IJESMR
International Journal OF Engineering Sciences & Management Research

IMPROVEMENT OF POWER QUALITY USING FUZZY CONTROLLER WITH TCR BASED ACTIVE POWER FILTER

V.Manoj Kumar Reddy
* PG Scholar, Madanapalli Institute of Technology, Madanapalli, AP

KEYWORDS: Thyristor controlled reactor, harmonics, shunt active filter, passive filter, PI controller, Total harmonic distortion, fuzzy logic controller,

ABSTRACT
This paper proposes a new control scheme to improve the power quality of an electrical power system by use of TCR based Shunt Active Power Filter. In this paper, we used a FACTS controller i.e. which is shunt controller. The TCR and tuned passive filter form a shunt passive filter (SPF).The SPF is used to compensate reactive power. The small-rating active power filter is used to suppress resonance occurred between the line inductances and shunt passive filter and to improve the filtering characteristics of shunt passive filter. A proportional–integral controller was used, for generating pulses to control the TCR. This paper introduces a new concept i.e. Fuzzy Logic Controller for controlling both TCR and SHAPF. The proposed Fuzzy logic controller (FLC) gives better dynamic and static performances compared to PI controller.

INTRODUCTION
Nonlinear loads because harmonic currents, which create serious problems in power supply system. Traditionally, passive filters are used to eliminate current harmonics of the supply network. However, these devices suffer from resonance. Recently, thyristor-switched filters (TSFs), which contain several groups of passive filters, are used to compensate reactive power [1]. The compensation amount of TSFs can be adjusted with the variation of load power [2]. However, the parallel and the series resonance could occur between TSF and grid impedance. Active filters are used overcome problems of passive filters [3]–[5]. However, the costs of active filters are relatively high for large scale system and require high power converter ratings [9], [10]. Hybrid filters decreases the problems of the active and passive filter [11]–[14]. Many control techniques such as instantaneous reactive power theory, synchronous rotating reference frame, sliding-mode controllers, neural network techniques, nonlinear control [15], feed forward control [16], Lyapunov function-based control [17], etc., have been used to improve the performance of the active and hybrid filters.

This paper proposes a new combination of shunt hybrid power and TCR filter to eliminate reactive power and suppress harmonics produced from load. Hybrid power filter consists of a series connected fifth tuned LC passive filter and small rating active filter.

In this method compensation is mainly done by TCR and passive filter, while APF is used to improve filtering characteristics and to damp resonance, which occurs between TCR and Passive filter and the source impedance.On the other hand, as published by some authors [15], the standard hybrid power filter is unable to compensate the reactive power because of the behaviour of the passive filter. Hence, the proposed combination of SHPF and TCR compensates for unwanted reactive power and harmonic currents. In addition, it reduces significantly the volt-ampere rating of the APF part. The control method of the combined compensator is presented. A control technique is used to decrease steady state error of the TCR and to improve dynamic response. It consists of a PI controller and a lookup table to extract the required firing angle to compensate a reactive power consumed by the load. The SHPF can maintain the low level of dc bus voltage at a stable value below 50 V. The proposed nonlinear control scheme has been simulated and validated experimentally to compute the performance of the proposed SHPF-TCR compensator with harmonic and reactive power compensation and analysis through the THD of the source and the load current. Proposed methodology is tested for a wide range of loads as discussed further. The simulation results show that the proposed topology is suitable for harmonic suppression and reactive compensation..

ISSN 2349-6193
Impact Factor (PIF): 2.243

IJESMR
International Journal OF Engineering Sciences & Management Research

CONTROL STRATEGY FOR APF

In the control of APF, the approaches are fully depends on open loop feed forward control and it is sensitive to the parameter mismatches so it effects the ability to accurate prediction of the current reference of voltage-source inverter and its performance [11] controllability.

Figure 1 shows the method of synchronous reference frame used to extract the reference current in closed loop control scheme. Figure 2 shows the harmonic detection block function. In the SRF method using Park's transformation [13] the 3-phase line currents are transformed into 2-phase quantities.

