

Fuzzy Hysteresis Controller Based Unified Power Quality Conditioner for Voltage Fluctuations and Harmonic Isolation

V Kalyani
M.Tech student, Vignan's Institute of Engineering for Women

K. Durga Syam Prasad
Associate Professor, Vignan's Institute of Engineering for Women

Abstract
Power quality problem makes the consumer un satisfy. FACTS devices such as UPQC are such devices to avoid power quality problems. This paper proposed an efficient hysteresis controller and fuzzy controller for unified power quality conditioner. In this harmonics and voltage fluctuations were dealed by UPQC with hysteresis control strategy. The performance of the control strategy applied unified power quality conditioner on distribution system checked with and without UPQC. And the performances of these two controllers of UPQC are compared. This strategy makes the industries to get pure power and to avoid the disturbances from polluted distribution system. The proposed dynamic model was developed in MATLAB/SIMULINK.
Keywords: power quality, voltage fluctuations, harmonics, hysteresis controller, fuzzy controller.

I INTRODUCTION

Day by day demand of electrical power increasing and power generating stations are far away from the load centers. Therefore very long transmission lines are required. And also different types of loads are used at load centers i.e. balanced and unbalanced loads. Because of the applications of hardware and software for control systems, power quality problems became a challenge for power electronic engineers. Because of advancement in all engineering categories, characteristics of loads have changed completely. Thereby loads are becoming very sensitive to the supplied voltages to them. As we know that power an electronic device draw non-sinusoidal currents from the source and also creates other problems by the rapid switching of power electronic devices. Due to this voltages and currents are disturbed. FACTS devices are making the consumers to satisfy by avoiding these power quality problems. One of the most popular and accurate device which is used for distribution system is Unified Power Quality Conditioner (UPQC). Different operation in compensation can be performed by UPQC according to its controller structure and back-to-back voltage source inverters. This is the operation of UPQC[1].

A sensitive load inside the power plants is protected by the Unified Power Quality Conditioner, and also restricts the entry of any other disturbances. Different kinds of the control strategies were developed to improve the operation of UPQC. Hysteresis and fuzzy controllers are two more strategies for the operation. The control circuit used for hysteresis controller generates a reference current (sine) of desired magnitude and frequency. And this sine reference current will be compared with the actual phase currents, and when the current exceeds the hysteresis band, the appropriate switches comes into action. Therefore the actual currents are within the hysteresis band. But the hysteresis level and the system decides the switch rate, therefore when the switch is required to operate near the switch rate, the variation of switch rate with changes of rate is unacceptable. Hysteresis control strategy is proportional to error and gives poor damping in the control of resonant systems[2][3].

In general fuzzy logic controllers are already used in washing machines, refrigerator, vacuum cleaners etc. Fuzzy controllers also have their attention in motion control systems such as discs, CD player etc. Output control of fuzzy logic is smooth control function despite a wide range of input variations. Fuzzification is a subjective valuation, and it transforms a measurement into valuation. Fuzzy controller systems are used four different shapes of membership functions (MF's) i.e. triangular, Gaussian, trapezoidal, sigmoid etc. Basically fuzzy system consists of mapping, it provides basis from which the interference or conclusion can be made.

II.OPERATING PRINCIPLE OF UPQC:

Unified power quality conditioner is a generalized synchronous voltage source. It is represented at the fundamental frequency by voltage phasor.

Voltage V_{pq} ($0 \leq V_{pq} \leq V_{pq\,max}$)

Angle ρ ($0 \leq \rho \leq 2\pi$)

UPQC does voltage and angle regulation. Synchronous voltage source exchanges both real and reactive power with the system. Real power must be supplied or absorbed to synchronous voltage source as it is able to generate the reactive power exchanged only. One of the sending end bus provides real power exchange. Both converters are operated from common dc link i.e., DC storage capacitor. Second converter provides a major function that injects voltage into the line with controllable magnitude and phase through an insertion transformer.

