Mitigation of Harmonics using Shunt-Series Active Power Filter for Power Quality Enhancement

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Abstract- **Harmonic and reactive power compensation in ac power networks with non linear loads, active filtering is proven to be efficient technique. This paper presents shunt and series active power filter – improved Unified Power Quality Conditioner (iUPQC) with two different control strategies, that is PI and Fuzzy Logic Control(FLC) for suppressing harmonics and to compensate reactive power. Because of dual topology of iUPQC extending its applicability in power-quality compensation, as well as in micro grid applications. By using this controller, beyond the conventional UPQC power quality features, including voltage sag/swell compensation, the iUPQC will also provide reactive power support to regulate not only the load-bus voltage but also the voltage at the grid-side bus. Simulation is carried out by using Simulink/Matlab-R 2014a to design iUPQC with PI and Fuzzy Logic Controller to calculate Total Harmonic Distortion (THD) value. Its value is to be well within the specified limit of IEEE standard(<5%). Simulation for without filter, with PI and FLC finally FLC gives better performance over PI is to be proven results are compared.**

Keywords– PI and Fuzzy Logic Controller, improved Unified Power Quality Conditioner, Total Harmonic Distortion, Power Quality Improvement.

1. INTRODUCT ION

Power quality is very sensitive due to non-linear loads, such as rectifier equipment, adjustable speed drives, domestic applications and arc furnaces. Power quality is any abnormal behaviour on a power system arising in the form of voltage or current. which adversely affects the normal operation of electrical or electronic equipement power quality is any deviation of voltage or current waveform form its normal sinusoidal waveshape. The most common types of power quality problems are presented below along with their drscription, causes and consequences are voltage sag/swell, very short interruptions, long interruptions, voltage spike, harmonic distortion, voltage fluctuation noise[1-3].

Harmonic contamination has become a major concern for power system specialists due to its effect on sensitive loads and on the power distribution system. Therefore the compensation for harmonics and reactive current is important owing to the wide use of power electronic equipments. A classical solution is suitable power conditioning methodology such as passive filtering and active power filtering to suppress harmonics in power system. Passive LC filter have been employed to eliminate line current harmonics and to improve the power factor. However, the harmonics problems still persists because of its inability to compensate random frequency variation in currents,tuning problems and parallel resonance. Hence a very interesting solutions is active power filter, which is connected either in series or parallel with the non linear loads. The active power filter concept uses power electronics to produce harmonic components, which cancel the harmonic components from the nonlinear loads[4].

2. ACTIVE POWER FILTER

Active power filter (APF) are filters, which can perform the job of harmonic elimination. Active power filters can be used to filter out harmonics in the power system which are significantly below the switching frequency of the filter. The active power filters are used to filter out both higher and lower order harmonics in the power system. The main difference between active power filters and passive power filters is that APFs mitigate harmonics by injecting active power with the same frequency but with reverse phase to cancel that harmonic, where passive filters use combinations of resistors (R), inductors (L) and capacitors (C) and does not require an external power sources or active components such as transistors. This difference, make it possible for APFs to mitigate a wide range of harmonics[5].

The Shunt Active Power Filters it compensate current harmonics by injecting equal-but-opposite harmonic compensating current. It operates as a current source injecting the harmonic components generated by the load but phase shifted by 180deg. They are usually connected across the load to compensate for all current related problem such as reactive power compensation, power factor correction, current harmonics and load unbalance compensation[6&7].

The series active power filter for current harmonic and load voltage compensation. The reduced switch-count inverter is used in the single-phase system to compensate voltage disturbance for low power applications. The frontend diode rectifier is used to supply the necessary active power under the voltage sag condition[8].

UPQC consist of two voltage source converter. They are operated from a common dc link provided by a dc storage capacitor. One converter is connected on the line referred as shunt converter and the other which is connected in series with the line referred as series converter. Shunt coupling inductor LSh is used interface the inverter from the network. It also helps in smoothing the current way shape. Sometimes on isolation transformer voltage rating of the series inverter. UPQC is on integration of shunt and series APFs with a common self- supporting dc bus. The shunt inverter in UPQC is controlled in current controlled mode such it delivers a current which is equal to the set value of the reference current as governed by the UPQC control algorithm. Additionally, the shunt inverter play important role in achieving required performance from a UPQC system by maintaining the dc bus voltage at a set reference value[9&12].

