Power Quality Improvement Using Intelligent Fuzzy Based Active Power Filter

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Abstract

Use of power electronic converters with non linear loads produces harmonic currents and reactive power. A shunt active power filter provides an elegant solution to reactive power compensation as well as harmonic mitigation leading to improvement in power quality. However, the shunt active power filter with PI type of controller is suitable only for a given load. If the load is varying, the proportional and integral gains are required to be fine tuned for each load setting. The present study deals with fuzzy logic based controller for shunt active power filter. MATLAB Simulink is used to prove the results.

Keywords: Fuzzy, Active Filters, Power Quality

I. INTRODUCTION

The active power filter is proved as the ultimate solution for mitigating harmonics and compensating reactive power developed by using non linear power electronic loads. As the ancient solution are faded out with detuning and fixed compensation effects, the active power filter is chosen with its flexibility to provide the compensating current for any adverse situations of supply and load. Many papers have been published in the area of active filters with PI controller. Some of them are [2], presented the instantaneous reactive power theory with comprising switching devices. Practically it didn't require any energy storage elements. The physical meaning of instantaneous reactive power was discussed in detail. [3] Proposed a new control technique for dc capacitor voltage. The active power filter with quad series voltage source PWM converter to suppress ac harmonics by injecting the compensating current was discussed. [4] Introduced the active power filter for three phase four wire system. The system had distinct advantages over the three single phase active power filters used at that time.

Moran [5] proposed an active power filter which runs with a fixed switching frequency. Reactive power compensation was also achieved even without sensing the reactive power components which makes the circuit simpler. Singh B. et.al. [6] Presented a review paper on active power conditioning technology. This paper covers configurations, control strategies, selection of components, and related economic and technical considerations aiming to give a broad perspective on active power filters. Chatterjee K. et.at. [7] Proposed Instantaneous Reactive Power Volt - amp Compensation and Harmonic suppressor system without sensing Reactive Volt Ampere demand. It don' t involve in complicated controllogic. It is the Cycle-by-Cycle reference current control mode by regulating DC link voltage. The hardware PI and PLL based sine wave generator was used to implement control algorithm. Jain, Shailendra Kumar et.al. [8] Presented the designing of shunt active power filter with experimental validations for the proposed design. In this paper the detailed designing procedure is adopted and reported. Jain S. K. et.al. [9] presented a fuzzy logic controller based shunt active power filter by sensing the line currents only unlike the conventional method of sensing the reactive currents. This paper was concluded that the dynamic behavior of the fuzzy logic controller is better compared to that of PI controller with steady state and transient responses. Singh G.K. [10] proposed a simple fuzzy logic controller for mitigating harmonics and compensating reactive power. This paper introduced the fuzziness in the limiter part and given an extensive results for the same with and without fuzzy logic.

This work will help to mitigating harmonics and compensating reactive power for unbalanced load also. Kishore Kumar Pedapenki et.al. [13] presented the fuzzy logic application to mitigate harmonics and to get good power quality. This paper had the design and application of fuzzy logic with RL load and rectifier RL load with various firing angles as loads proved that the fuzzy logic was the better in all the cases compared to PI controller. By seeing the literature review, the fuzzy logic controller is superior in all aspects, it offers flexibility in taking linguistic inputs and can adapt to any system. This paper presents application of the membership functions of the fuzzy based shunt Active Power Filters. The implementation of the

II. SYSTEM CONFIGURATION AND CONTROL

Fig. 1 presents the scheme of active filtering. The system consists of a three phase non linear load. The controllers are

(a) PI controller

(b) Fuzzy Controller. Fig. 2 fuzzy controller unit. Reference currents are the sinusoidal waves with frequency as the source voltage and the magnitude as the output of the controller. This can be done by dividing the each voltage wave with the maximum value to get the unit voltage wave and then multiplied with the output of the controller to get the required reference wave. This is compared with the actual currents and the error is process in the hysteresis controller.

In present work, the performance of the shunt active power filter is evaluated with fuzzy logic controller (FLC). The effectiveness of FLC is investigated with different membership functions.

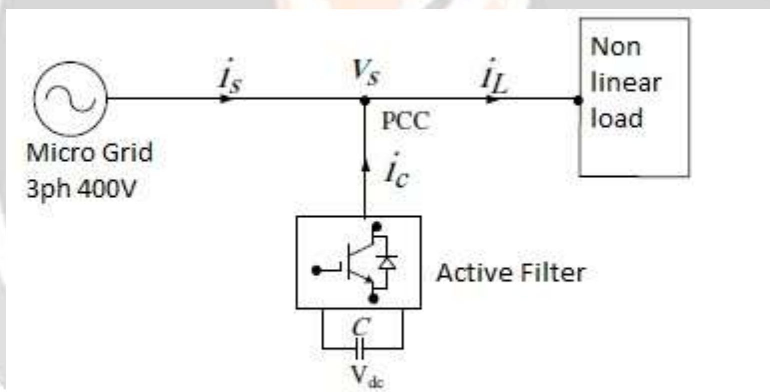

Fig.1 Shunt Active Power Filter.