This injecting voltage acts as synchronous ac voltage source.

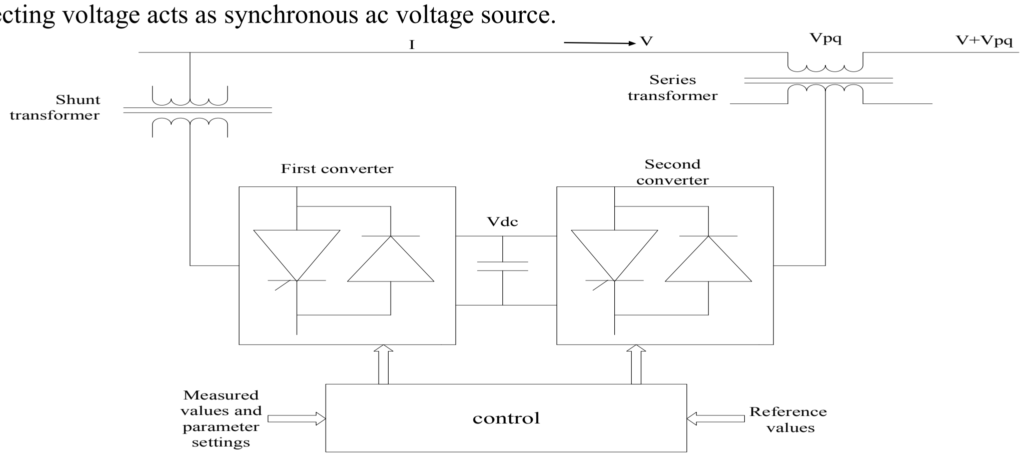


Figure (1). Block diagram of Unified Power Quality Conditioner

. The line current flows through the source resulting in real and reactive power exchange. The reactive power exchanged at the terminals of insertion transformer. The real power turns to DC power at the DC link .Second converter's real power demand is supplied by first converter i.e., either absorbing or supplying. The dc power demand of second converter turned to AC by first converter and coupled to line through shunt connected transformer.

III.CONTROL STRATEGY:

To know the difference between actual performance and ideal performance, one should compare the actual value with the reference values. control strategies show a way to generate reference signals for both the series and shunt active power filters. Active power filters are nothing but power electronic circuits which are connected to the power system to correct the fundamental voltage and harmonics. Active power filter is an ideal harmonic compensator and its characteristics will not influence by source impedance unlike passive filter. Series active filters are used for harmonic compensation for power electronic circuits. In other hand shunt active power filter not only compensate harmonics but also create some problems i.e., enlarging of voltage ripples. The compensation accuracy of UPQC depends on time delay and on its ability to go with minimum error calculation of reference signals for the compensation of distortions or any other undesirable happenings. Different controlling methods of unified power quality conditioner are classified into three types i.e., time-domain, frequency-domain, and new techniques.

P-Q theory[5], algorithms based on d-q reference frames or time domain methods. Fourier method comes under frequency domain method. And some of the new techniques for fuzzy, wavelet conversion, neural networks, space vector modulation etc. All these methods gives similar results for balanced and non-sinusoidal conditions, but gives different results under non-sinusoidal unbalanced conditions. The proposed controller design comprises of three parts i.e., reference signal generation (phase locked loop and hysteresis controller),Shunt converter control and series converter control.