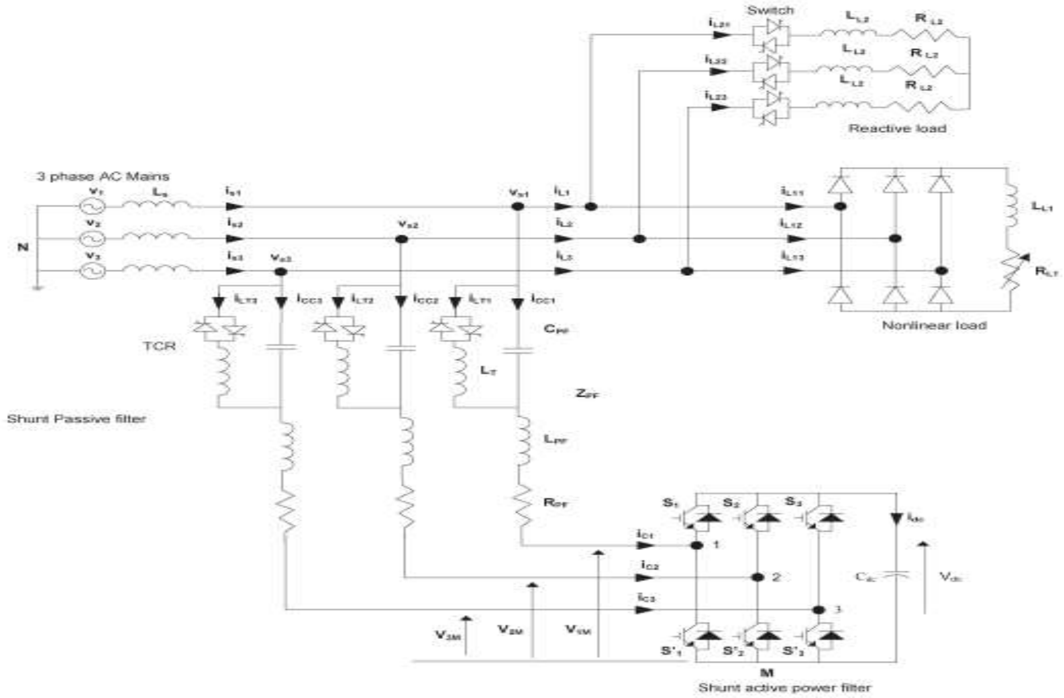

Figure 1 Proposed SHPF_TCR compensator

Positive and negative sequence components are two main blocks corresponded, transformation of de – qe axes by generating positive sequence phase information from PLL circuit was done in positive sequence component of load current. All harmonic components [14]-[15] are included in AC quantities of positive sequence waveform while the fundamental line current component is dc quantity. The negative sequence component of the current is same but from the PLL it generates negative sequence phase information. If the voltages and currents are balanced in 3-Φ system then the output signal is '0' for the block. The dominant harmonic component is the output from the comparison of the positive and negative sequence controller. To convert 3-Φ components in to 2- Φ components inverse transformation is applied [16].

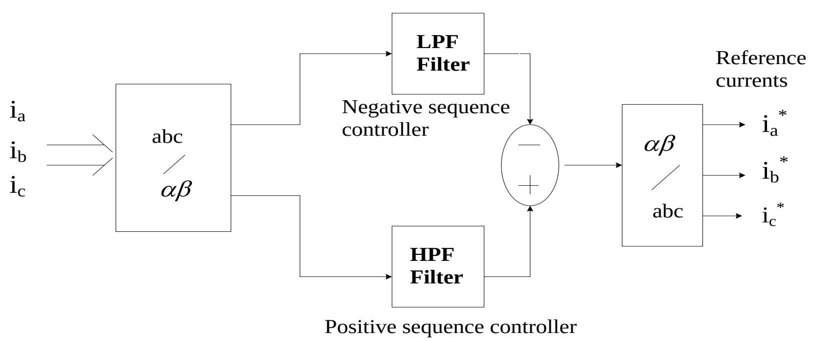

Figure 2 Scheme of harmonic detection

IJESMR
International Journal OF Engineering Sciences & Management Research

Both the currents from the harmonic component and dc voltage control block is compared and signal is send.

The control target is determined by summing the capacitor voltages at every cluster. The voltage reference is taken from the dc capacitor is used for generating u-phase overall voltage signal and is divided into V1, V2. In feature this control strategy is extended to N-phase H-bridge cascaded inverter [17].

