REDUCTION of SHORT and LONG DURATION FAULTS in THREE PHASE –THREE WIRE SYSTEM USING UPQC

Mr. Jalli Manohar[1], Smt. Saleha Tabassum[2]

M.TECH(PS)[1],M.TECH(EEE)[2]

([1,2]Electrical and Electronics department/ KSRMCE, JNTUA, Anantapur,India)

[1]manoharjalli@gmail.com
[2]tabassumeee@gmail.com

Abstract: **The power electronics based devices are to produce the quality power in the electrical power supply. nowadays the power quality reduced equipment applications are increasing so that the power engineers to develop the dynamic solutions to power quality custom power devices (CPD) that deals with the load current and supply voltage to called the UPQC(unified power quality conditioner).**

This paper investigated the development of UPQC control schemes and algorithms for power quality improvement and implementation of a versatile control strategy to enhance the performance of UPQC. The proposed control scheme gives better steady-state and dynamic response. The validity of the proposed control method is verified by means of MATLAB/SIMULINK.

Keywords — **CPD, UPQC, POWER QUALITY.**

I.INTRODUCTION

Reliability of supply and power quality (PQ) are two most important facets of any power delivery system today. Not so long ago, the main concern of consumers of electricity was the continuity of supply. However nowadays, consumers want not only continuity of supply, but the quality of power is very important to them too. The power quality problems in distribution power systems are not new, but customer awareness of these problems has recently increased. The power quality at the point of common coupling (PCC) with the utility grid is governed by the various standards and the IEEE-519 standard is widely accepted.

Utilities and researchers all over the world have for decades worked on the improvement of power quality. There are sets of conventional solutions to the power quality problems, which have existed for a long time. However these conventional solutions use passive elements and do not always respond correctly as the nature of the power system conditions change. The increased power capabilities, ease of control, and reduced costs of modern semiconductor devices have made power electronic converters affordable in a large number of applications. New flexible solutions to many power quality problems have become possible with the aid of these power electronic converters.

Nowadays equipment made with semiconductor devices appears to be as sensitive and polluting as ever. Non-linear devices, such as power electronics converters, increase overall reactive power demanded by the equivalent load, and injects harmonic currents into the distribution grid. It is a well-known that the reactive power demand causes a drop in the feeder voltage and increases the losses. The presence of harmonic currents can cause additional losses and voltage waveform distortions, and poor power quality. Also, the number of sensitive loads that require ideal sinusoidal supply voltages for their proper operation has increased. The increasing of the electronic equipment sensitive to power variations drives the interest in power conditioning technologies. So, in order to keep the power quality within limits proposed by standards, it is necessary to include some of the compensation.

The power electronic based power conditioning devices can be effectively utilized to improve the quality of power supplied to customers. One modern solution that deals with both load current and supply voltage imperfections is the Unified Power Quality Conditioner (UPQC), which was first presented in 1995 by Hirofumi Akagi. Such a solution can compensate for different phenomena, such as: voltage sags, voltage swells, voltage imbalance, flicker, harmonics and reactive currents.

UPQC is a combination of series and shunt active filters connected in cascade via a common dc link capacitor. The series active filter injecting the voltage, which is added at the point of the common coupling (PCC) such that the load end voltage remains same by any voltage disturbance. The main aims of the shunt active filter are to compensate the load reactive power demand and unbalance,eliminate the harmonics from the supply current, and the regulate common dc link voltage.

The paper is organized as follows. The structure of the UPQC is presented in Section II. Then, in Section III, the control principles are described in detail. The simulation model is presented in Section IV. Simulation results in this section demonstrate the efficacy and versatality of the proposed design technique. Finally, Section V gives the conclusion.

II. STRUCTURE OF UPQC

The UPQC is a custom power device that integrates the series and shunt active filters are connected back-to-back on the dc side and sharing a common DC capacitor, as shown in Fig.2. It employs two voltage source inverters (VSIs) that are connected to a common DC link is a energy storage capacitor. These two one of the VSI is connected in series with the feeder and the other is connected in parallel to the same feeder.