IV.REFERENCE SIGNAL GENERATION:

For the control purpose, obtaining an accurate harmonic reference signal is a critical problem of UPQC. Conventional control strategies senses the shunt and series active filters currents/voltages and control to the reference signal components. In this adaptive noise cancelling theory is used and adopted to measure harmonics of non-linear voltages and currents are implemented. Frequency, load current and terminal voltages are inputs to phase locked loop. Distorted voltages are sensed and these are given to the PLL which generates sinusoidal signals[6]. These sensed voltages are multiplied by suitable gain value before giving as an input to the PLL[4].

$$I_f = I_L - KK_0 E_m \sin wt - KK_1 E_m \sin wt$$

Where

$$K_1 = \frac{1}{wRC} I_f E_m \sin wt \,.\, dwt$$

$$V_s = V_s - KK_0 E_m \sin wt - KK_1 E_m \sin wt$$

Where

$$K_1 = \frac{1}{wRC} I_f E_m \sin wt \,.\, dwt$$

$$I_L = I_P + I_Q + I_H$$

$V_L = V_P + V_Q + V_H$

Where

I_P - fundamental active component load current

I_Q - fundamental reactive component load current

I_H - harmonic component of load current

V_P - fundamental reactive component of load voltage

V_H - harmonic component of load voltage

$I_f = I_L - KK_0E_m \sin wt$

$I_f = I_P + I_Q + I_H - KK_0E_m \sin wt$

$I_F = I_Q + I_H$

$I_P = KK_0E_m \sin wt$

The detecting voltage and current signals are just the harmonic components and reactive power of non-linear voltage and current.

V.CONTROL SCHEMES OF SHUNT AND SERIES CONVERTERS:

Adaptive controller for shunt converter is implemented in simulink. I_{load} is sensitive load current. And the measured currents of load side are fed into adaptive controller. The fundamental reference sinusoidal signals are obtained using PLL through adaptive filters. Load current and active filter currents are inputs to the shunt firing circuit. The gate signals by means of hysteresis current controller are the inputs the IGBTs of inverter. The root mean square value of load active current is

$$RMS(F(t)) = \sqrt{\frac{1}{T}\int_{t-\tau}^{\tau} (f(t))^2}$$

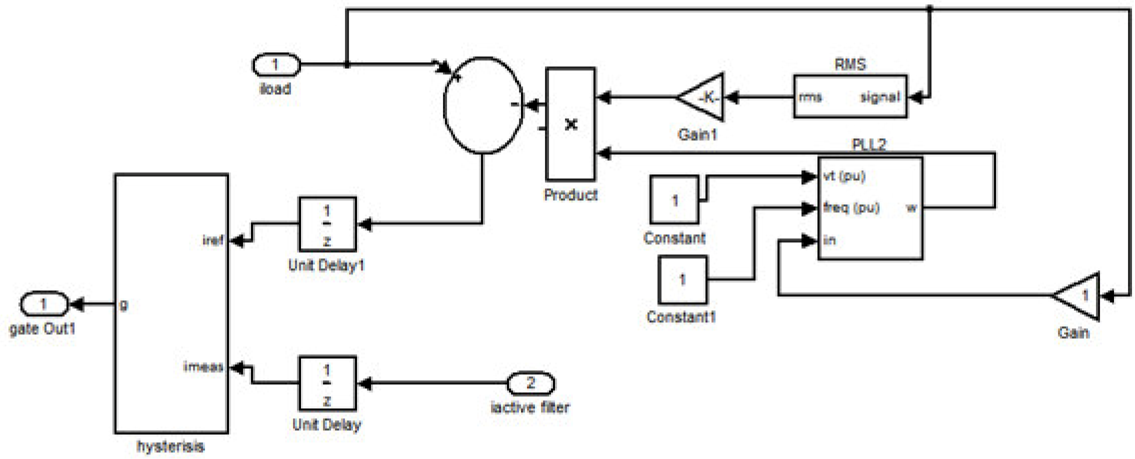


Figure (2). Shunt controller of Unified Power Quality Conditioner.

The distortions and unbalances present in the supply voltages will be cancelled out by injecting voltages through insertion transformer. It makes the voltages at PCC are perfectly balanced and sinusoidal.

The output of Phase locked loop for both series and shunt controllers are same. Active filter voltage and load voltages are the inputs to the series firing circuit.

