International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Fuzzy Based Power Quality Improvement using Active Power Filter

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ABSTRACT

In the 20th century, Electricity is the vital need of human, thus it's become mandatory for electrical engineers to minimise the loss in the line to regain the desire output. After extensive consultation with experts, the study on THDi mitigation in the power system is presented in court. The goal of this dissertation is to illustrate how fuzzy logic with a PI controller may reduce THDi. A PI and Fuzzy controlled shunt active power filter is discussed to extend the (Total Harmonic Distortion) THDi within the permissible limit described by the IEEE Std. 519-1992 and to compensate reactive power and enhance PF. The recent scenario in the distribution system is harmonic produced by the nonlinear load and unbalanced condition of load / current.Implementation, ease of use, and cost savings are also guaranteed. The Matlab/Simulink® package is used to simulate the suggested controller. Investigation of system execution under various loading situations is necessary for successful verification.

Keywords: Fuzzy, Power Quality, Active power filter, Microgrid, Nonlinear load, THDi, Approach to omit THDi in small grids.

Introduction

Highlight a section that you want to designate with a certain style, and then select the appropriate name on the style The growing concern over power quality, awareness of the harms to the power system, penalties imposed by utility companies, and standards to the limit of THDi by IEEE and other organizations are the factors that have led to the development and widespread use of a variety of techniques, methods, and methods for harmonic elimination. Signals whose frequency is an integral multiple of the fundamental frequency are known as harmonic signals. Two types of frequency exist. I Basic frequency ii) harmonics frequency [1-4]: If the fundamental frequency's energy is higher than the harmonic frequency's energy, the waveform will be sinusoidal, and if the fundamental frequency's energy is lower than the harmonic frequency's energy, the waveform will be deformed or square.The most important sources of current distortion are inverters and power electronic converters, which are frequently found in distributed loads and Micro grid power sources. THDi causes overheating of parts and excessive power usage. The most popular method for reducing THD in a system is a passive power filter, although this method falls short when it comes to making up for line loss compared to an active harmonics filter. As a result of the fuzzy and PI base control active harmonic filter being adopted, which is why it is more common than the passive filter, we will discuss how to improve the power quality of the power network in this proposal.

Conventionally, passive filters are used for currentharmonics diminution while capacitor banks are utilized forpower factor alteration. Neither of them solves the problem inanadequate way, and usually introduced other problems, such as resonances [5]. Moreover, their performance depends on systemimpedance and also affected from passive filter component sagging.The part of the capacitor voltage is to compensate for inverter losses and any transient fluctuations in real power between the AC and DC sides following load changes, Several DC bus voltage control topologies have been recommended in literatures.

Fuzzy logic system evolved for more than four decades and have evidence to be a dominant technique in dealing with unreliability, parameter variation and especially where the system model is complex or not precise defined for the designed control action. For that justification, the evaluation of the performance of nonlinear controllers such as those based on fuzzy logics to decode the unbalance load condition and distortion of outcome is vital [6].

Electric utilities and end users of electric power are suitably all the time more concerned about meeting the growing energy demand. Nearly, seventy-five percentage of total global energy demand is supplied by the burning of fossil fuels. But increasing air pollution, global warming concerns, withdrawing fossil fuels and their increasing cost have made it essential to appear towards renewable sources as a future energy solution. As the earlier period of decade, there has been an enormous attention in many countries on renewable energy for power generation. The market liberalization and Governments incentives have additional accelerated renewable energy sector growth [7-9].

Shunt active power filters (APF) are used widely for the reduction of current harmonics and development of the power factor in power systems with nonlinear loads, such as diode rectifiers. A pulse width modulation (PWM) power converter comprises the main element of the APF.

The recurring or learning based control has established to accomplish high steady-state performances for control systems. The iterative learning algorithm is proposed to achieve zero tracking error without full acquaintance of the system model as discussed in Lenwari (2010). However, its dynamic behaviors were not fulfilled in some conditions predominantly under non-periodic disturbances because the control uses the information from the preceding iteration to compute the system input. The author proposed an investigation of the use of genetic algorithm to optimize the learning gain of a simple proportional-type (P-type) learning control function to current control for shunt active filters. The advantage of the proposed control is its effortlessness, potentially appropriate for commercial active filters. All design conception is demonstrated and the results obtained in the simulation confirm the improvement in the dynamic responses throughout the transient condition while the harmonic control accuracy in steady-state can remain excellent with the proposed control system [10-14].

METHDOLOGY OF PROPOSED APF

The principal objective of the work is to explore the shunt active power filter in three phase networks under unbalance load and nonlinear load conditions using hysteresis current controller by fuzzy and PI controller with control algorithm based on "The p-q theory" that function under closed loop control system [15-16]. The objectives of this are

- To mitigate current harmonic from both non-Linear load and unbalance load in the power system.
- To enhance the quality of power factor.
- To balance the Reactive power in power system.
- To make the entire system stable and reliable.

The Proportional-integral-derivative control (PI controller) based shunt active harmonics filter are not more proficient as compare to Fuzzy logic-based control shunt active harmonic filter. We will see the outcome of both controller in result.

Shunt APF Configuration

The Shunt active power filter (SAPF) is an admire approach for neutralize the harmonics in system and also compensate reactive power from the line. Election of active harmonic filter for specific application is an important assignment for consumer/users and application engineers.The most habitual used of APF configuration is the shunt Active harmonics filter, which infuse current harmonics into the point of common coupling (PCC).Fig.1 shows the fundamental principal of SAPF.