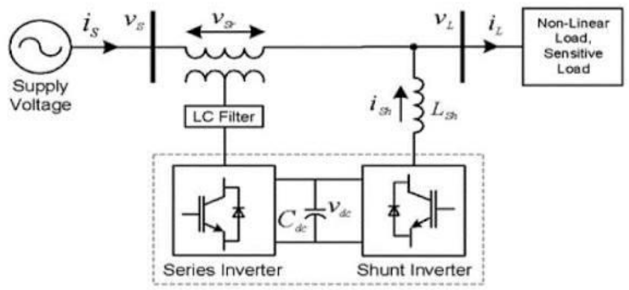


Fig.1: iUPQC in block diagram

3. CONTROL STRATEGY

In this work the performance of UPQC is enhanced by developing a novel control strategy using FLC. The benefits of FLC over the conventional controller are that FLC even works without a perfect mathematical model. Also FLC is capable of handling nonlinearity and is more robust compared to conventional PI controller which also improves the performance of UPQC. The two different control schemes used in the paper are described as follows.

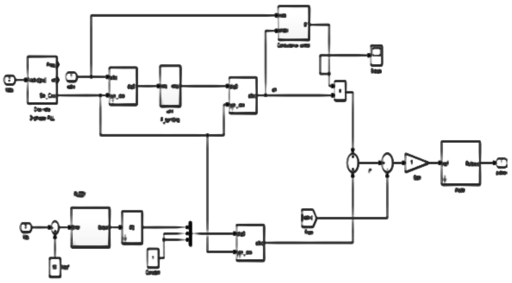


Fig.2: Control Strategy of Fuzzy Logic Controller

3.1. PI CONTROLLER

It consists of PI controller, limiter and three phase sine wave generator for reference current generation and generation of switching signals. The output of the controller is directly proportional to the summation of proportional of error and integration of the error signal which is mathematically represented as is utilized to electrically is the inverter from the network. The DC link is realized using a capacitor which interconnects the two inverter and also maintains a constant self- support dc bus voltage across it. An LC filter that serves as a passive low pass filter (LPF) helps to eliminate high frequency switching ripples on generator inverter on voltage. A series injection transformer is used to connect the series inverter to the network. A suitable turn ratio often considered to reduce the current or

$$I_{max}(t) = \mathbf{K}_i \int_0^t e(t)\,dt + \mathbf{K}_p\, e(t)$$

Where, Kp is the proportional constant that determines the dynamic response of the DC-side voltage control and Ki is the integral constant that determines its settling time.

3.2. FUZZY LOGIC CONTROLLER

The Fuzzy Logic Controller eliminates the draw backs of PI controller. The difficulty with PI controller is that it is a feedback system, with constant parameters, and no direct knowledge of the process.

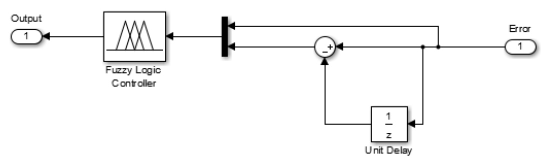
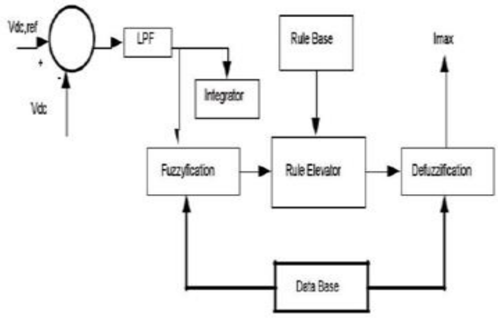