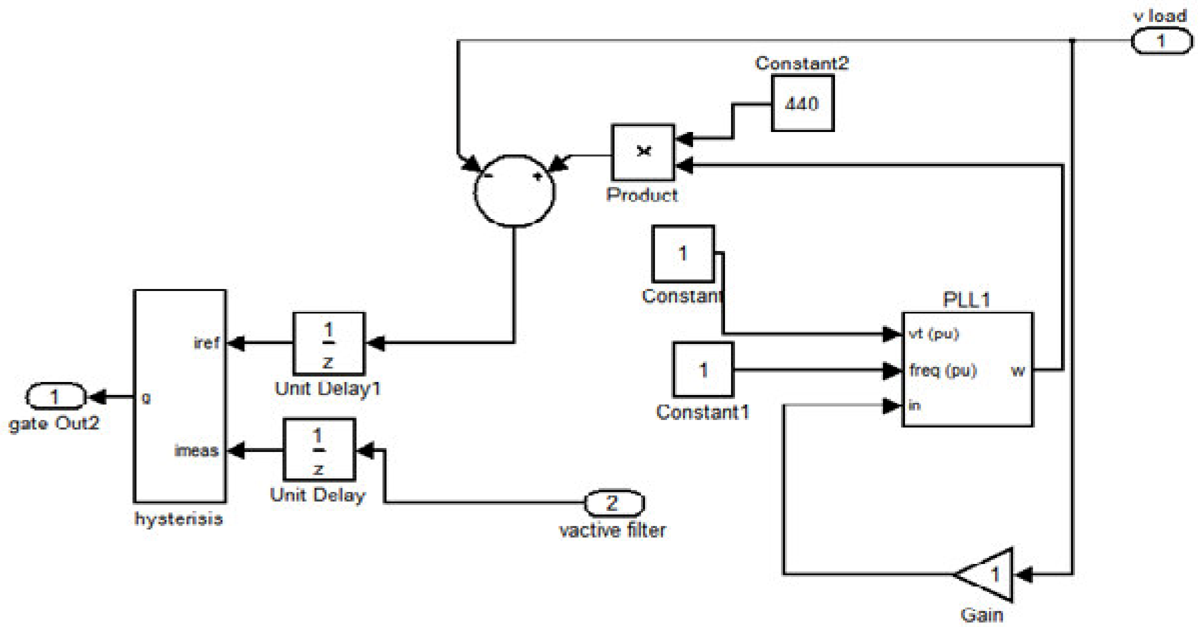


Figure (3). Series controller of Unified Power Quality Conditioner

VI.HYSTERESIS CONTROLLER:

In this the corresponding switch is switched ON when actual current goes below a certain value and it is OFF when the current goes above a maximum value. The amplitude of the currents lies between two limits. Hysteresis controller finds their applications in motor drives, power factor correction circuits and power converters. To implement switching source, sample output current is compared with reference signal to close the loop of regulator. This switching current source should have large output impedance.