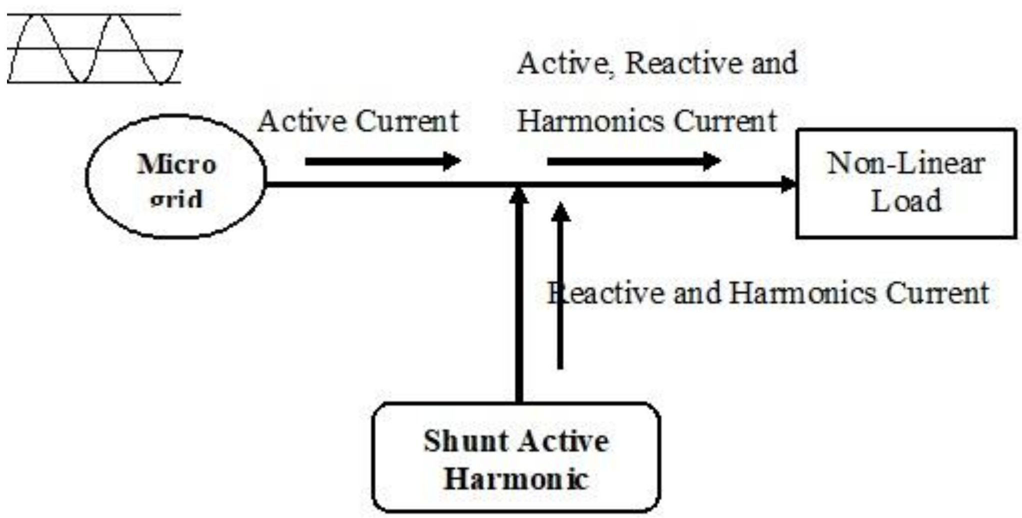

Figure 1. Fundamental principle of SAPF

Power Module

It's made up of an inverter that can be Single-Phase or Three-Phase that use IGBTs. Sources can be determined by the energy store in the filter, it can be CSI current Source Inverter, if it uses inductance or VSI Voltage Source Inverter, if it use Capacitor, in this technique of Current Harmonic mitigation VSI is used [17].

The module need to be pair to the Micro grid through an inductance directly in the Point of Common Connection of the network, and the energy used to execute the compensation is stored intimate in the DC side of the inverter with capacitor.

Control of the Shunt Active Harmonics Filters

The Shunt Active Harmonic Filter Execution in three steps. The First is Harmonic identification technique to recognize harmonic level in the network. The second is to manage the compensation currents and the last one is the control strategies of the inverter to infuse theses currents into the power network. Comprehensive control system is depicted in fig2.

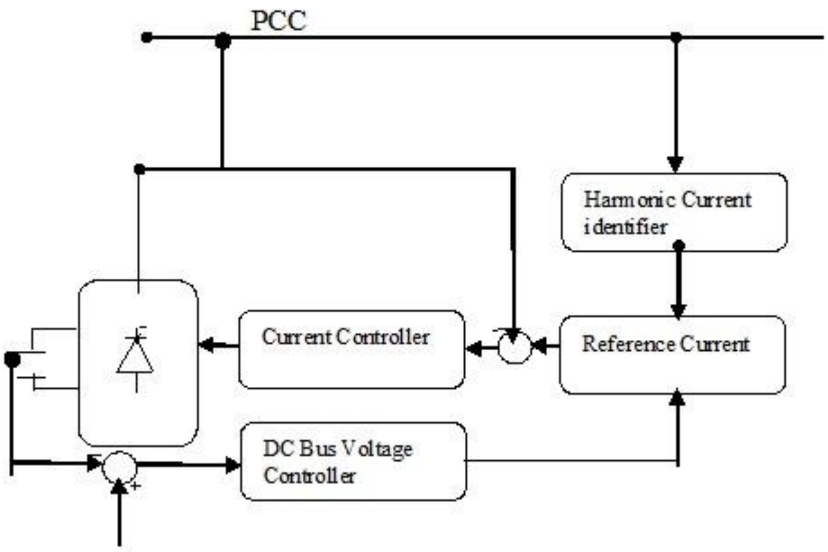

Fig2: Comprehensive control system of PI controller.

Proportional-Integral Controller

Without Filter there is a huge amount of Harmonic current present in the system, which cause overheating of equipment, loses in the network, increment of reactive power, Lower the quality of power, reduce the power factor quality, which make the life harder. With assist of shunt active power, it is possible to restraint the harmonic current as per the IEEE Standard 519-1992 [18-19]. We will debate on the Shunt Active Power Filter base on PI Controller to mitigate the Harmonic current of Micro grids and Fuzzy Logic Controller Base Shunt Active Power Filter to dominate the THD. Fig. 3 shows the MATLAB model of the proposed system