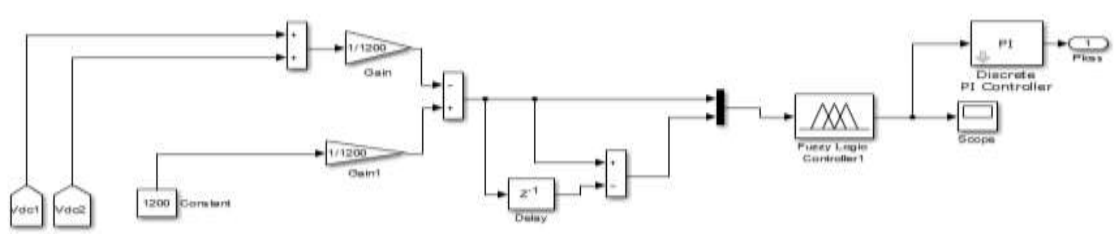

Fig.2 Fuzzy Control For Active Filter

To obtain unit voltages, the actual source voltages are divided by peak value of the source voltage the equations are:

$$V_m = \sqrt{\frac{2}{3}(v_{sa}^2 + v_{sb}^2 + v_{sc}^2)} \qquad (1)$$

Where $v_{sa} = V_m Sin(wt)$

$$v_{sb} = V_m Sin(wt - 120)$$

$$v_{sc} = V_m Sin(wt - 240)$$

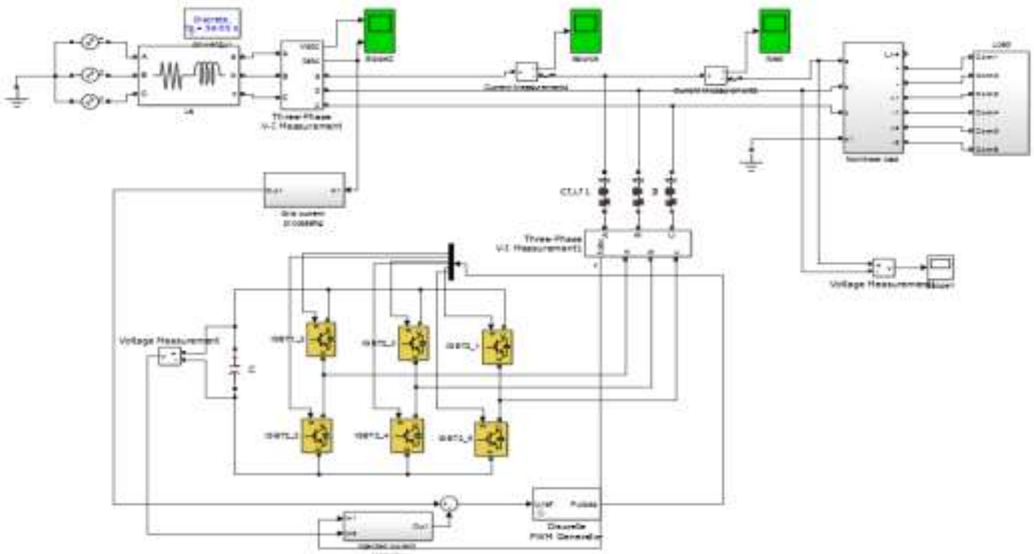

Fig. Show MATLAB Model of Proposed System.

III. FUZZY LOGTC CONTROLLER

The Fuzzy logic uses membership functions with values increasing between 0 and 1.The power loss for the Active filer is calculated by regulating the DC link Voltage. The real capacitor voltage is compared with a prescribe value. Fuzzy setsare selected based on the error in the dc link voltage. We have chosen 7 by 7 membership function. For the feasibility of the program are as below:

- ND: Negative Big
- NM: Negative Medium
- NS: Negative Small
- ZE: Zero
- PS: Positive Small

  Are used.