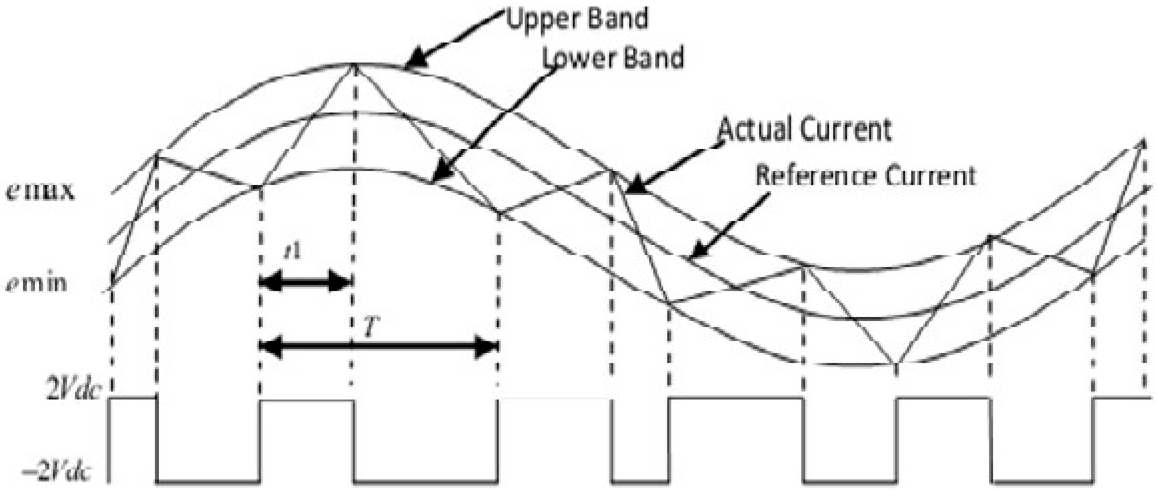
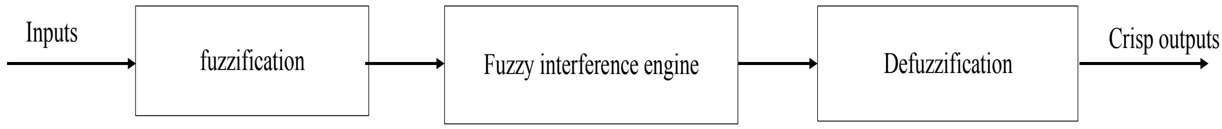


Figure (4). Basic operation of hysteresis control.

VII.FUZZY CONTROLLER:

Fuzzy logic has great importance in giving in expensive solution and gives better performance than other techniques. The accuracy of fuzzy techniques depends on the selection of number of membership functions. Present fuzzy logic is using in domestic and industrial applications. Fuzzification relates to impression and vagueness in a natural language. And it transforms a measurement into a valuation into fuzzy sets in certain input. Fuzzy logic is used to improve stability of power system. Conversion of set of modified control output values to single point-wise values is called defuzzification. For non-normalized fuzzy sets denormalization is not used.



Figure(5). Block diagram model of fuzzy control

VIII TEST SYSTEM SIMULATION MODEL:

The single line diagram of a Unified Power Quality Conditioner device compensated transmission line is shown below

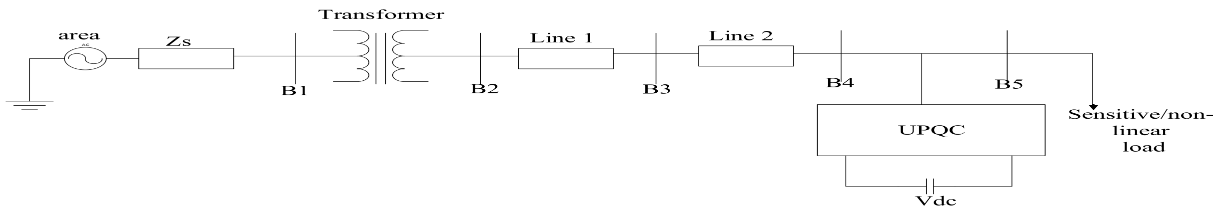


Figure (6). Single line diagram of UPQC

The simulink model of the proposed Unified Power Quality Conditioner is shown below