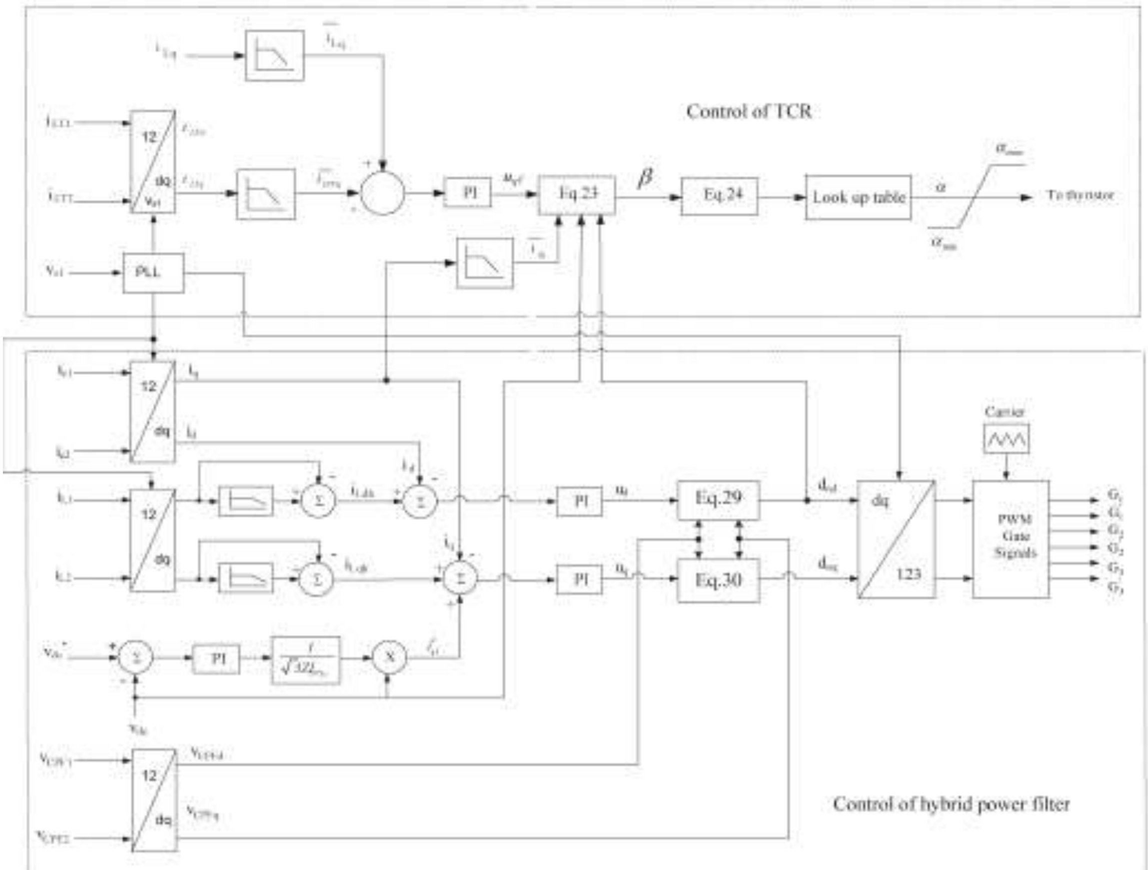

Figure 3 Control Diagram

The Figure 3 shows the complete control diagram for phase-u of proposed u AAPF is given in [17], which contains the source current direct control, feed forward compensation of load current, voltage-balance control and voltage control.

With the usage of the one or more cascade converters the compensation performance was better.

FUZZY LOGIC CONTROLLER

The fuzzy logic controller is one of the advanced soft computing controller which is used for controlling the system output. As compared with the other conventional controllers, fuzzy logic controller has the advantage of fast computing, better response, low settling time and high running response. The fuzzy logic controller operation can be explained in mainly four ways i.e 1. Fuzzification, 2. Membership function, 3. Rule-base formation and 4. Defuzzification.

