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Shunt Active Power Filter for Remove Harmonics Using Conventional PI and Fuzzy Logic Controllers

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Abstract : *The widespread use of power electronics devices such as inverter, rectifier, and so on. in power systems causes severe problems linked to power quality. The widespread use of nonlinear single-phase power electronic devices in the low voltage side has increased harmonic pollution in power systems to the large extent. One such problem is the generation of current and voltage harmonics causing the distortion of load waveform, heating of equipment, voltage fluctuation, voltage dip, etc. This paper provides a detailed study of shunt active power filter under two current control strategies, namely, p–q and d–q; their comparative analyses are performed to determine which method is better than the other. In both methods, a reference current is generated for the filter, which compensates either the reactive power or the harmonic current component in a power system. In this work, a current controller, known as the harmonic current controller, is described, which is used to provide remedial gating sequence of the IGBT inverter and thus helps remove the harmonics component. For proper pulse generation, conventional PI controller and fuzzy logic controller are used in this paper. A comparison of both the controllers is conducted, which highlights the superiority of the fuzzy logic control scheme.*

Keywords- *p–q (instantaneous active and reactive power theory)**,** (d–q) synchronous frame reference Theory, shunt active power filter (SAPF), harmonics, fuzzy logic controller, MATLAB.*

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I. Introduction

Power electronic converters are nonlinear devices that inject harmonics in the grid. M. Kala Rathi et al. [1] discussed various nonlinear loads, such as adjustable speed drives, uninterruptible power supply, switched mode power supply, etc., connected to the grid. These nonlinear devices are the main cause for the development of harmonics, sub-harmonics, and inter-harmonics in the current and voltage spectrum. To reduce such harmonics, power systems are generally provided with two types of filters: active and passive filters.

Bhim Singh et al. [2] stated that nonlinear devices are the main cause for the production of harmonics, sub-harmonics, and inter-harmonics in the current and voltage spectrum. To reduce such harmonics, power systems are generally provided with two types of filters: active and passive filters. Passive filters comprise only the passive elements like the inductor, capacitor, and resistor. Passive filters are affordable, but they have some disadvantages, such as the inability to adapt to the network characteristic variations, which leads to the usage of active filters. Active filters are further classified into series, shunt, and hybrid active filters. A hybrid active filter is the combination of both passive and active filters.

Yap Hoon et al. [3] reviewed the emerging active power filter (APF) field compared to traditional passive filters and clearly described its functions and its classifications based on circuit configuration, overall control system, and applications. A detailed literary review on the control algorithms of APFs is presented, where frequency-domain, time-domain, impedance synthesis, instantaneous power, DC-link voltage regulation, and current reference following the techniques are studied and discussed.

G. Jayakrishna et al. [4] found that the harmonics that are injected back to the AC main source cause harmonic problems. Among the often-cited problems is poor use of the AC source, increased system losses, poor power factor, erroneous operation of solid-state devices, excessive heating in transformers and motors, and significant electromagnetic interference with communication circuits. Shilpy Agrawal et al. [5] reviewed FLCs (fuzzy logic controllers) that they generate a good deal of interest in certain applications. The advantages of FLCs over conventional controllers are that they do not need an accurate mathematical model, can work with linguistics inputs, can handle non-linearity, and are more robust than conventional nonlinear controllers.Gupta Net al. [6] reviewed power-quality compensator systems and found that they need to follow the recommendations regarding harmonics limits provided by international regulating bodies such as IEEE 519-

1992, IEC61000-3-2, IEC 1000-3-2, and IEC1000-3-4. Usually, passive filters and active power filters are the possible solutions for power-quality problems. Tuned passive filters are cheap and effective compensators for the elimination of specific harmonic components, but they are associated with several drawbacks such as fixed compensation, large size, and resonance. These shortcomings of passive filters have been circumvented by the remarkable progress made by various researchers in the last two decades on the analysis, design, and cost-effective solution of active power filters.For the DC supply source of the three-phase active filter, PI and fuzzy logic controllers have been studied and compared [7]. This study shows that a trade-off must be found between the two criteria to limit the total harmonic distortion ratio of the source current or to minimize the settling time and the DC capacitor variation under transient conditions. An appropriate voltage controller must be synthesized to assure high dynamic performance with a simplified design of the capacitor.

A. Arulkumar et al. [9] discussed the active and reactive theories. According to the authors, the instantaneous p–q theory was introduced by Akagi et al. in 1984. Since then, many scientists and engineers have made significant contributions to its modifications in three-phase four-wire circuits and its applications to power electronic equipment. The p–q theory is based on a set of instantaneous powers defined in the time domain. No restrictions are imposed on the voltage and current waveforms, and it can be applied to three-phase systems with or without a neutral wire for three-phase generic voltage and current waveforms.

II. Fuzzy Logic Controller

In recent times, fuzzy logic controllers have generated a good deal of interest in certain applications.

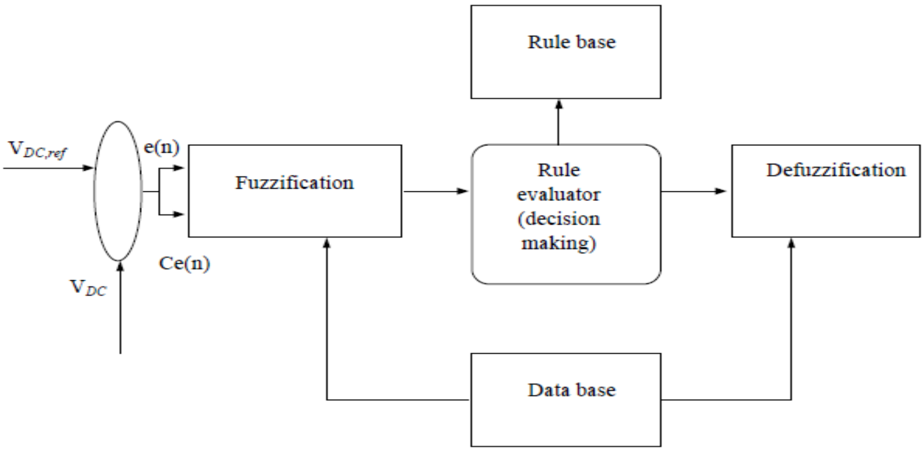


Fig.1. Fuzzy logic controller

The advantages of fuzzy logic controllers over conventional controllers are that they do not need an accurate mathematical model, can work with linguistics inputs, can handle non-linearity, and are more robust than conventional nonlinear controllers. Fuzzy logic-based control systems, or simply fuzzy logic controllers, can be found in a growing number of products, such as washing machines, speedboats, air conditioners, handheld autofocus cameras, etc. The inference engine is the heart of a fuzzy controller and fuzzy rules operation [8].