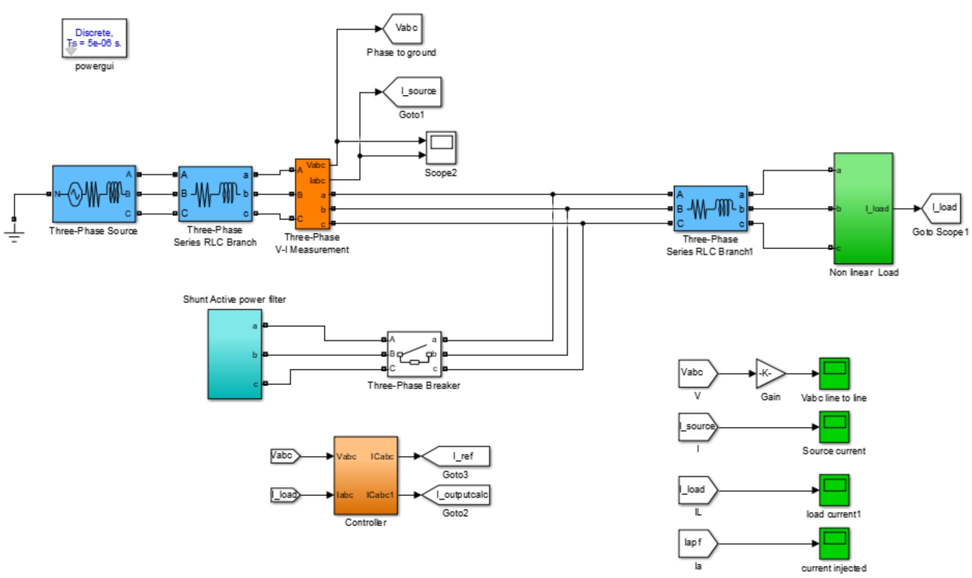

Fig.3 MATLAB Model of the proposed system

In the Fig3 Clear we can see the control and Harmonic mitigation circuit of PIController, with the help of infuse current controller, current infused in the system tocancel the opposite harmonic currents, with assist this we can confined the THD of thewithin the permissible limit. So that Active Filter confines the load Harmonic current atthe load terminal, hindering its penetration into the network, its draw a supplementaryharmonic current in order to retain the load end voltage sinusoidal [20]. All other figure till 10 shows the different parts with the graph.

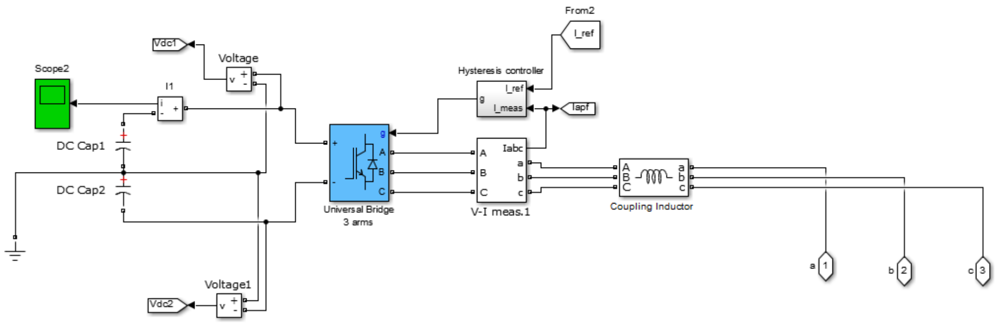

Fig.4 Shunt active controller

PI Controller is a feedback controller, which control the difference between the output and desired set point.

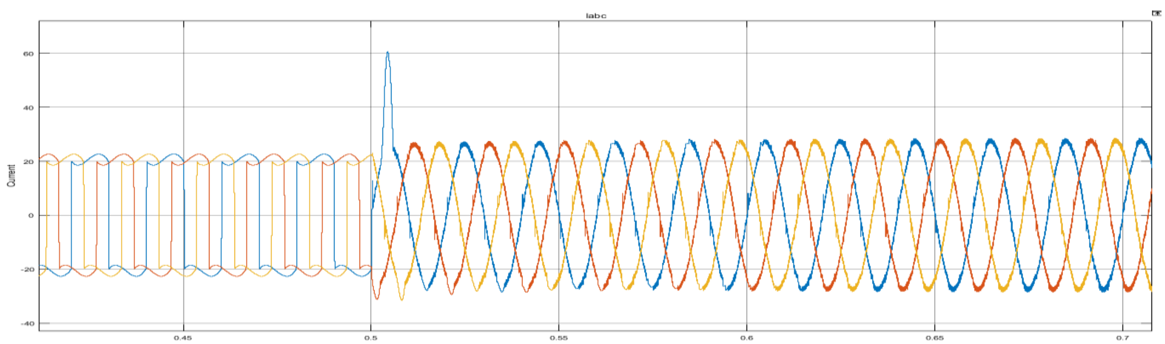

Fig.5 Current- Source side

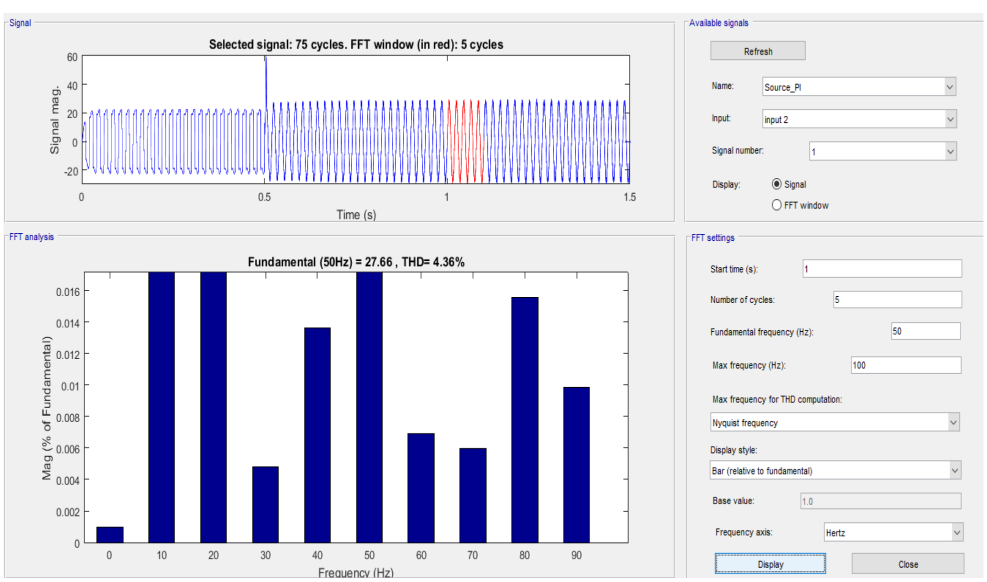

Fig. 6 THD - using PI controller

In the result of Source side, we can perceive that THD is 4.36%, which can be confines at load site with the assist of Active Filter.