Input and Output membership functions are same. Fuzzy interference is done by using membership Function those are as follow:

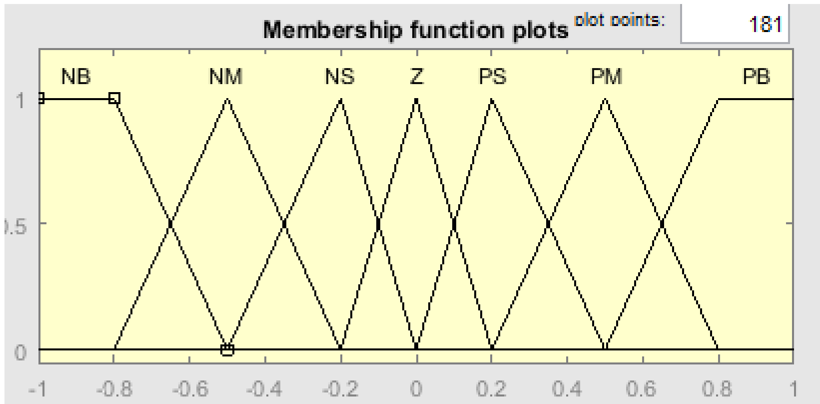

Fig.4.3: Membership function used for input error and delta error

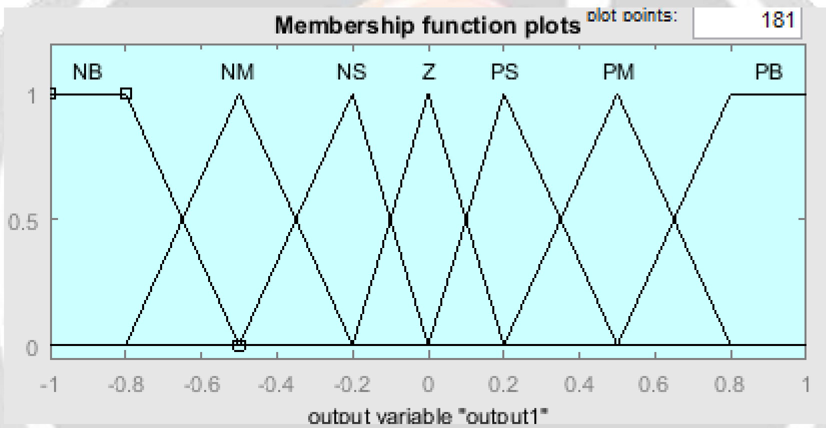

Fig.4.4: Membership function for output

The rules were described as below:

- IF VDC is LN THEN power is PB.
- IF VDC is SN THEN power is PL.
- IF VDC is ZE THEN power is PM.
- IF VDC is SP THEN power is PS.
- IF VDC is BP THEN power is ZE0

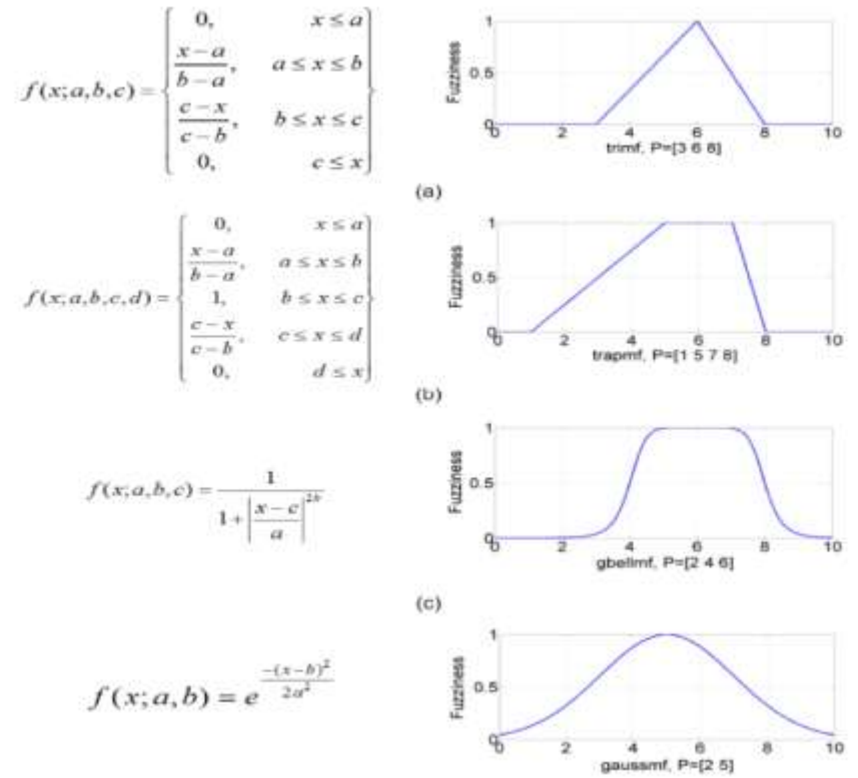

Fig. Equation and shapes of membership function in Fuzzy Logic.

