented on 415 V distribution network in MATLAB. Simulation result with and without SAPF configuration are shown in figure 15 and 16 respectively. The compensating current generated by SAPF is shown in figure 17. The THD comparisons of system without SAPF, with PI controller SAPF and Fuzzy logic controller SAPF is done. From above analysis, it is found that using Fuzzy logic controller base SAPF is more capable to reduce current harmonics of the system.

XI. CONCLUSION

This paper has presented a simulation study of PI and FUZZY logic based hysteresis current controlled active shunt power filter for harmonic compensation of the non-linear load. Using PI controller the source current THD is reduce 26.92% to 2.39%. Using FUZZY logic controller the source current THD is reduce 26.92% to 1.89%. It is found from simulation results that shunt active power filter improves power quality of the power system by eliminating harmonics of the source current, which makes the source current sinusoidal and in phase with the source voltage.

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