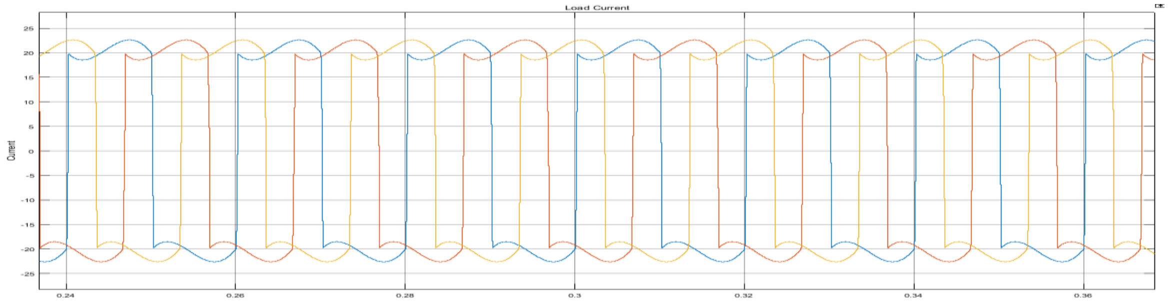

Fig. 7 Current- load side

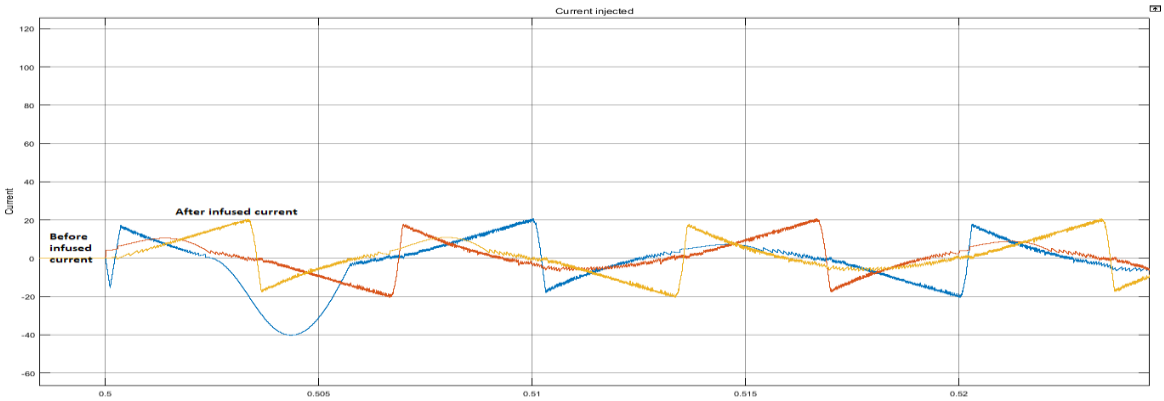

Fig.8 used Current waveform

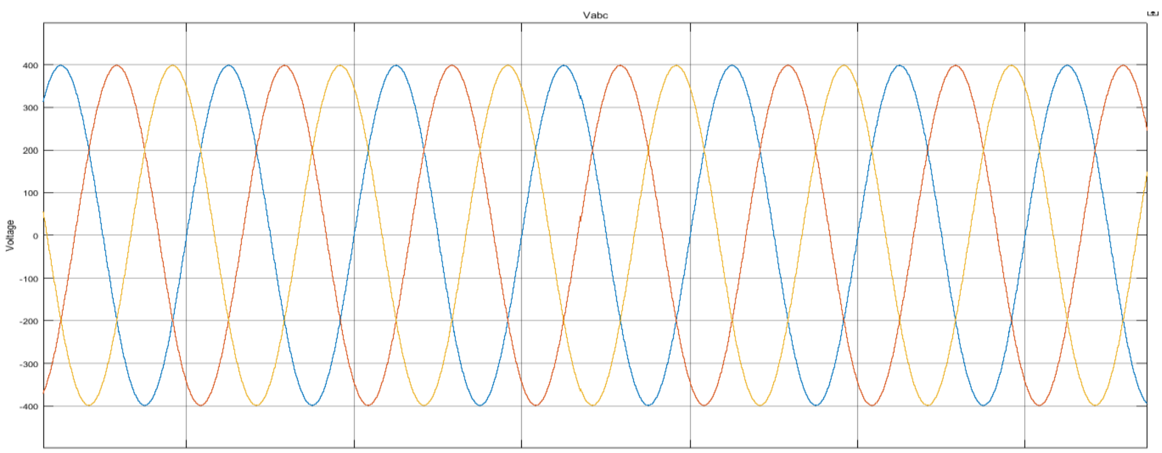

Fig.9 Line to Line Voltage

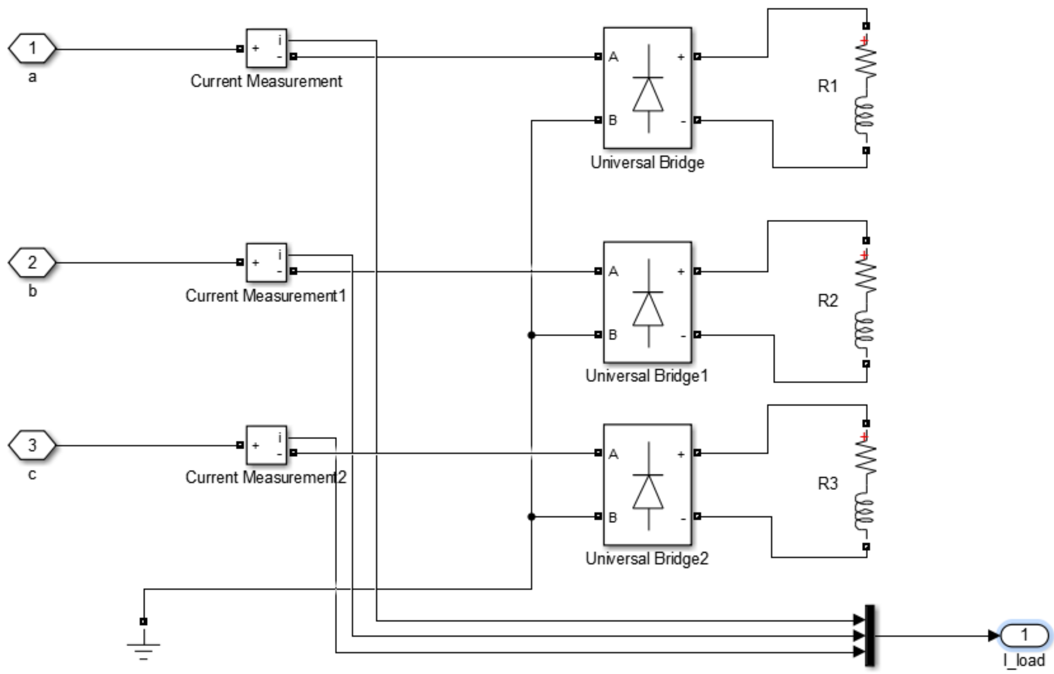

Fig.10 Connected load to the System

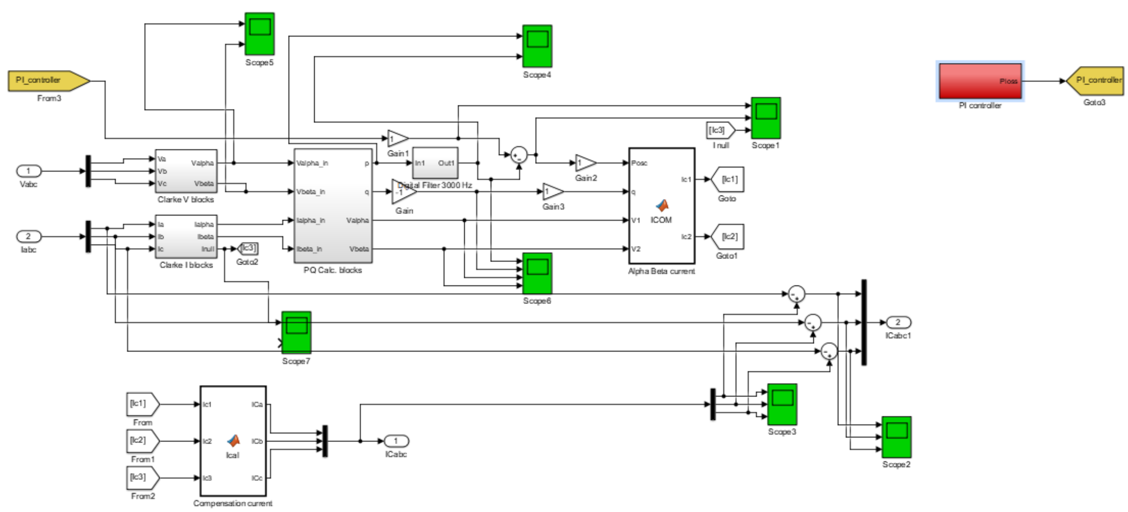

Fig.11: Reference Current Generator

Now as said above, THD is confines to 4.36%, which is less than the Source Side. It's feasible to reduce the Current Harmonic of power system below the 10% or near to 3%, promptly we will go our main topic that is Fuzzy logic controller. We will perceive toward the Grid Power Quality Enhancement using Control-Based Shunt Active Power Filter.

MathFUZZY LOGIC CONTROL BASED APF

Fuzzy logic begins with fabricates on a set of users provide human language commands. Fuzzy logic converts these commands to their mathematical equivalents. Boons of fuzzy logic add its simplicity and its feasibility. Fuzzy logic can control problems with vague and incomplete data, it can model nonlinear function of arbitrary complexity.If system is changing continuously, then fuzzy logic will fabricate a better clarification than the conventional control method. Fuzzy logic models, known as fuzzy inference system (FIS), embody of a number of conditional "if -then" rules.