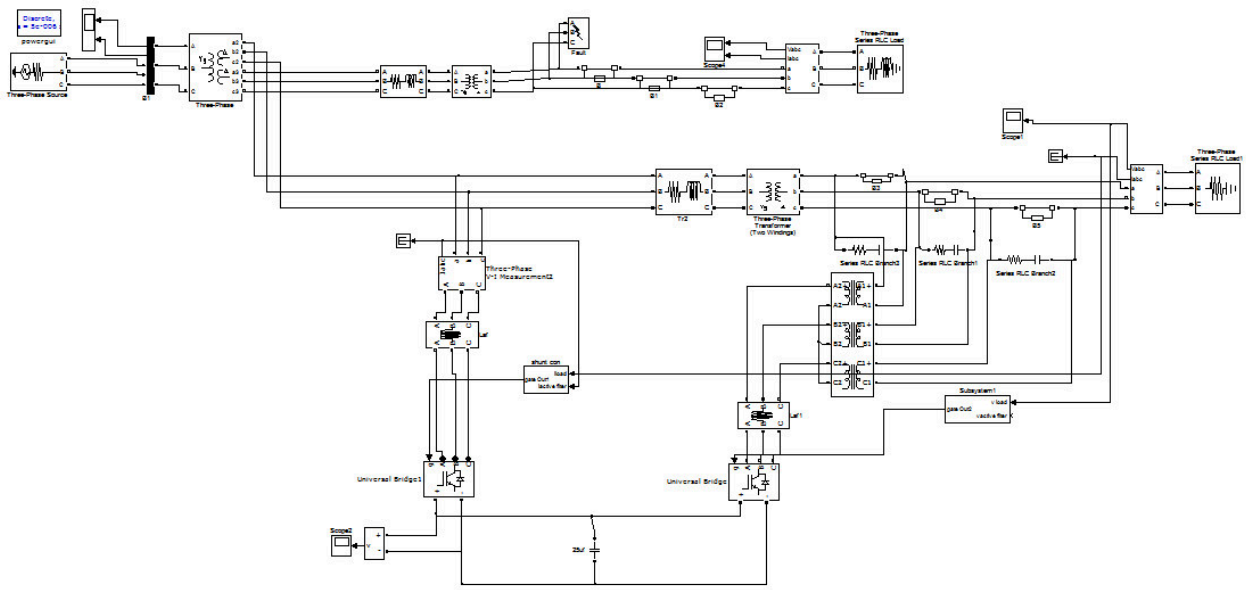


Figure (7). SIMULINK model of proposed Unified Power Quality Conditioner

The proposed system and the parameters are listed below:

Source: 9kv, 50HZ, star grounded.

Three- phase three-winding transformer: 100MVA, 50HZ

Winding 1 : 13 kv(rms), 0.002 pu, 0.08 pu

Winding 2 : 115kv, 0.002 pu, 0.08 pu

Winding 3 : 115kv, 0.002 pu, 0.08 pu

RL branch : 0.001 ohms, 0.005 H

Two- winding three-phase transformer: 100MVA, 50HZ

Winding 1 : 115kv, 0.002pu, 0.08pu

Winding 2 : 11kv, 0.002 pu, 0.08 pu

RL-load : 200kw,11kv, 50HZ, star grounded

R-load : 100kw, 11kv, 50HZ

IX TEST SYSTEM RESULTS:

Before applying UPQC to the test system the voltage and current waveforms are shown in fiure (a) and (b). Because of the fault on the transmission line the voltage waveform has sag and due to the non-linear load on the system the current waveform has harmonics.