Control strategy of the proposed system is shown below

Table.1 Control Strategy

E \ ΔE	NB	NM	NS	Z	PS	PM	PB
NB	NB	NB	NB	NB	NM	NS	Z
NM	NB	NB	NB	NM	NS	Z	PS
NS	NB	NB	NM	NS	Z	PS	PM
Z	NB	NM	NS	Z	PS	PM	PB
PS	NM	NS	Z	PS	PM	PB	PB
PM	NS	Z	PS	PM	PB	PB	PB
PB	Z	PS	PM	PB	PB	PB	PB

IV. RESULT AND DISCUSSION

The Shunt Active Harmonic Filter model and controller have been executed utilizing MATLAB Simulink toolboxes. The parameter used in the model is listed below in Table II. In this model comparison of actual current and reference current is done, Analyses of Current waveforms and related Total Harmonic Distortion (THD). The Quality of these controllers is then analogizing with respect to changes in the filter inductance Lf.

System Parameter		Value
Three Phase Source Voltage	Vs	400V
Frequency	F	50Hz
Nonlinear Load	Rs, Ls	10Ω, 0.1H
FilterInductance	Lf	2 mH
DC Capacitance	Cdc	400 µF

At the first, the system is simulated in the absence of the Shunt Active Filter. Fig.4.7. and Fig.4.14 manifest the load voltage and Current separately which reveal a considerable distortion in the current waveform. The THD in fig.4.7 has been approximately calculated to 43.92%.