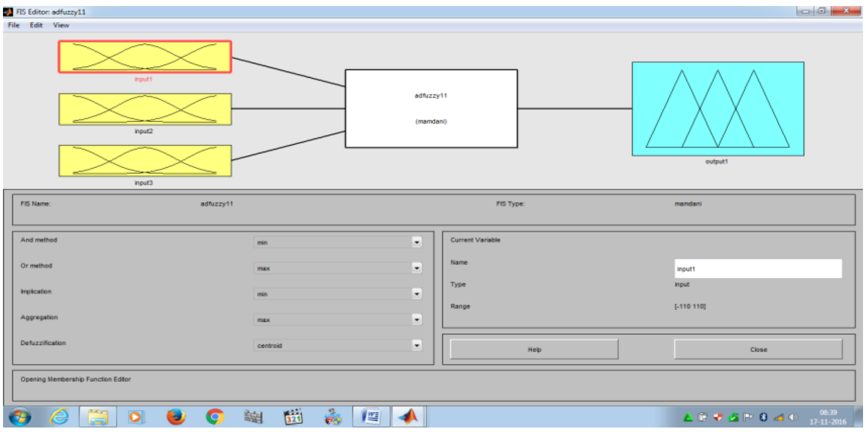


Fig.2. FIS Fuzzy editor with three inputs and one output

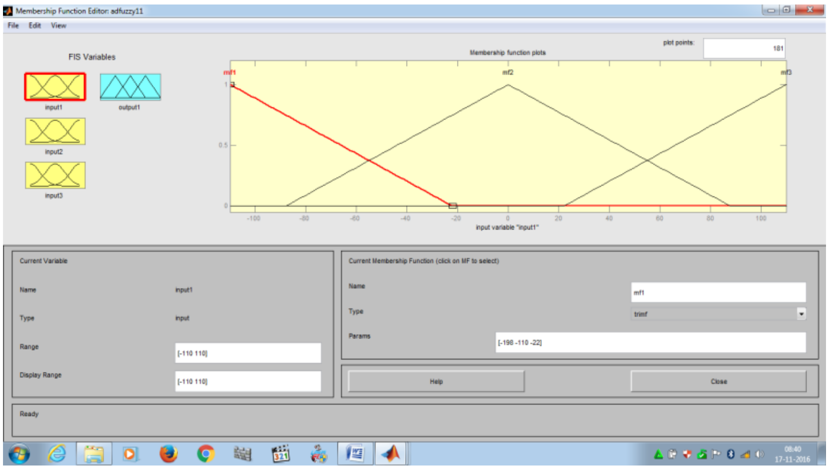


Fig. 3. Developed membership functions using the Simulink

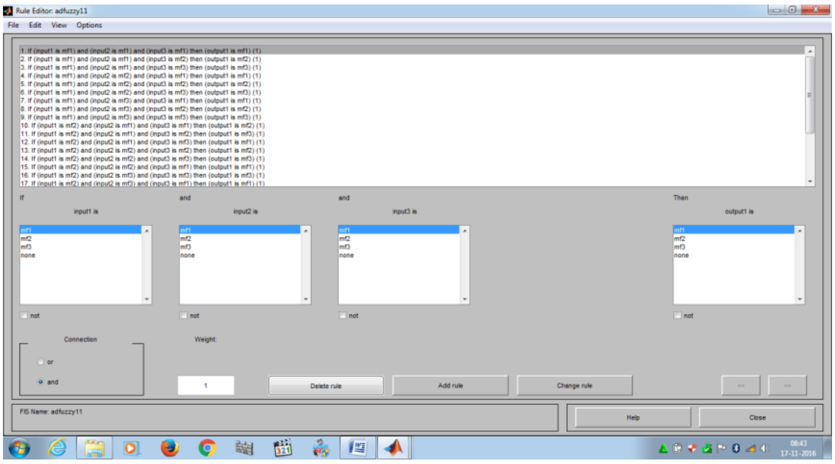


Fig.4. Fuzzy rules used in the development of the fuzzy logic coordination scheme

The fuzzy editor with three inputs and one output is shown in Fig. 2, the membership function is shown in Fig.3,and the fuzzy rules used in the development of the fuzzy logic coordination scheme are shown in Fig. 4.

III. Pi & Fuzzy Control Strategies

PI controller and fuzzy logic controllers have been used to estimate the reference current for active power filters [10]. The hysteresis current controller method is used to generate the switching patterns of the voltage source inverter. However, this control scheme exhibits uneven switching frequency. This approach permits one to define an ingenuous way for computing a lookup control using the instantaneous supply voltage and the reference current slope as input variables and the hysteresis band as an output variable to maintain a constant modulation frequency.

Source currents are sensed and converted into the unit sine currents, whereas the corresponding phase angles are maintained. The unit current vectors are represented as i_a, i_b, and i_c , as shown in Equations (1)–(3), respectively.

$i_a = \text{Sin}\ \omega t$ (1)

$i_b = \text{Sin}(\ \omega t-120^0)$ (2)

$i_c = \text{Sin}(\ \omega t+120^0)$ (3)

The DC-side capacitor voltage is sensed and compared with a reference voltage. The voltage error $e=V_{dc\ ref}-V_{dc}$ at the n^{th} sampling instant is used as an input for the PI controller. The error signal passes through the low-pass filter to cancel the higher-order components, passes only the fundamental and its transfer function is defined as $H(S)=K_p+K_I/S$. The proportional gain is derived using $K_p=2\zeta\ \omega_n c$ (Kp=0.93). The transfer function is defined as the damping factor and the natural frequency, ωn, should be chosen as the fundamental frequency. Similarly, the integral gain is derived using $K_I=C\ \omega_n^2$. This PI controller estimates the magnitude of the peak reference current and controls the dc-side voltage. To implement the fuzzy logic algorithm of an SAPF in a closed loop, the dc-side voltage is sensed and compared with the desired reference value to compute the error signal as follows: $e=V_{dc\ ref}-V_{dc}$. The error sign and change of error signal are used as inputs for fuzzy processing.

The output of the fuzzy logic estimates the magnitude of the peak reference current, I_{max}, and considers the response of the active power demand for harmonic and reactive power compensations [10].

IV. Simulation and Results

The entire system is simulated in MATLAB/Simulink environment using the Sim-power system Toolbox. Fig. 5 and Fig. 6 show the simulation diagrams of PI-based active power filter MATLAB/Simulink diagram and the fuzzy-based active power filter MATLAB/Simulink diagram, respectively. Various simulated waveforms of conventional PI-based active power filters are shown in Figs. 7–16, and the simulated wave forms of fuzzy-based active power filters are shown in Figs. 17–26. The parameters of the system are listed in Table 1.

Table 1.

System parameter	Values
Supply voltage	230 volts
DC voltage	400 Volts
Frequency	50 Hz
Source inductance	0.05mH
Load resistance	0.1 Ω
Load inductance	1μH
Coupling inductance	1mH
Coupling resistance	0.01 Ω

The performance of the fuzzy logic control strategy is evaluated through simulation power devices, such as IGBTs and diodes. Fuzzy-based active power filter simulation results are verified and presented in the chapter shows superiority of the fuzzy logic control strategy with this controller total harmonic distortion reduces to a considerable amount.