IJESMR
International Journal OF Engineering Sciences & Management Research

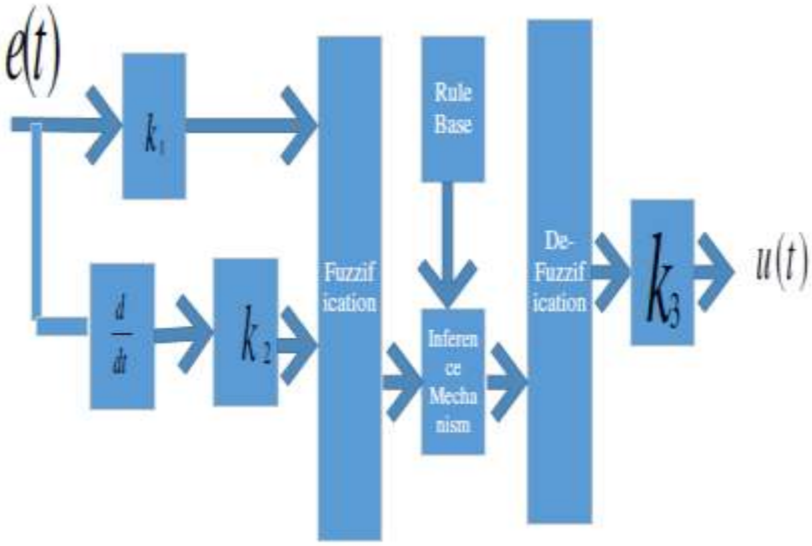

Figure 4 Block diagram of Fuzzy Logic Controller

The basic block diagram for the fuzzy logic controller as shown in Figure 4. The rule base taken for this system is shown below in table 1. The input variables such as error and error rate are expressed in terms of fuzzy set with the linguistic terms VN, N, Z, P, and VP [12]. In this type of mamdani fuzzy inference system the linguistic terms are expressed using triangular membership functions. L(e, ce) = {VN, N, Z, P, VP}

e \ er	VN	N	Z	P	VP
VN	VN	N	Z	P	VP
N	VP	P	Z	N	VN
Z	N	Z	P	VP	VN
P	N	N	VN	P	P
VP	N	Z	P	P	VP

Table 1 Seven variable rule base

The inputs for the fuzzy system are represented as error and error rate and its rule base formations are shown in above table. The fuzzy rules are obtained with the statement of if-then statements. The given fuzzy inference system is a combination of two inputs and one output. These two inputs are related with the logical AND/OR operators. AND logic gives the output as minimum value of the two inputs and OR logic produces the output has maximum value of two inputs. I.e if the input1 is zero and input2 is zero then the output is zero. The input and output membership function are shown in figure 5 and figure 6.

The membership function for the input error is as shown below.

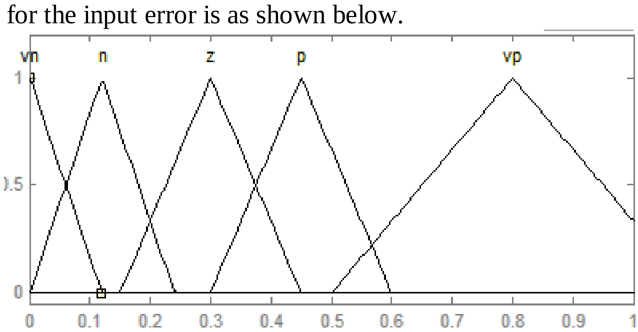

Figure 5: membership function representation for input 1

ISSN 2349-6193
Impact Factor (PIF): 2.243
IJESMR
International Journal OF Engineering Sciences & Management Research

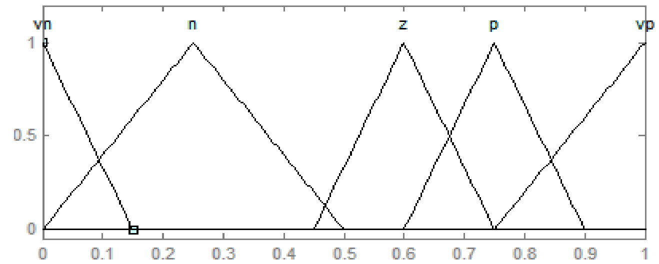

Figure 6: membership function representation for input 2

The membership functions used here is Triangular type and its range is -1 to 1 i.e., universe of discourse. And the relation between input and output variables obtained with the help of if-then rule base formation. The de-Fuzzification is done by using Centroid method.

EXPERIMENTAL RESULTS

Simulations were performed numerically using Matlab/Simulink environment, in order to verify the operation of the proposed SHPF-TCR. Here simulation is carried out in several cases, in that 1).Steady state and dynamic response of SHPF-TCR Hybrid Power Filter operated under PI Controller, 2). Steady state and dynamic response of SHPF-TCR Hybrid Power Filter operated under Fuzzy logic controller.