Fig.3: Basic diagram of Fuzzy Logic Controller

The Fuzzy Logic Control, which directly uses fuzzy rules is the most important application in fuzzy theory. Using a procedure originated by Ebrahim Mamdani in the late 70s,three steps are taken to create a fuzzy controlled machines. Fuzzy rational control is concluded from Fuzzy set hypothesis in 1965, where move is amongst participation and non-enrollment capacity. In this way,restriction or limits of fuzzy sets can be vague and uncertain. FLC's are a fabulous decision when exact numerical equation computations are in comprehensible. It indicates piece graph of the fuzzy rational control plan. Keeping in mind the end goal to execute the control calculation of a shunt dynamic force channel in a shunt circle, the DC capacitor voltage VDC is detected and after that differd and the coveted reference esteem VDC ,ref. the blunder signal e(n)=VDC, ref_VDC is gone though Buttorworth plan Based LPF with a cut off recurrence of 50 Hz, that pass just the principle segment.



Fuzzy Logic Controller

Fig.4: Represents block diagram of FLC

The Fuzzy Logic Control guideline plan includes characterizing decides that partner the info variables to the yield model properties. As FLC is not need of the framework displayes, the outline is fundamentally taking into consideration the simple feeling for, and experience of, the procedure. Another method for standard base outline in light of the general element conduct of the procedure has been presented in which is further adjusted. The information variables of the Fuzzy Logic Control are the mistake and the change of blunderce. The yield is the change of the reference current ($Imax)

Table - 1: FUZZY RULES

e \ Δe	NB	NM	NS	ZE	PS	PM	PS
NB	NB	NB	NB	NB	NM	NS	ZE
NM	NB	NB	NB	NM	NS	ZE	PS
NS	NB	NB	NM	NS	ZE	PS	PM
ZE	NB	NM	NS	ZE	PS	PM	PB
PS	NM	NS	ZE	PS	PM	PB	PB
PM	NS	ZE	PS	PM	PB	PB	PB
PB	ZE	PS	PM	PB	PB	PB	PB

FUZZY INPUTS

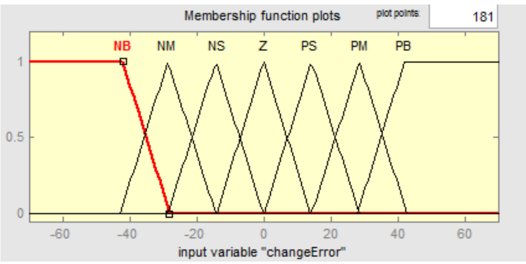


Fig.5:(a)

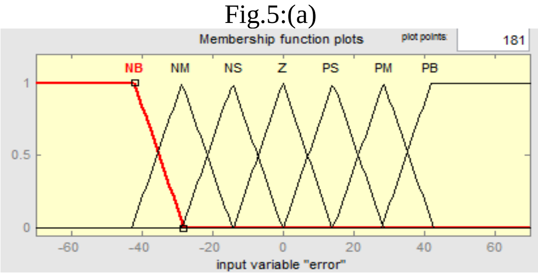


Fig.5:(b)

Fig.(a): Membership function of input variable "error"
Fig(b): Membership function of input variable"change error"

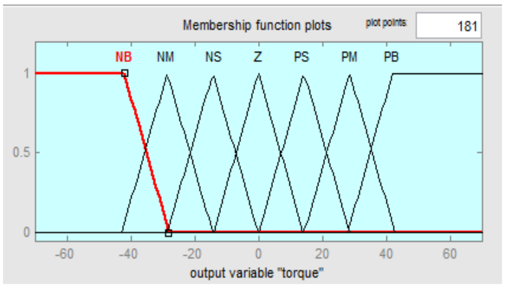


Fig.5:(c): Membership function output variable "torque"

4. PROPOSED MODEL

The proposed model with and without UPQC simulation as shown in fig 8 and 9. The analysis of model is done by comparing the performance analysis of PI and FLC controllers. In the modified UPQC the star connected transformer is connected with LC filter to suppress the neutral current and the LC filter is earthed. In series and shunt active power filter the selective harmonic eliminations technique isused to mitogate voltage sag/swell in the system. In fuzzy and pi based control technique is used mitigate the harmonics distortions which are present in the system.