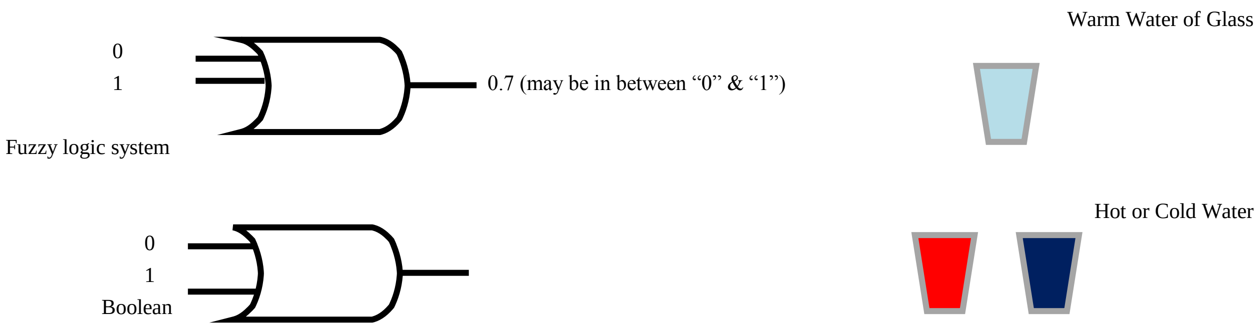

Fig.12: Basic concept of Fuzzy Logic Controller

Control Methodology

The main intend of the control method is to give absolute gate pulse to the voltage source inverter to depict opposite harmonic accommodating current. A complete diagram of the proposed SAPF is given in the fig. 00
Capacitor Voltage-1200V (600V each), Capacitor voltage is constant.

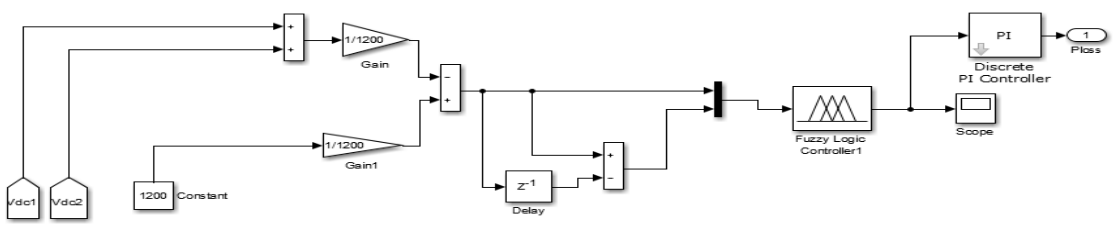

Fig.13: Control system of fuzzy Logic

The capacitor that energize the active filter employed as voltage source and its voltage should retain constant to corroborate that the performance of the filter is conserved and the voltage fluctuations of the semi-conductors do not pass the limits described. Here is the suggested dc link capacitor voltage is sensed and equate with the reference set value. From the error and the rate of change of error fuzzy controller provide a reference signal to be synchronized for the SAPF to the reference current generator. And the mention current generator provides a mention current with the guidance of load current and source voltage by claiming instantaneous active (p) and reactive (q)power theory, to the current controller. Reactive power, balance the unbalance load current and improve power factor of system can be achieve by using hysteresis controller, Hysteresis controller compare the provided signal and provide the gate pulse to the voltage source inverter. And inverter outcome passes through the filter inductor to the network and withdraw an opposite harmonic from the network. And by this method harmonics are cutback.

Fuzzy Controller Based DC Link Voltage Monitor

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:

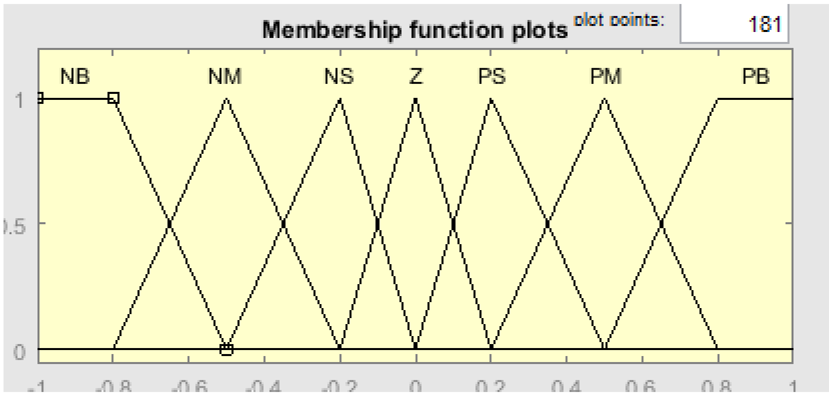

Fig.14: Membership function used for input error and delta error

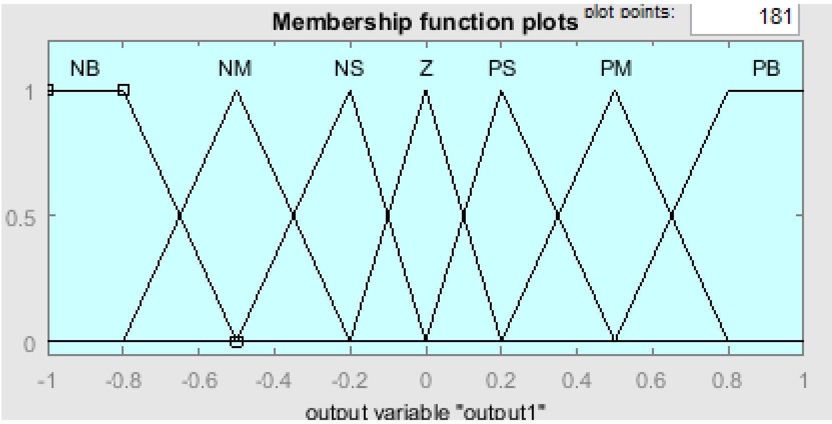

Fig.15: Membership function for output

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

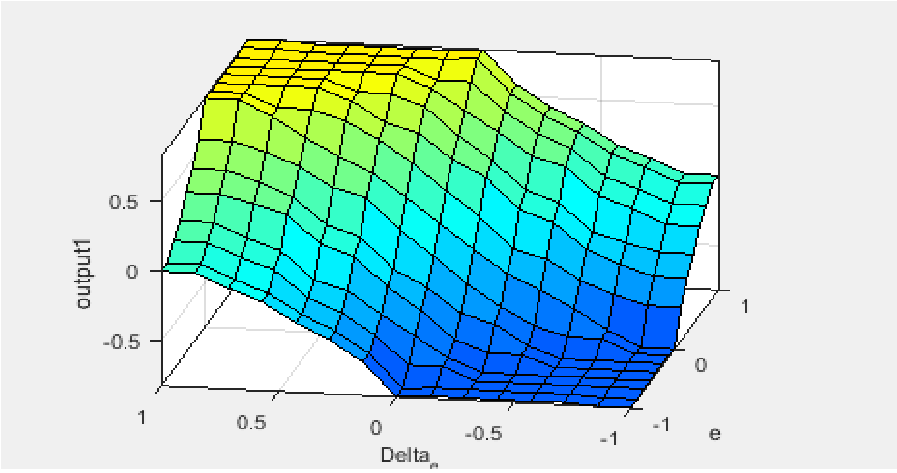

Fig.16: Surface view: Relation between e, delta e and output

The input and output variables are transferred into linguistic variables. Control rule table is given below.

ΔE / E	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

TABLE I: Control strategy for the dc bus voltage

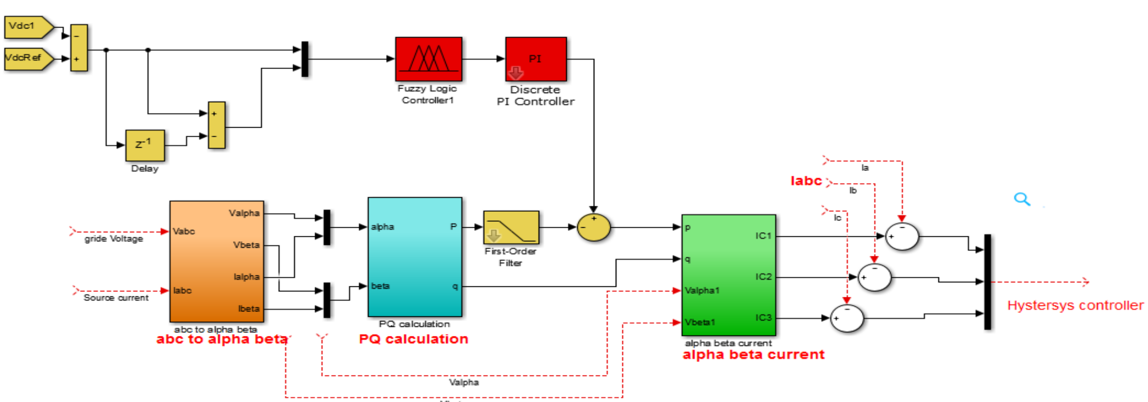

Fig.17: MATLAB Simulation of Fuzzy Logic

Simulation result

The Shunt Active HarmonicFilter 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

TABLE II: System parameter

Simulation results without filter

At the first, the system is simulated in the absence of the Shunt Active Filter. Fig.18 and Fig.19 manifest the load voltage and Current separately which reveal a considerable distortion in the current waveform. The THD in fig.20 has been approximately calculated to 43.92%.

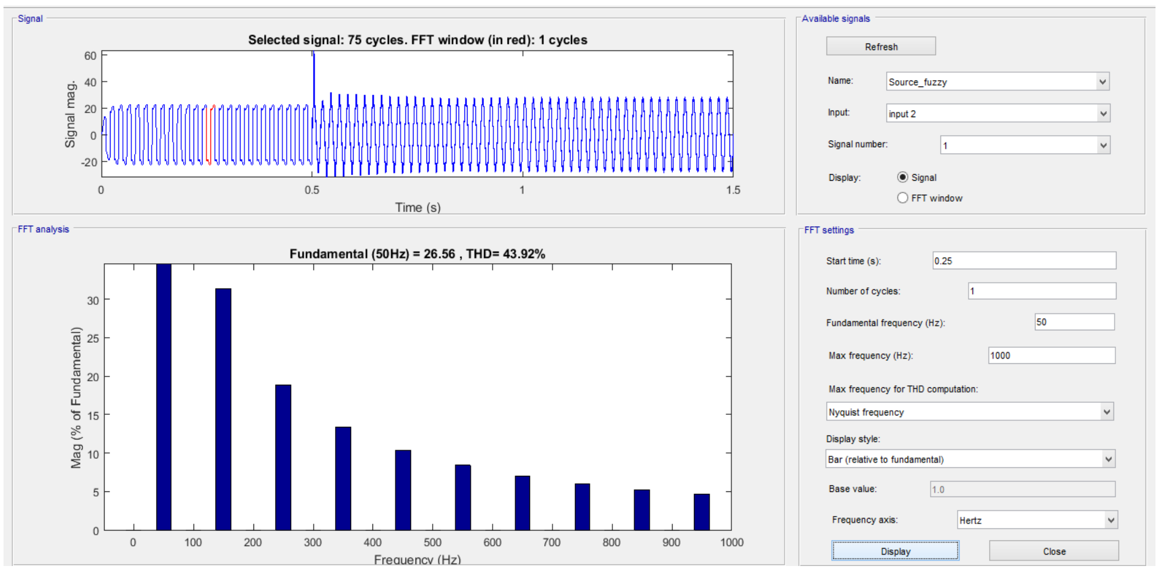

Fig.18 THD in the absence of APF

Simulation of results using SAPF

The Source Current waveform and its Harmonic Contorted (THD) after commencement of SAPF requisition using Fuzzy logic respectively represented in fig.4.9. The outcome of capacitor voltage (Vdc) is given in fig.4.8.