Case 1: Steady state and dynamic response of SHPF-TCR Hybrid Power Filter operated under PI Controller:

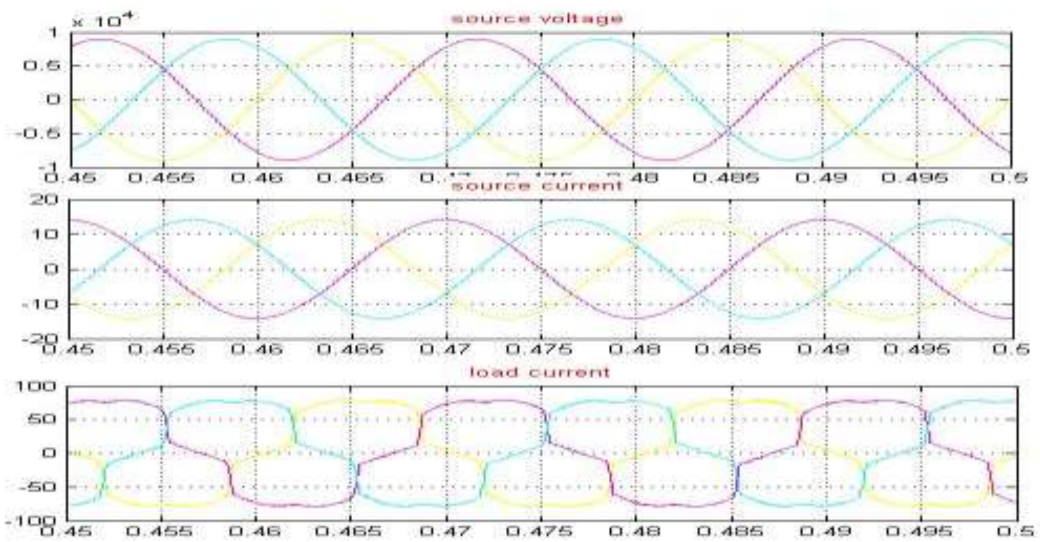

Figure 7: Static response of the system under PI controller

As in Figure 7 First waveform shows source voltage second waveform shows source current and third waveform shows load current of the static response of the system operating under PI controller.

IJESMR
International Journal OF Engineering Sciences & Management Research

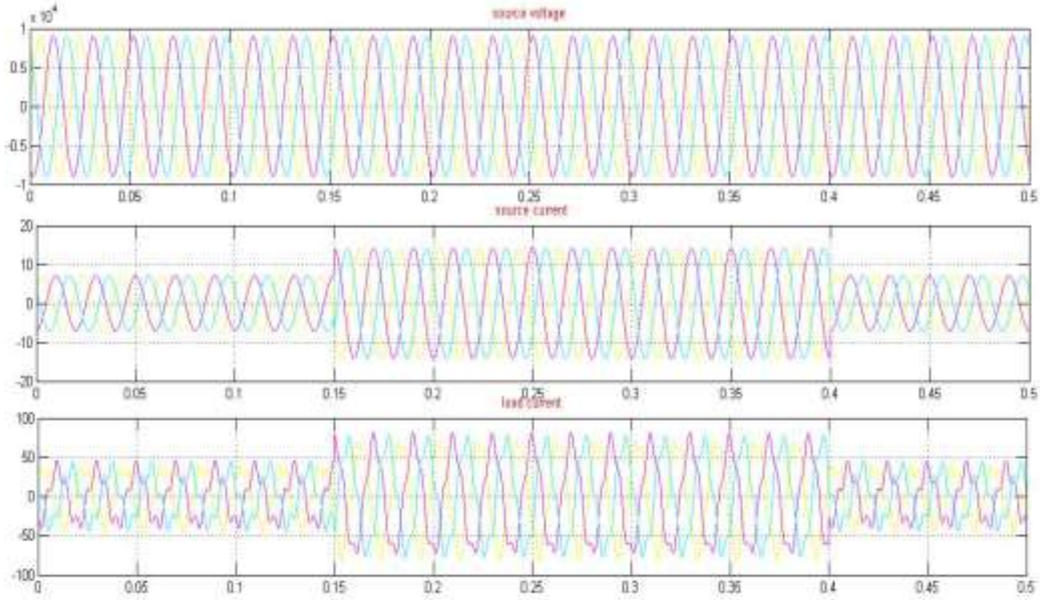

Fig:8 dynamic response of the system operating under the PI controller

As in Figure 8 First waveform shows source voltage second waveform shows source current and third waveform shows load current of the dynamic response of the system operating under PI controller