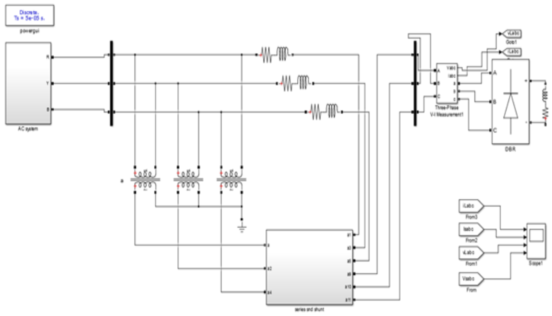


Fig.6: With Fillter in Fuzzy Simulation

5. SIMULATION RESULT

A three-phase four-wire UPQC is connected to a 415v, 50Hz three-phase four-wire distribution system with nominal distributed line parameters. It is conneceted to a linear RL load and non-linear load comparised of three-phase Diode Bridge Rectifier(DBR) feeding an RL load. This configuration is modelled in MATLAB/Simulink and the performance of this UPQC is evaluated in terms of mitigation of voltage and current harmonics.

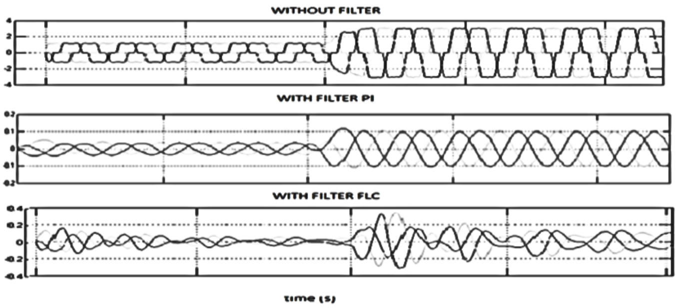


Fig.7:(a)

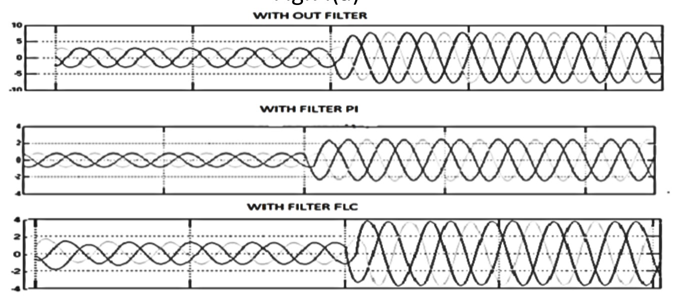


Fig.7:7(b)

Fig.7:(a) Three Phase Load Current
Fig.7:(b) Three Phase Source Current

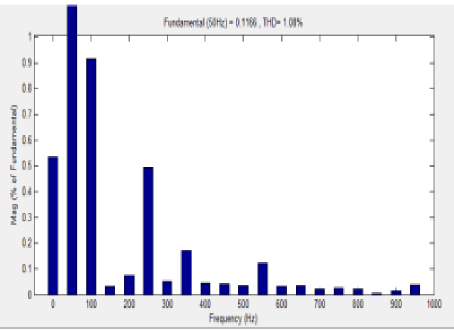


Fig.8(a)

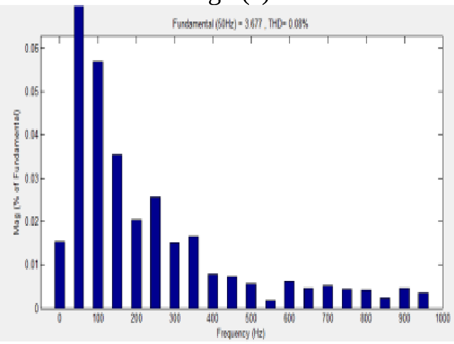


Fig.8(b)

Fig.8(a) THD of load current in with Fuzzy controller based UPQC
Fig.8(b) THD of source current in with Fuzzy controller based UPQC

6. CONCLUSIONS

The simulation of non-linear load with iUPQC is successfully accomplished using PI Controller and Fuzzy Logic Controller. The Fuzzy logic controller gives better response with THD of 1.08% in the PI controller compared to THD of 4.88% in the case of PI controller and also the THD of 24.00% without controller in the load current. Work and extend using in the future analysis another controller can be used such as Neuro-Fuzzy for better performance.

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