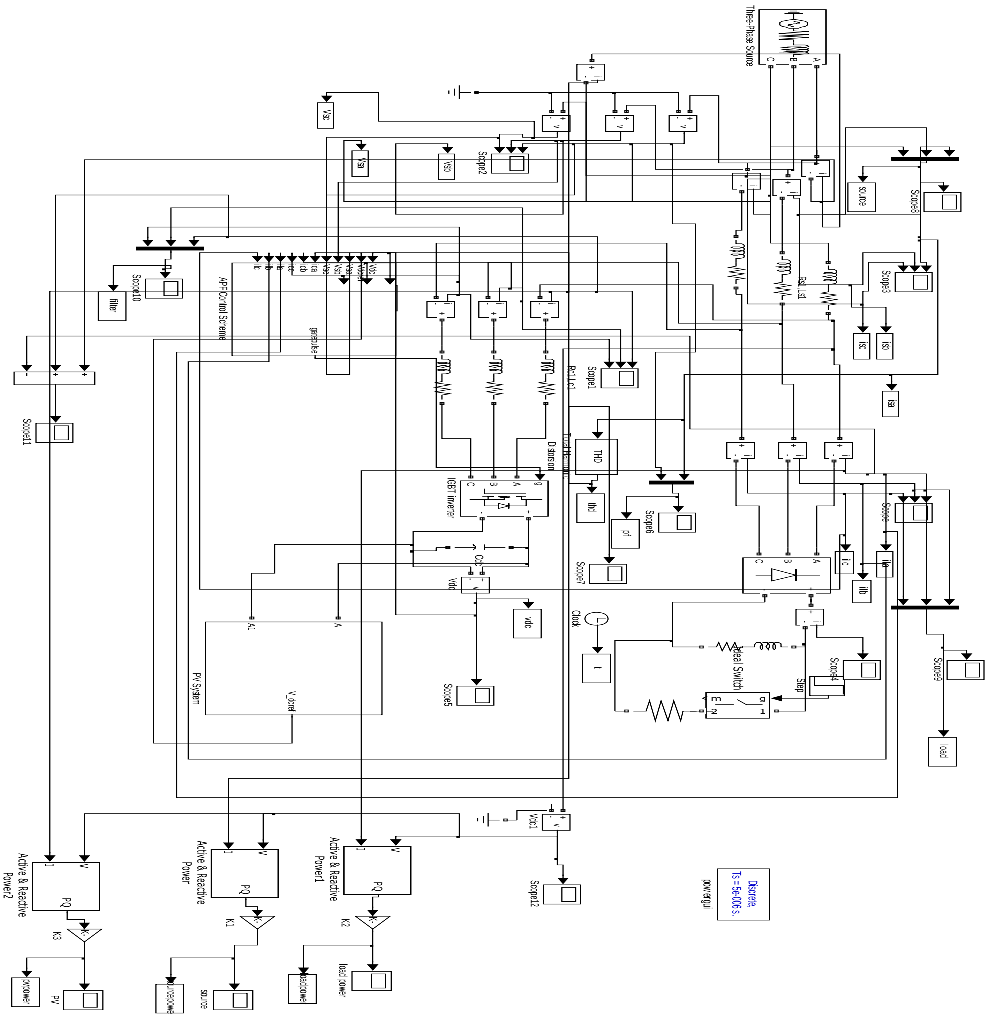


Fig.5. Simulation diagram of a PI-based active power filter

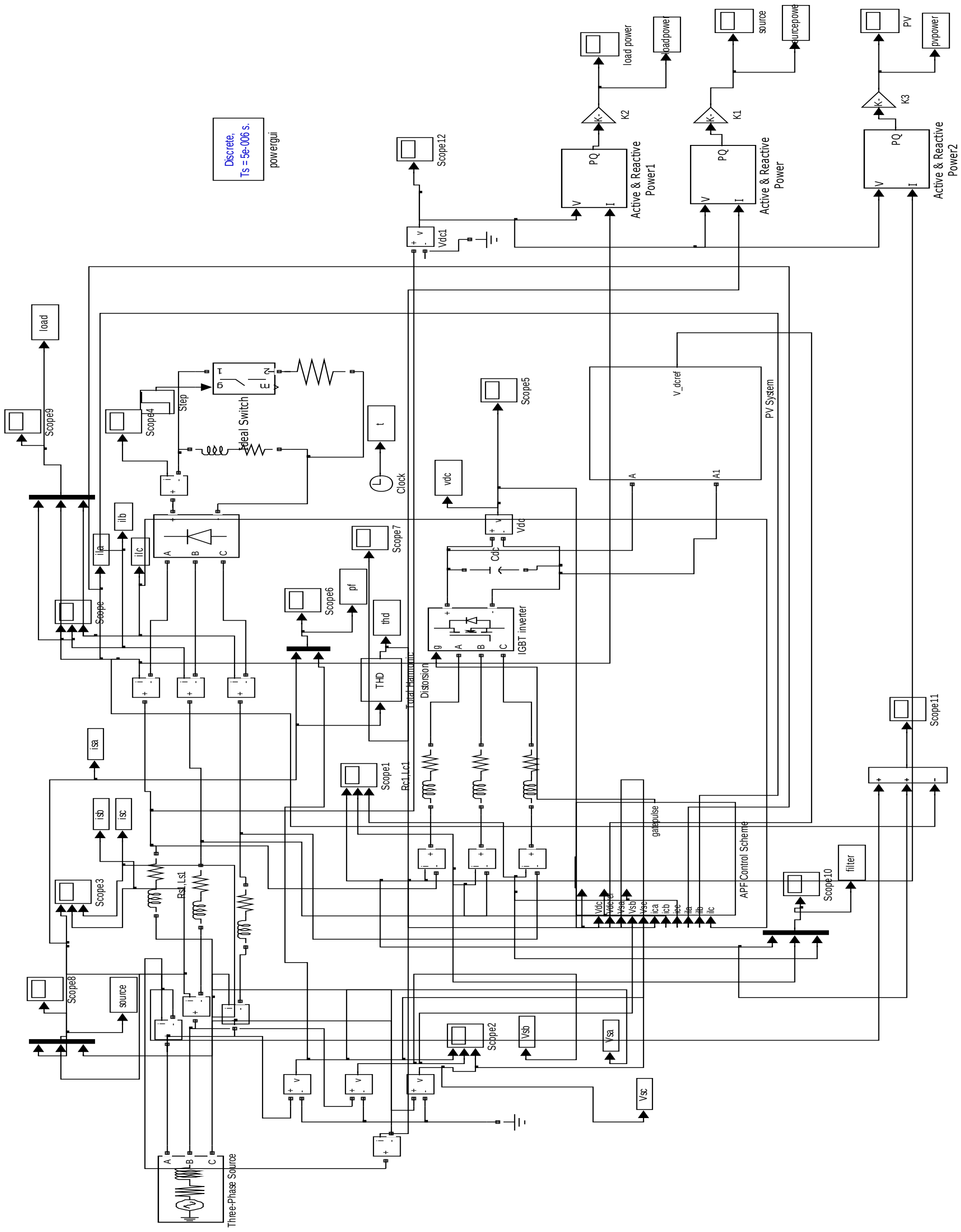


Fig.6. MATLAB/Simulink diagram of a fuzzy-based active power filter

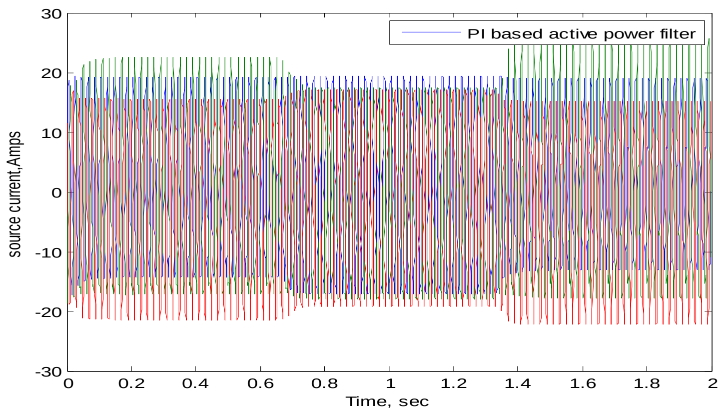