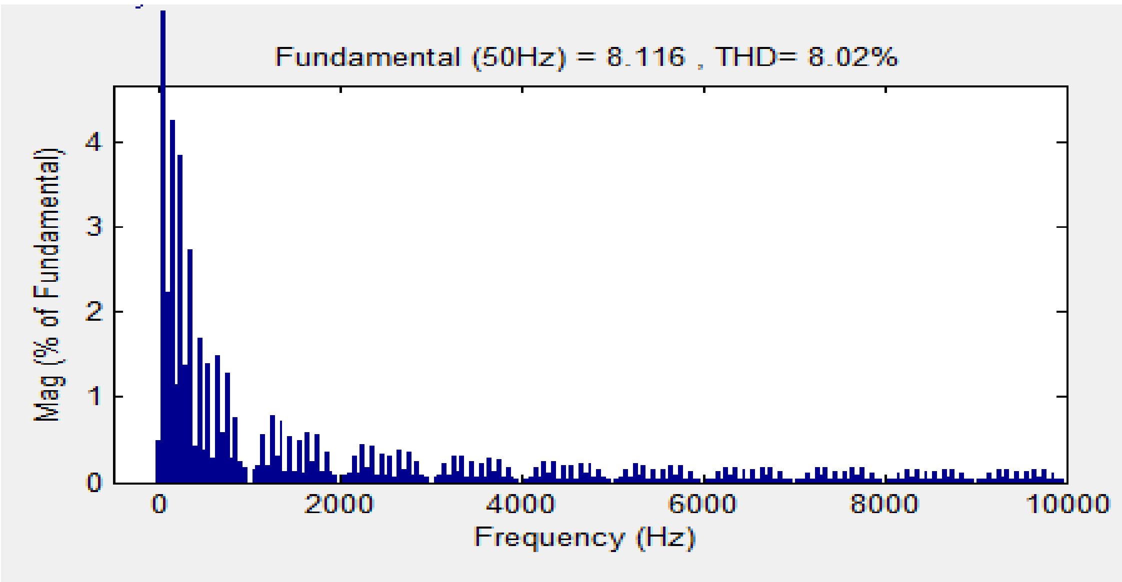

Figure 9: THD of Source Current operating under PI controller

Fig 9 shows the FFT analysis of source current of the system operating under the PI controller, we attain THD as 8.02%

IJESMR
International Journal OF Engineering Sciences & Management Research

Case 2: Simulation Result with Fuzzy Controller

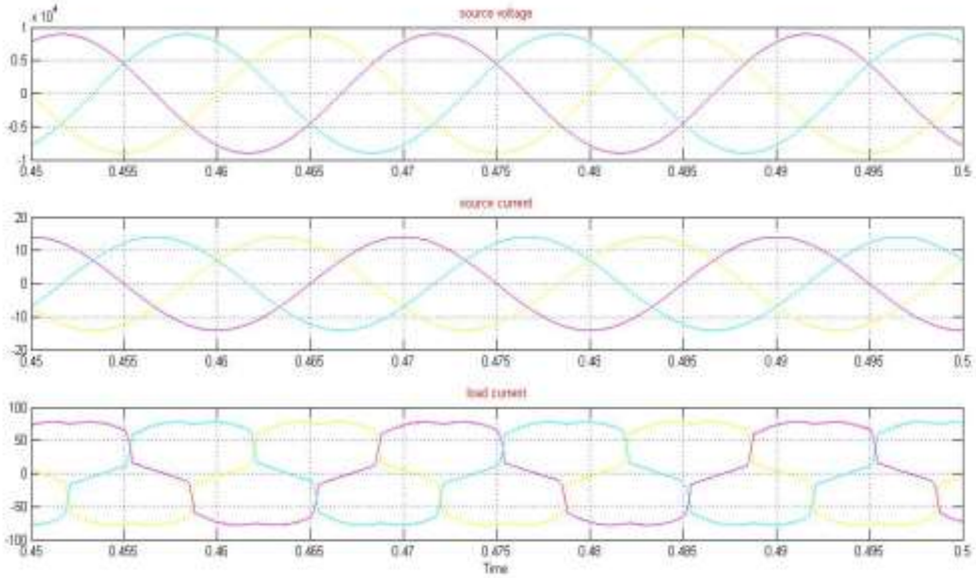

Figure 10: static response of the system operating under fuzzy logic controller

As in Figure 10 First waveform shows source voltage second waveform shows source current and third waveform shows load current of the static response of the system operating under fuzzy logic controller