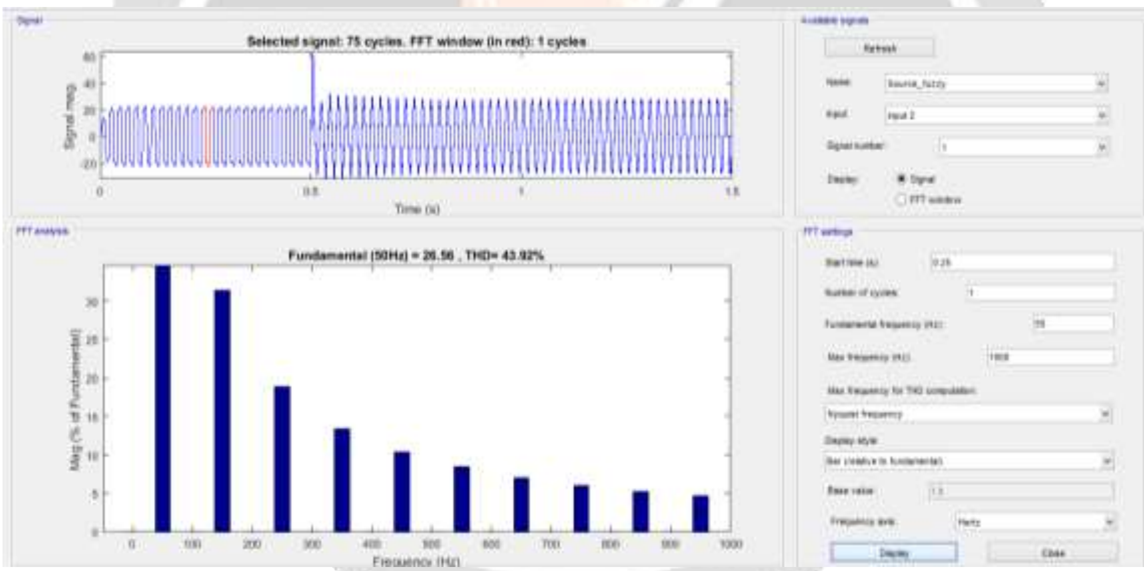

Fig.4.7: THD in the absence of APF

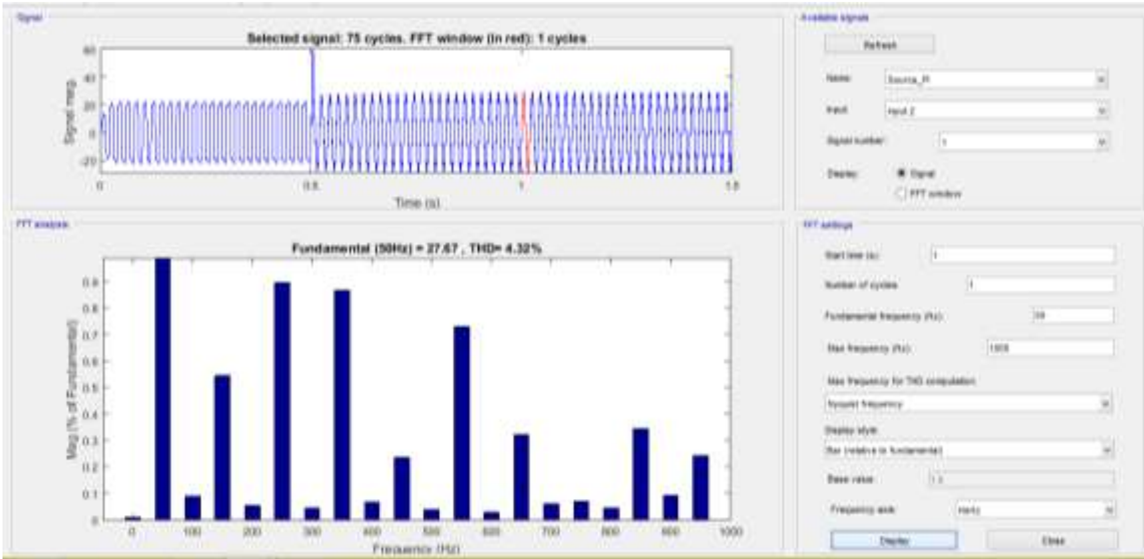

Fig.4.9: Output of Source PI of THD

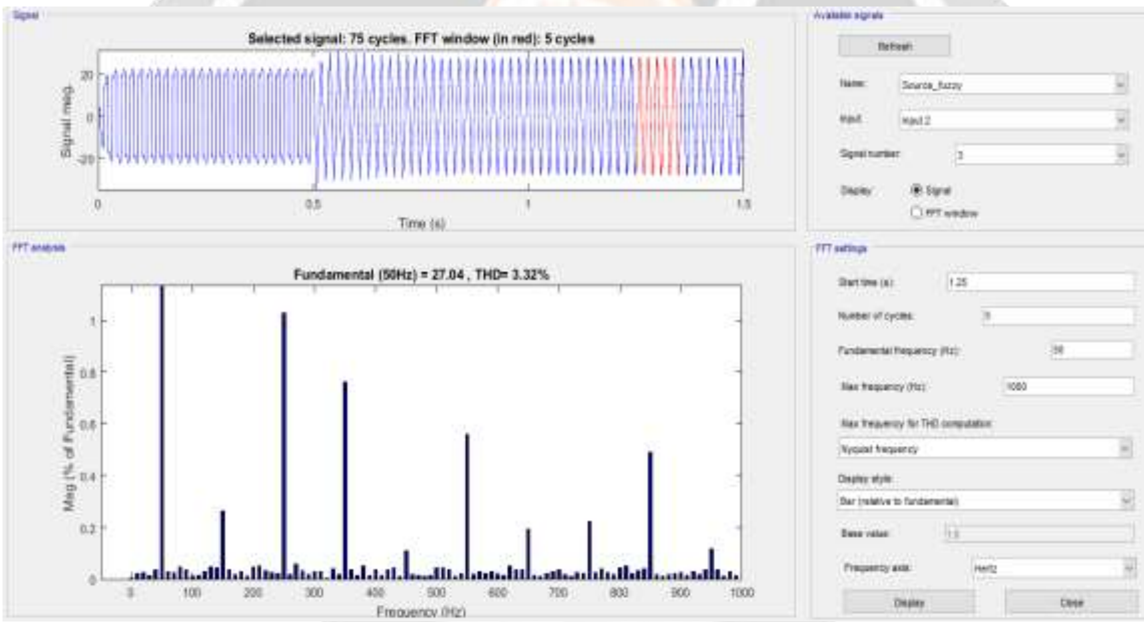

Fig.5.8: Reduction of THD by using Fuzzy logics

V. CONCLUSION

The active power filter controller with fuzzy logic control been seen to eminently minimize harmonics in source current when the load demands non sinusoidal current, irrespective of whether the load is fixed or varying. Simultaneously, the power factor at source also becomes unity, if the load demands reactive power. Thus fuzzy logic controller is far superior to PI type of controller which requires me tuning of proportional and integral constants every time the load changes. In present work, the performance of fuzzy logic controller has been examined with four types of membership functions - triangular, trapezoidal and G-Bell and Gaussian. A range of values of the load is considered to robustly test the controller. It has been demonstrated that triangular membership function offers most acceptable results while the Gaussian membership function offers poorest of the four. The fuzzy logic controller with triangular membership function, therefore, significantly improves the performance of a shunt active power filter.

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