Fig.7a

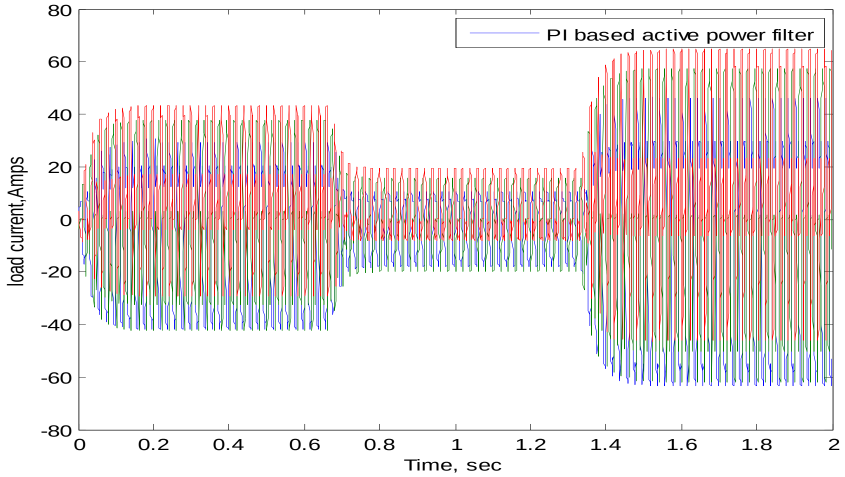


Fig. 7b

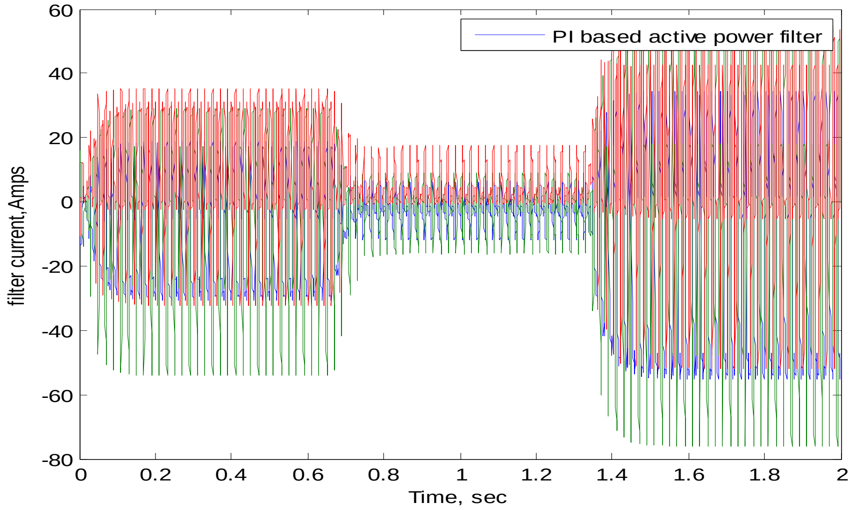
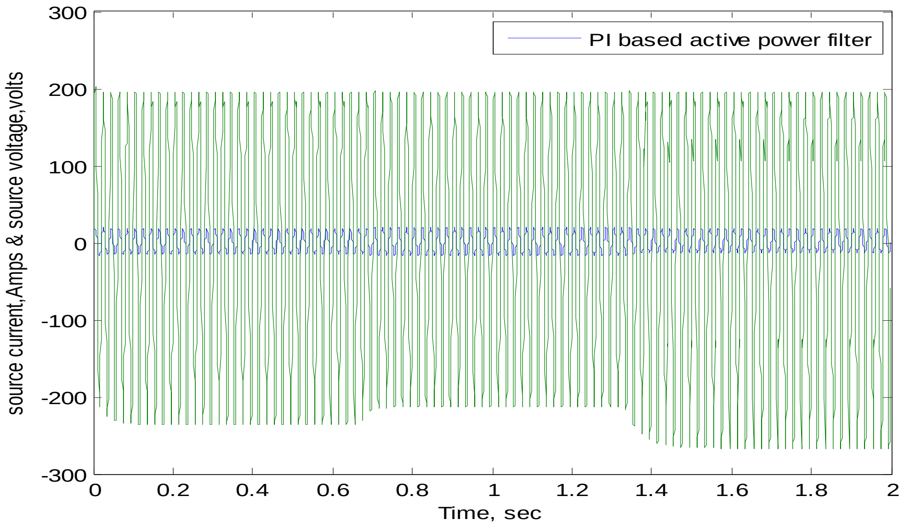


Fig. 7c

Fig. 7. PI-based active power filter: 7a. source current, 7b. load current, 7c. filter current.