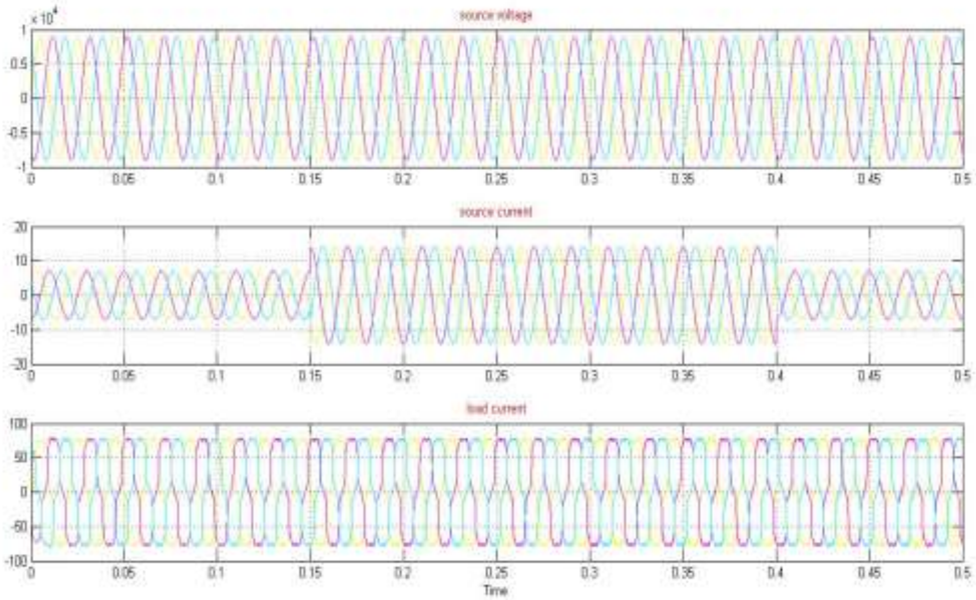

Figure 11: Dynamic response of the system operating under fuzzy logic controller

As in Figure 11 First waveform shows source voltage second waveform shows source current and third waveform shows load current of the dynamic response of the system operating under fuzzy logic controller

IJESMR
International Journal OF Engineering Sciences & Management Research

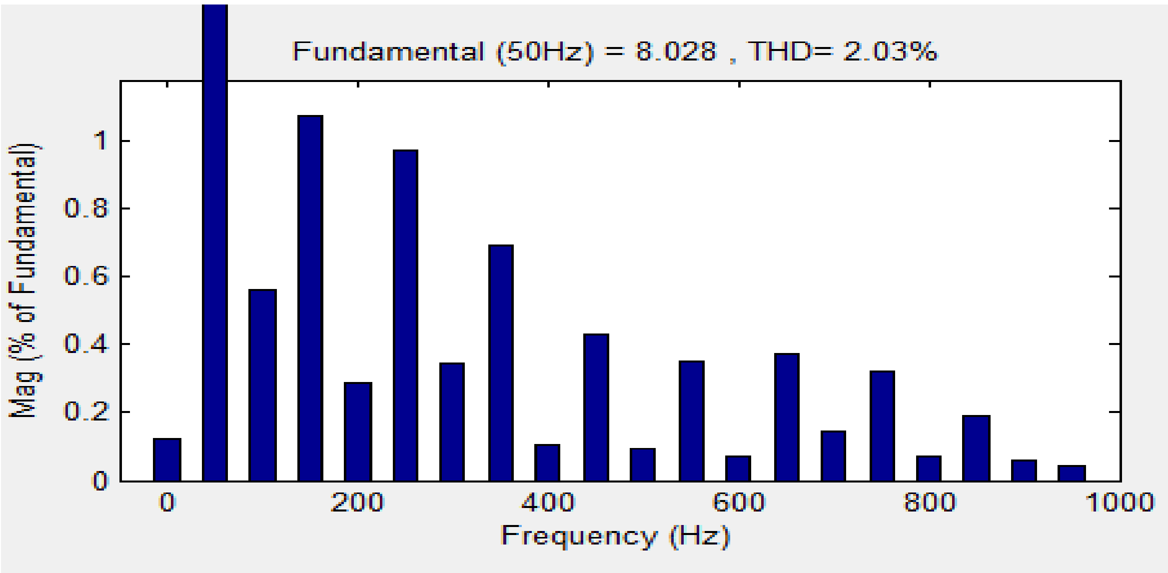

Fig 12: THD of Source Current operating under Fuzzy logic controller

Fig 12 shows the FFT analysis of source current of the system operating under the Fuzzy logic controller, we attain THD as 2.03%

CONCLUSION

Power quality issues are compensated by using shunt active filter along with thyristor controlled reactor. This paper mainly highlights the concept regarding utilization of non-linear load and their effects on source current of the power system. These harmonics in source currents are effectively eliminated with the shunt active power filter based TCR. In this paper we also proposes the concept of FLC based active power filter along with thyristor controlled reactor. This fuzzy controller mainly concentrates on the reduction of steady state error. From the simulation result we conclude that the fuzzy controller puts better effort for controlling as compared with PI controller.