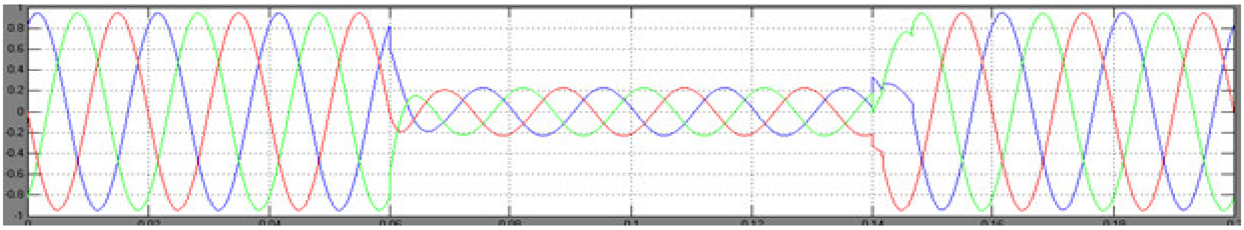


Figure (a) : voltage sag after applying fault on the line model

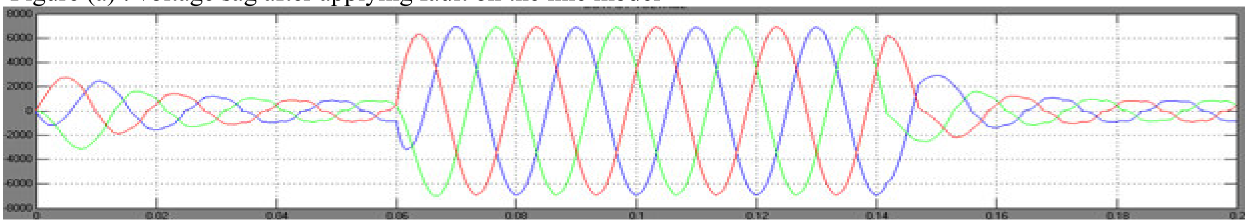


Figure (b) : source current with harmonics(Total Harmonic Distortion – 25.79%)

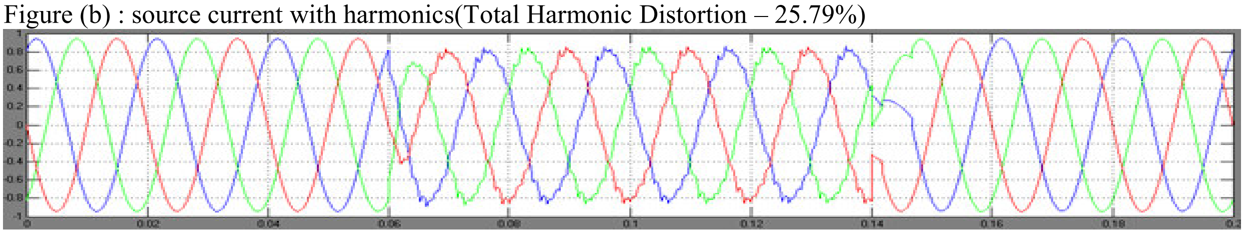


Figure (c) : the voltage waveform after connecting hysteresis controller based UPQC.

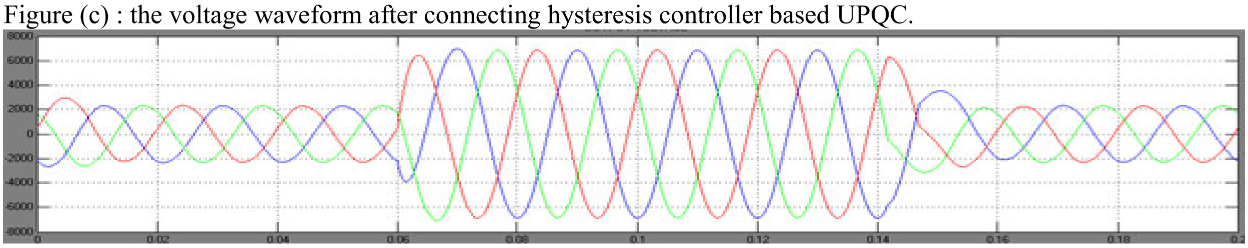


Figure (d) : the source current waveform after applying hysteresis controller based UPQC
The total harmonic distortion of the above source current waveform is 20.32%