]Fig. 8. PI-based active power filter source current source voltage

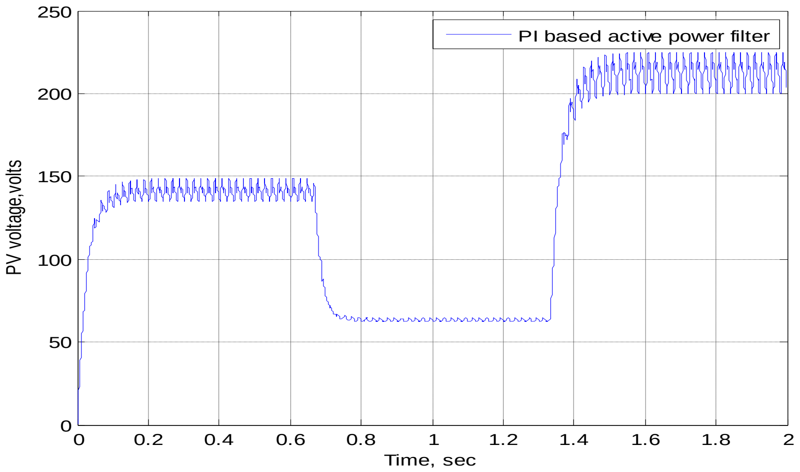


Fig. 9. PI-based active power filter PV voltage

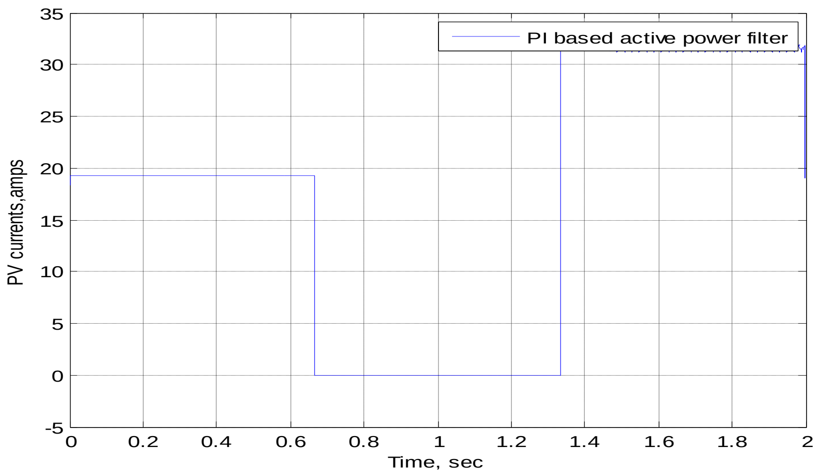


Fig.10. PI-based active power filter PV current

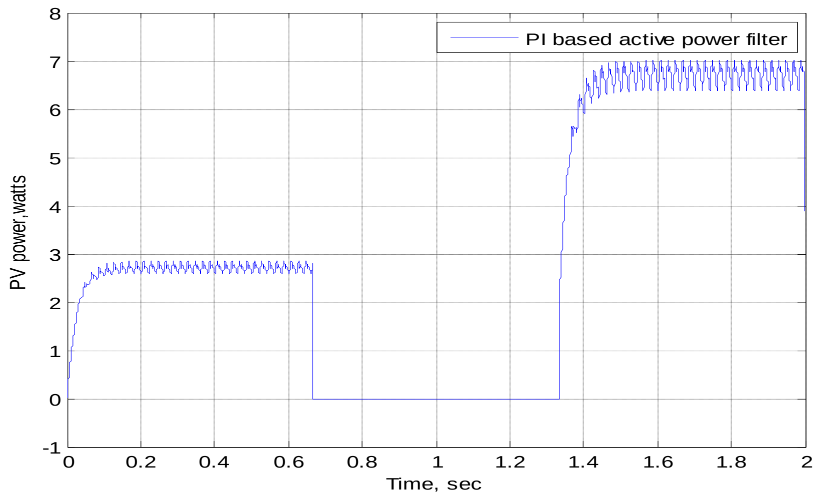


Fig. 11. PI-based active power filter PV power

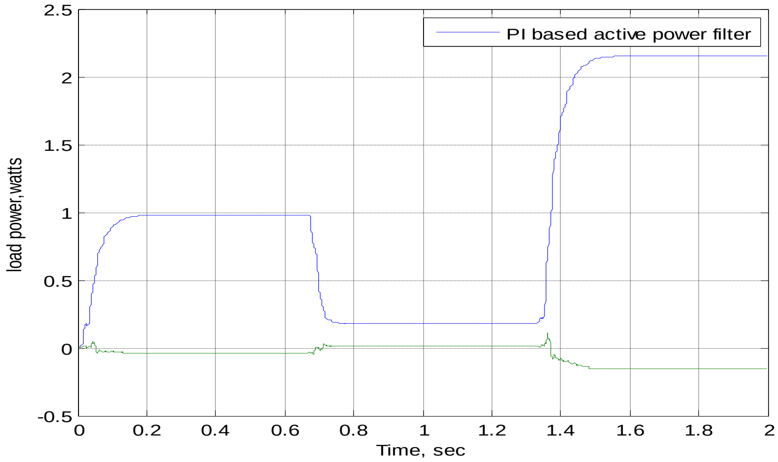


Fig. 12. PI-based active power filter PV load power

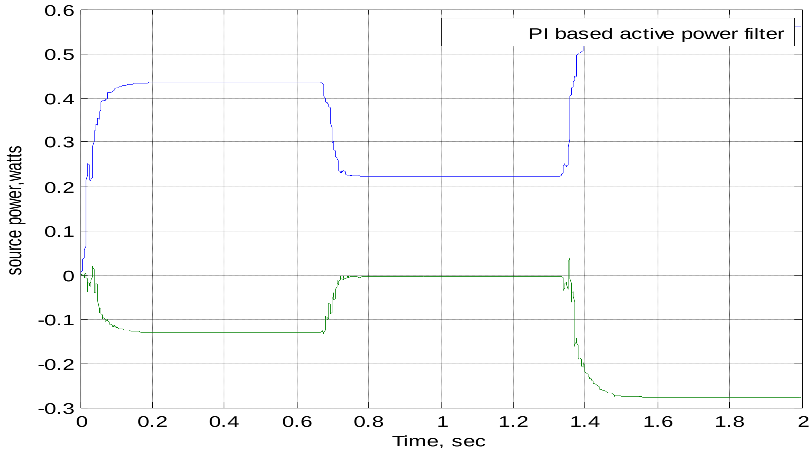


Fig. 13. PI-based active power filter PV source power

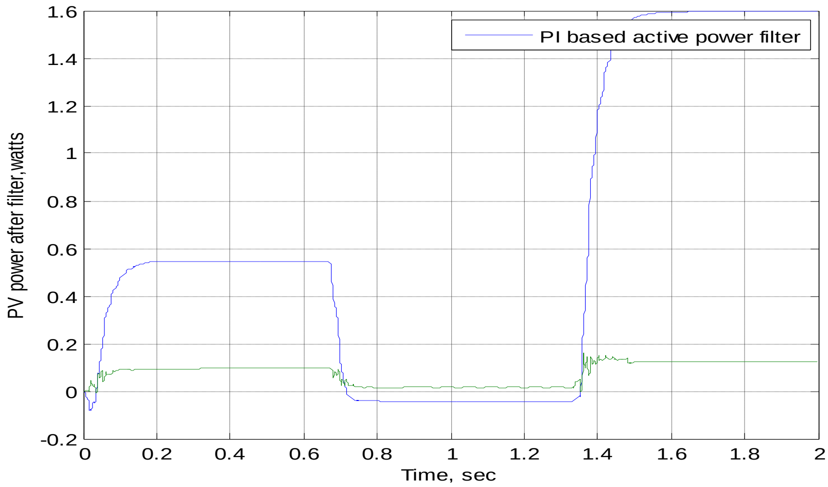


Fig. 14. PI-based active power filter PV power after filter

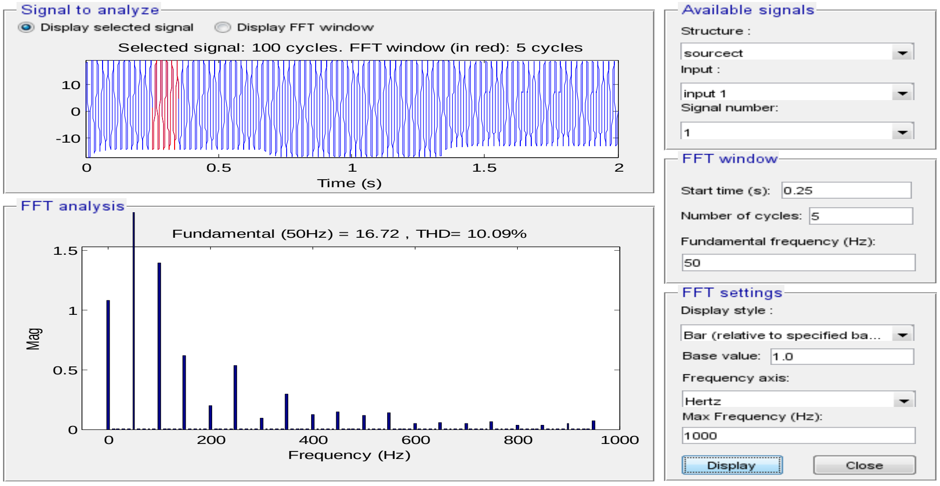


Fig. 15. FFT analysis in PI-based active power filter with source current.