REFERENCES

1. Zhong Chen, Member, IEEE, Yingpeng Luo "Comainly hintrol and Performance of a Cascaded Shunt Active Power Filter for Aircraft Electric Power System" on IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, VOL. 59, NO. 9, SEPTEMBER 2012.
2. A. Hamadi, S. Rahmani, and K. Al-Haddad, "A hybrid passive filter configuration for VAR control and harmonic compensation," IEEE Trans. Ind. Electron., vol. 57, no. 7, pp. 2419–2434, Jul. 2010.
3. A. Varschavsky, J. Dixon, M. Rotella, and L. Moran, "Cascaded nine-level inverter for hybrid-series active power filter, using industrial controller," IEEE Trans. Ind. Electron., vol. 57, no. 8, pp. 2761–2767, Aug. 2010.
4. A. Luo, X. Xu, L. Fang, H. Fang, J. Wu, and C. Wu, "Feedback– feed forward PI-type iterative learning control strategy for hybrid active power filter with injection circuit," IEEE Trans. Ind. Electron., vol. 57, no. 11, pp. 3767–3779, Nov. 2010.
5. S. Rahmani, N. Mendalek, and K. Al-Haddad, "Experimental design of a nonlinear control technique for three-phase shunt active power filter," IEEE Trans. Ind. Electron., vol. 57, no. 10, pp. 3364–3375, Oct. 2010.
6. B. Singh and J. Solanki, "An implementation of an adaptive control algorithm for a three-phase shunt active filter," IEEE Trans. Ind. Electron., vol. 56, no. 8, pp. 2811–2820, Aug. 2009.
7. A. Bhattacharya and C. Chakraborty, "A shunt active power filter with enhanced performance using ANN-based predictive and adaptive controllers," IEEE Trans. Ind. Electron., vol. 58, no. 2, pp. 421–428, Feb. 2011.
8. D. Ganthony and C. M. Bingham, "Integrated series active filter for aerospace flight control surface actuation," in Proc. EPE, 2007, pp. 1–9.

IJESMR
International Journal OF Engineering Sciences & Management Research

9. E. Lavopa, E. Summer, P. Zanchetta, C. Ladisa, and F. Cupertimo, "Realtime estimation of fundamental frequency and harmonics for active power filters applications in aircraft electrical systems," in Proc. EPE, 2007, pp. 4220–4229.
10. E. Lavopa, M. Summer, P. Zanchetta, C. Ladisa, and F. Cupertimo, "Real-time estimation of fundamental frequency and harmonics for active power filters applications in aircraft electrical systems," IEEE Trans. Ind. Electron., vol. 56, no. 8, pp. 2875–2884, Aug. 2009.
11. M. Odavic, P. Zanchetta, and M. Summer, "A low switching frequency high bandwidth current control for active shunt power filter in aircrafts power networks," in Proc. IEEE IECON, 2007, pp. 1863–1868.
12. V. Biagini, M. Odavic, P. Zanchetta, M. Degano, and P. Bolognesi, "Improved dead beat control of a shunt active filter for aircraft power systems," in Proc. IEEE ISIE, 2010, pp. 2702–2707.
13. H. Hu, W. Shi, J. Xue, Y. Lu, and Y. Xing, "A multi resolution control strategy for DSP controlled 400 Hz shunt active power filter in an aircraft power system," in Proc. IEEE APEC, 2010, pp. 1785–1791.
14. A. Eid, M. Abdel-Salam, H. El-Kishky, and T. El-Mohandes, "Active power filters for harmonic cancellation in conventional and advanced aircraft electric power systems," Elect. Power Syst. Res., vol. 79, no. 1, pp. 80–88, Jan. 2009.
15. A. Eid, M. Abdel-Salam, H. El-Kishky, and T. El-Mohandes, "On power quality of variable-speed constant-frequency aircraft electric power systems," IEEE Trans. Power Del., vol. 25, no. 1, pp. 55–65, Jan. 2010.
16. J. C. Wu and H. L. Jou, "Simplified control method for the single-phase active power filter," Proc. Inst. Elect. Eng.—Elect. Power Appl. , vol. 143, no. 3, pp. 219–224, May 1996.
17. Z. C. Zhang, J. B. Kuang, X. Wang, and O. T. Boon, "Forced commutated HVDC and SVC based on phase-shifted multi-converters," IEEE Trans. Power Del., vol. 8, no. 2, pp. 712–718, Apr. 1993.