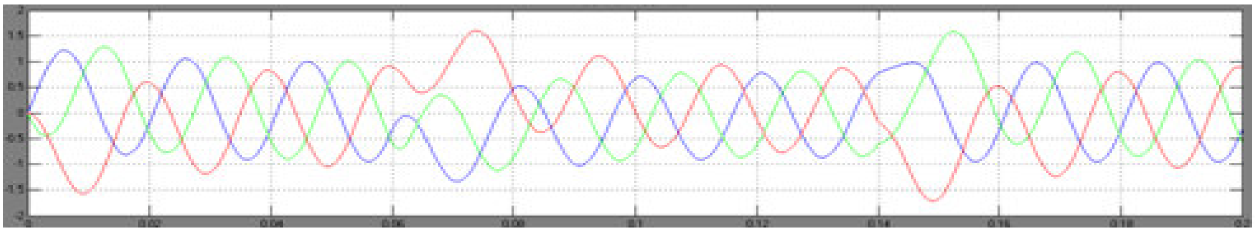


Figure (e) : load voltage waveform after applying fuzzy logic to the test system. In this we can observe a great improvement in voltage fluctuation.

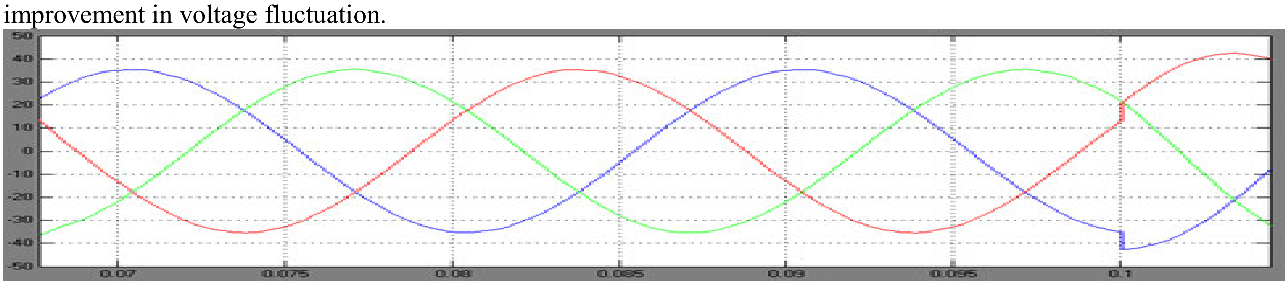


Figure (f) : after applying the fuzzy logic the source current(Total Harmonic Distortion – 0.70%)

X. CONCLUSION:

By observing the load current and voltage waveforms of fuzzy hysteresis controller based unified power quality conditioner, we can say that the shunt controller of UPQC can isolate the harmonics and the series controller of UPQC satisfies the load voltage requirement. UPQC with hysteresis controller can eliminate harmonics upto a little extent but not that much effectively. But a fuzzy controller based UPQC isolate harmonics very effectively.

XI. REFERENCES:

[1]. " Understanding FACTS – concepts and technology of flexible ac transmission systems". Narain G Hingorani, ISBN: 0517803-3455-8.

[2]. Bhim Singhy and Venkateswarlu.p,2010 "A simplified control algorithm for three-phase,four-wire Unified Power Quality Conditioner". Journal of power electronics,Vol.10,No.1,pp 91-96.

[3]. PengCheng Zhu, Xun Li, Yong Kang and Jian Chen, 2005 "Analysis and experimental verification of a control scheme for unified power quality conditioner" Int. J. EnergyTechnology and Policy, Vol. 3, No. 3, pp 253.

[4] "Design and simulation of phase locked loop controller based three phase unified power quality conditioner for non linear and voltage sensitive loads", International journal of applied engineering research, ISSN-0976-4259.

[5]. Tan Zhili,,Li Xun,Chen Jian,Kang Yong,Duan Shanxu, 2006 "A direct control strategy for UPQC in threephase fourwire system" IEEE, pp 1117.

[6] Y.Mohamandrezapour,M.B Bana sharifan,2009 " Design And Simulation Of UPQC by Synchronous Reference Frame Theory considering loading of series and shunt Inverters",Jornal of Applied science vol 4no 14 , pp 25992605.