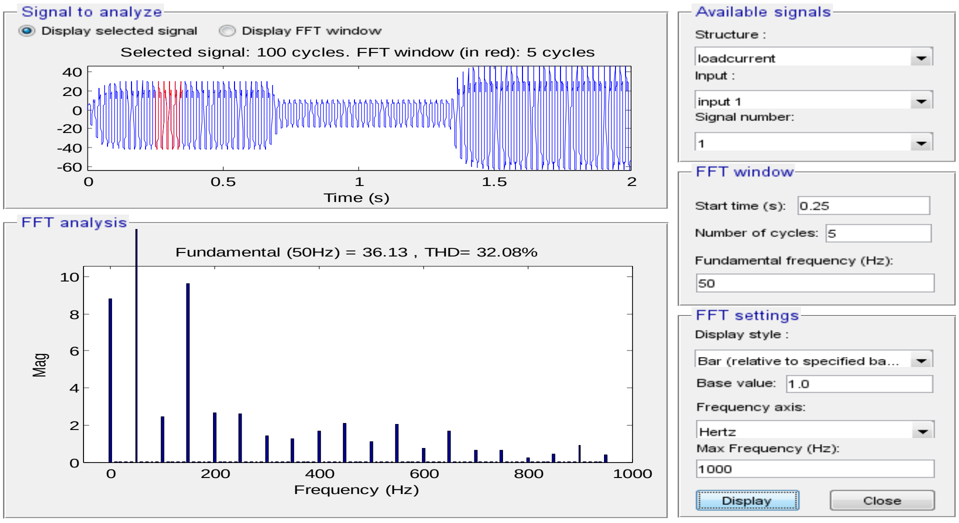


Fig. 16. Performance of FFT analysis in PI-based active power filter with load current.

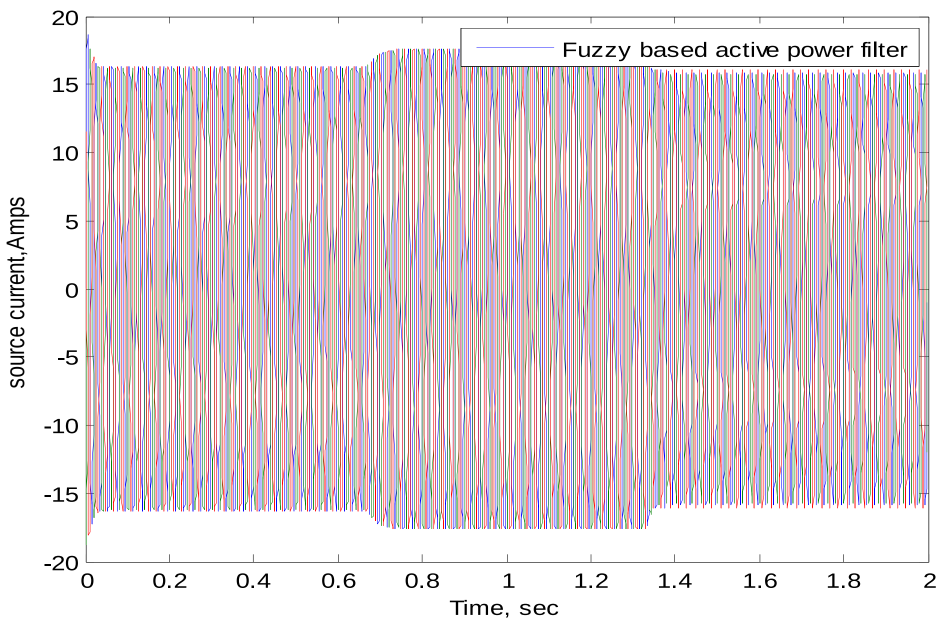


Fig:17a

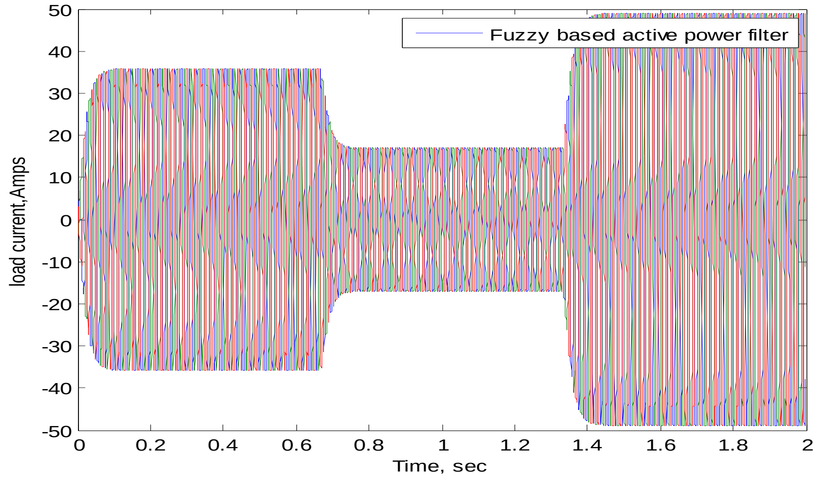


Fig. 17 b

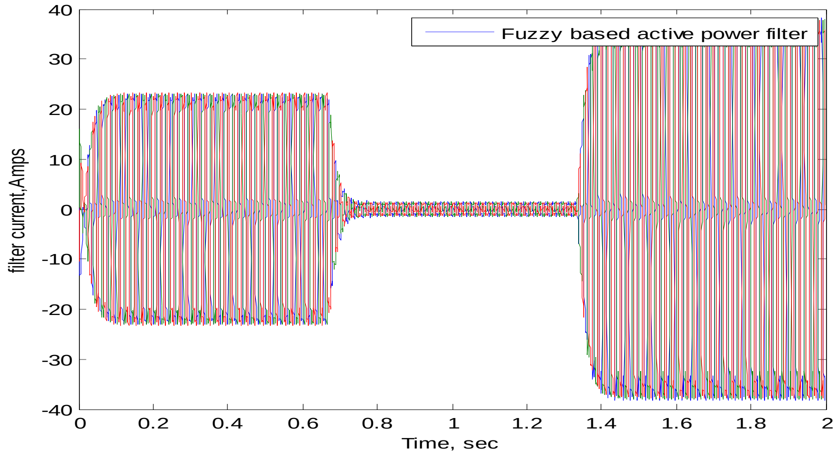


Fig. 17 c

Fig . 17. Fuzzy-based active power filter: 17 a. source current; 17 b. load current ; 17 c. filter current.