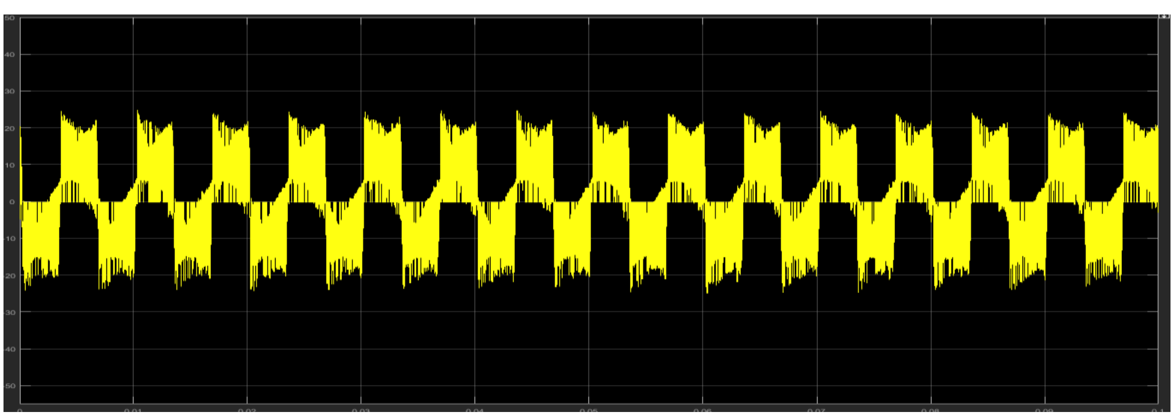

Fig.19 Capacitor Voltage dc

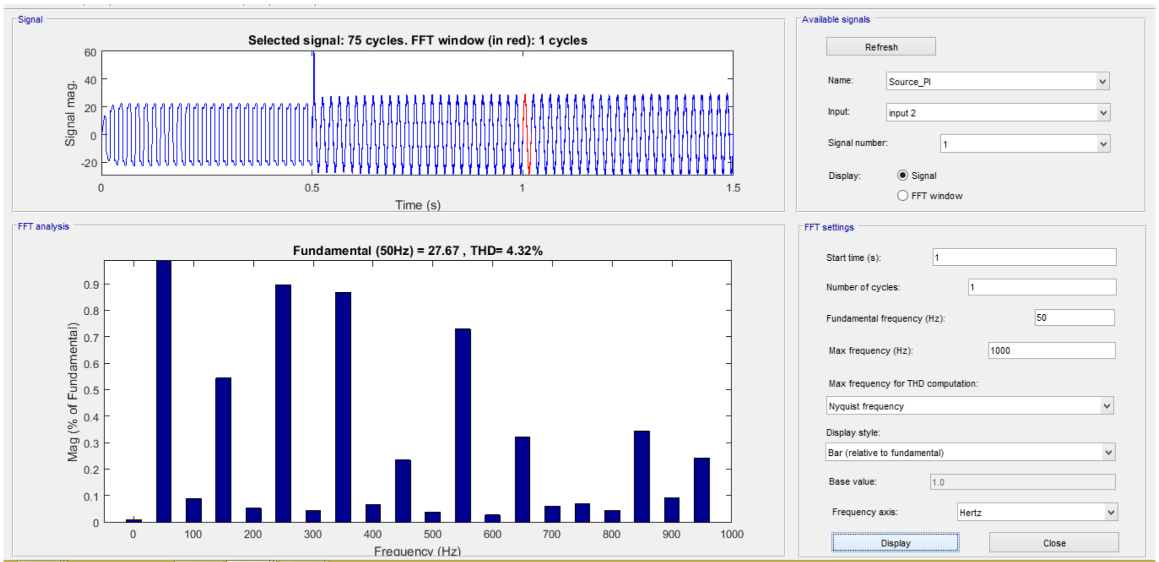

Fig.20: Output of Source PI of THD

CONCLUSION

In this simulation, the primary motto was to compare the PI control based active filter and Fuzzy Logic control based active power filter and execute them to know the quality and performance and their outcomes. Clearly, we can see in the results the outcome of Fuzzy Controlled based active power filter is more feasible and efficient (3.32%) than the PI control based active power filter (4.36%). The factual objective was to reduce the THD fabricated by nonlinear load and balancing the current from an unbalanced load condition and to enhance power factor. The examination of outcome manifest that the performance of theactive power filter is extremely satisfied to mitigate the harmonics, unbalance loading,reactive power, and also to enhance the power factor, what was the motto of the work.The Simulation are simulated in MATLAB Simulink and manifest that shunt active power filer work extremely good to consummate the objective of the work.

The p-q theory is utilized to the active power filter controller to lead the mitigate the reactive power of the network, Harmonics and to produce sinusoidal source current with less harmonic and unity PF.Total Harmonic Distortion percentage achieved from 43.92% to 3.32% for extremely nonlinear load.

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