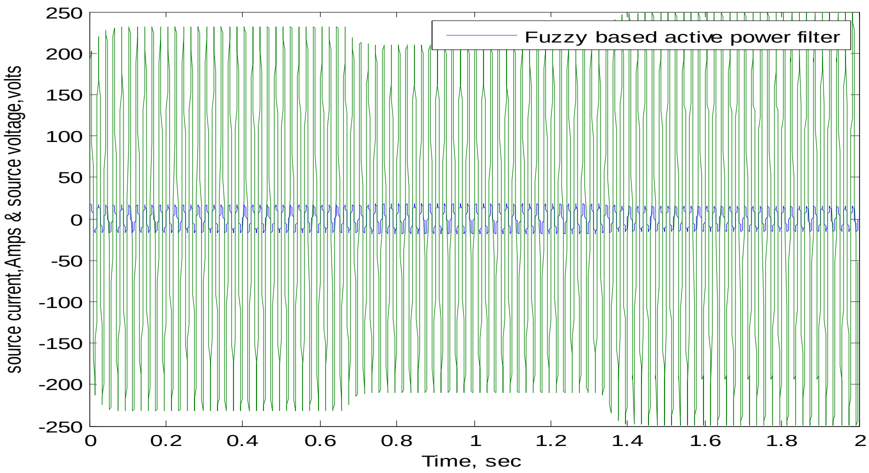


Fig. 18. Fuzzy-based active power filter source current source voltage

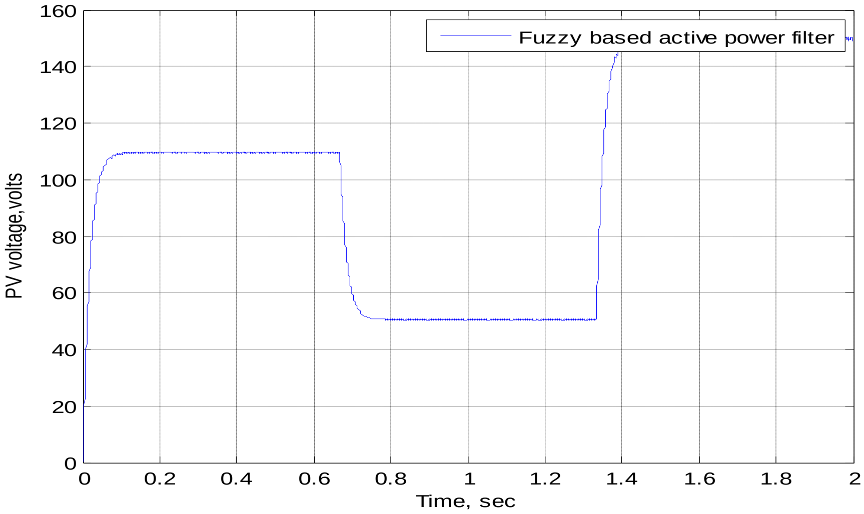


Fig . 19. Fuzzy-based active power filter PV voltage

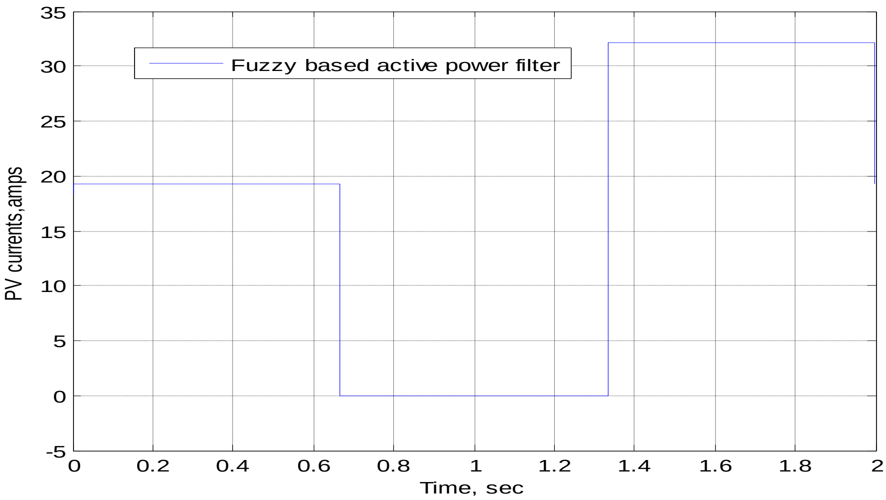


Fig. 20. Fuzzy-based active power filter PV current

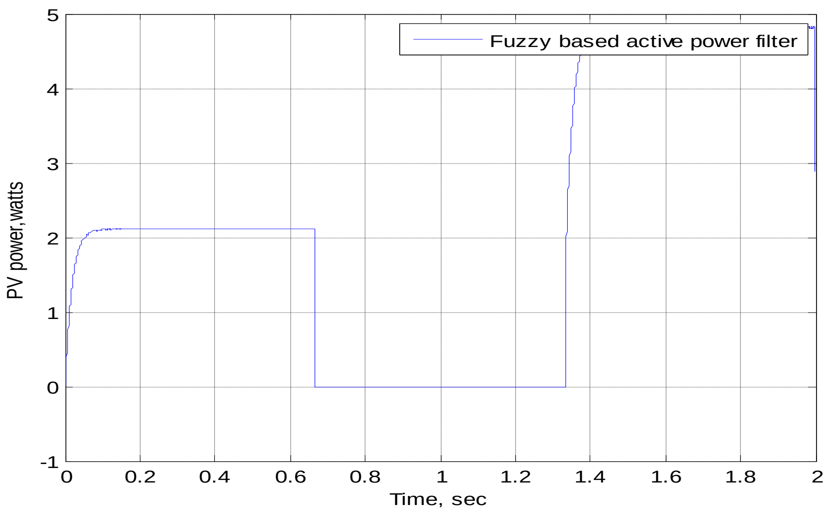


Fig . 21. Fuzzy-based active power filter PV power

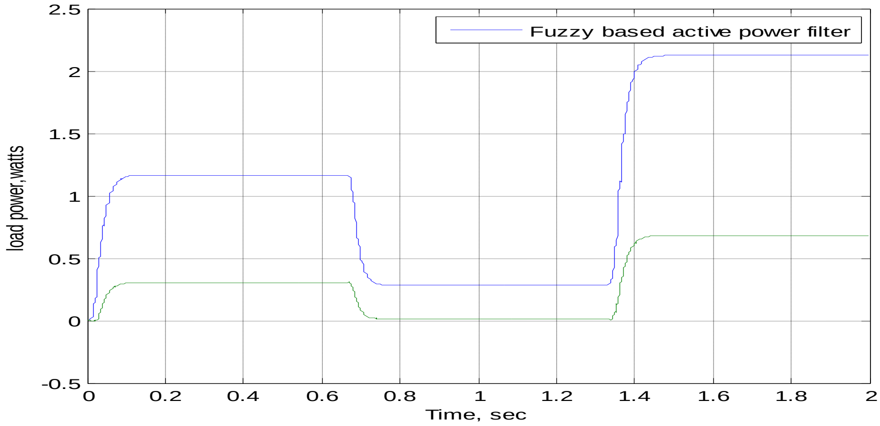


Fig . 22. Fuzzy-based active power filter PV load power

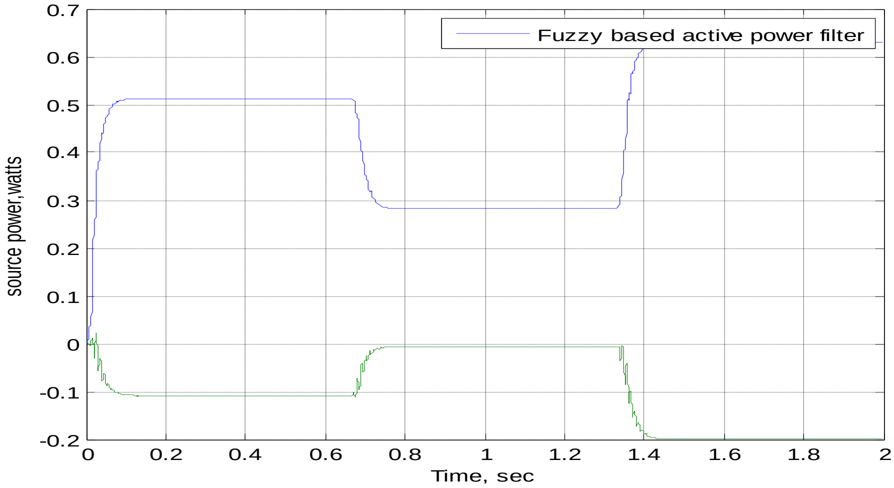


Fig.23. Fuzzy-based active power filter PV source power

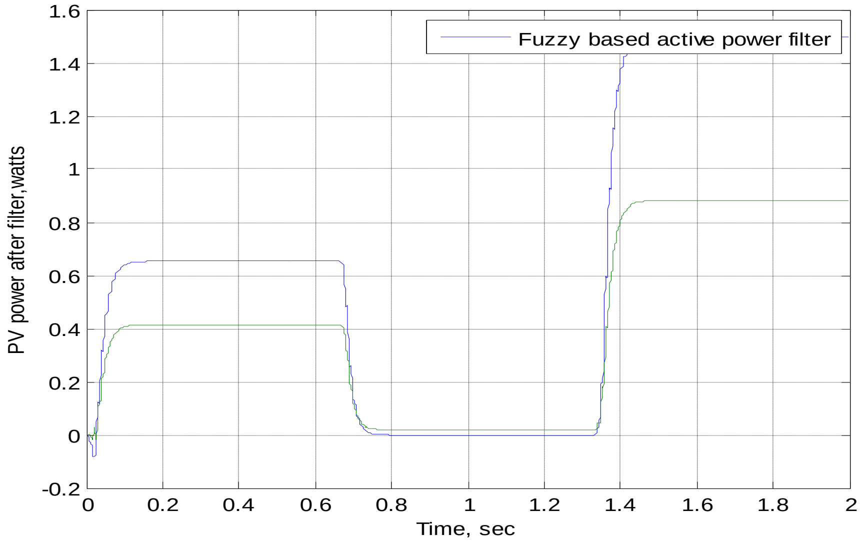


Fig .24. Fuzzy-based active power filter PV power after filter

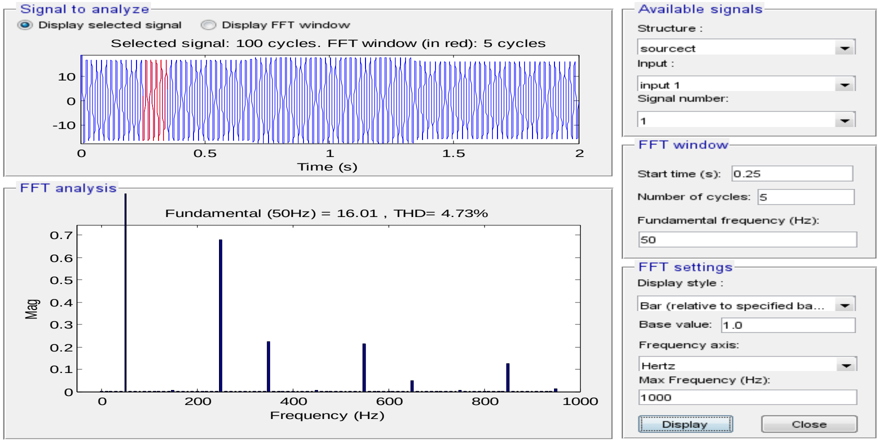


Fig.25. Performance of FFT analysis in fuzzy-based active power filter with source current.

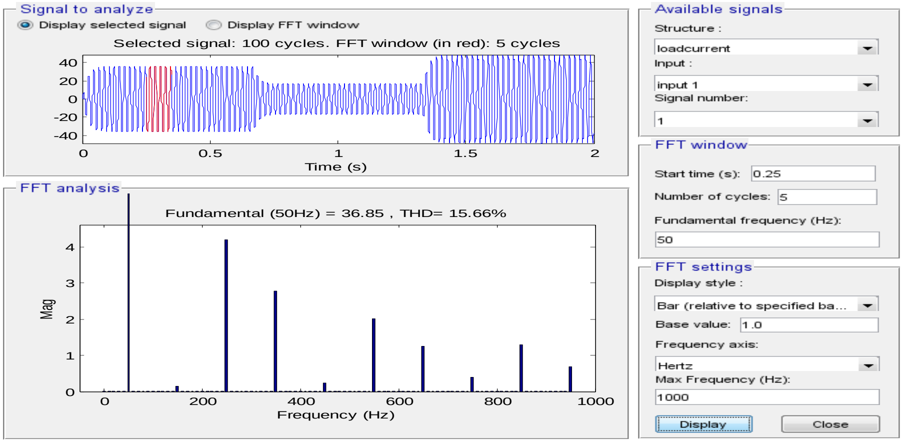


Fig.26. Performance of FFT analysis in fuzzy-based active power filter with load current.

V. Conclusion

In this paper, The PI/fuzzy logic controller based three-phase shunt active power filter facilitates current harmonics and reactive power compensation in the distribution system. Fuzzy logic controller is compared with the conventional PI method to verify their positive affect on SAPF performance. MATLAB/Simulink environment was used to simulate the proposed system and SAPF was in compliance with the IEEE-519 recommended harmonic standard. SAPF achieved a low total harmonic distortion of the source current, which highlights the superiority of the fuzzy logic control scheme.

References

[1]. M. Kala Rathi, N. Rathina Prabha .Grid Interconnected Photo Voltaic System Using Shunt Active Filter for Power Quality Improvement. International Journal of Power Electronics and drive system; vol.9 DriveSystem ; Vol. 9, No. 1, March 2018, pp. 365-376.

[2]. Bhim Singh , et al., "A Review of Active Filter for Power Quality Improvements, "IEEE Transactions on Industrial Electronics,vol. 46 , pp. 960-970, 1999.

[3]. Yap Hoon , Mohd Amran Mohd Radzi , Mohd Khair Hassan etc.all. Control Algorithms of Shunt Active Power Filter for Harmonics Mitigation: Energies 2017, 3 December 2017.pp 1-29.

[4]. G. Jayakrishna, K.S.R.Anjaneyulu "Fuzzy Logic Control based Three Phase Shunt Active Filter for Voltage Regulation and HarmonicReduction" International Journal of Computer Applications vol 10– No.5, November 2010.

[5]. Shilpy Agrawal, Vijay Bhuria. Shunt Active Power Filter for Harmonic Mitigation by using Fuzzy Logic Controller. International Journal of Advanced Research in Computer Engineering & Technology Volume2, Issue 6, June 2013.pp.1950-54.

[6]. Gupta N, Singh SP, Dubey. SP. DSP based adaptive hysteresis-band current controlled active filter for power quality conditioning under non-sinusoidal supply voltages. International Journal of Engineering, Science and Technology 2011;3(4).pp.236–52.

[7]. Mazari B, Mekri F. Fuzzy hysteresis control and parameter optimization of a shunt active power filter. Journal of Information science and Engineering 2005;21.pp.1139–56

[8]. Swati Pal, Pallavi Singh Bondriya etc. MATLAB-Simulink Model Based Shunt Active Power Filter Using Fuzzy Logic Controller to Minimize the Harmonics. International Journal of Scientific and Research Publications, Volume 3, Issue 12, December 2013 ,pp.1-5

[9]. A.Arulkumar etc.. all . PI Controller Based Shunt Active Power Filter with Cascaded Multilevel Inverter. IJIRSET Volume 3, Special Issue 3, March 2014.PP.535-39.

[10]. Karuppanan P, Mahapatra KK. PI and fuzzy logic controllers for shunt active power filter—a report. ISA Transactions 2012;51 pp.163–9.

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