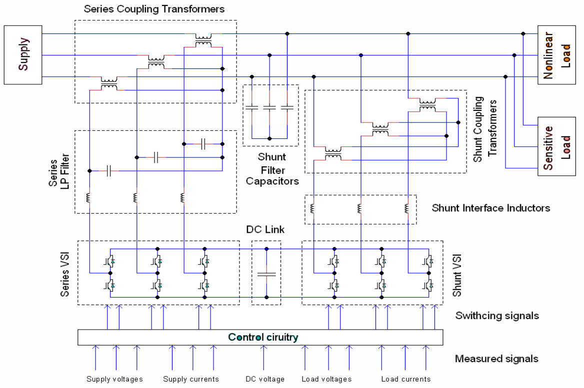

Fig.1 Power circuit diagram of a three-phase UPQC

A . Description of Shunt APF

The shunt active filter is responsible for power factor correction and compensation of load current harmonics and unbalances. Also, it maintains constant average voltage across the DC storage capacitor. The shunt part of the UPQC consists of a VSI (voltage source inverter) connected to the common DC storage capacitor on the dc side and on the ac side it is connected in parallel with the load through the shunt interface inductor and shunt coupling transformer. The shunt interface inductor, together with the shunt filter capacitor are used to filter out the switching frequency harmonics produced by the shunt VSI. The shunt coupling transformer is used for matching the network and VSI voltages..

B. Description of Series APF

The series active filter compensation goals are achieved by injecting voltages in series with the supply voltages such that the load voltages are balanced and undistorted, and their magnitudes are maintained at the desired level. This voltage injection is developed by the dc link storage capacitor and the series VSI. Based on the measured supply or load voltages the control scheme generates the appropriate switching signals for the series VSI switches. The output voltages of the series VSI do not have the shape of the desired signals, but the switching harmonics, which are filtered out by the series low pass filter. The amplitude, phase shift, frequency and harmonic content of injected voltages are controllable.

The design of UPQC power circuit diagram includes the selection of the following three main parameters are:

- ☐ shunt interface inductors;
- ☐ dc link reference voltage;
- ☐ dc link capacitor.

III. CONTROL STRATEGY OF UPQC

A .Control of the shunt active filter

The sensed DC link voltage Vdc is compared with a reference voltage V*dc. The error signal obtained from the in Fuzzy Logic Controller. The Fuzzy logic Controller output i*sb is considered as the magnitude of three-phase reference supply currents. The three-phase unit current vectors (usa, usb, usc) are derived in phase with the three-phase supply voltages (vsa, vsb, vsc). The unit current vectors from the three phase of supply currents. Multiplication of magnitude i*sp with (usa , usb , usc) results in three phase reference supply currents (i*sa, i*sb, i*sc). Subtraction of load currents (C) from the reference currents are results in three-phase reference currents(i*sha, i*shb, i*shc) form the shunt APF. These reference currents are compare with the actual shunt compensating currents (isha, ishb, ishc) and the geting error signal is converted into PWM gating signals to the shunt APF supplies harmonics currents and reactive power demand of the load.

The magnitude of the supply voltage is compute from the three-phase sensed values of voltages are

$$V_{sm}= [\tfrac{2}{3}(v^2{}_{sa} + v^2{}_{sb} + v^2{}_{sc})]^{\frac{1}{2}} \text{ ....(1)}$$

The three-phase unit current vectors are compared as

$$u_{sa}= \frac{v_{sa}}{v_{sm}},\ u_{sb}= \frac{v_{sb}}{v_{sm}},\ u_{sc}= \frac{v_{sc}}{v_{sm}} \text{ ....(2)}$$

Multiplication of three-phase unit current vectors (usa, usb, usc) with the amplitude of the supply current (i_{sp}) results in three-phase reference supply currents as

$$i^*{}_{sa}=a,\ i^*{}_{sb}=b,\ i^*{}_{sc}=c \text{ …….. (3)}$$

Where

$a=i_{sp}.\,u_{sa}$

$b=i_{sp}.\,u_{sb}$

$c=i_{sp}.\,u_{sc}$

To obtain reference currents, three-phase load currents are subtracted from three-phase supply currents as

$i^*_{sha}=a_1$, $i^*_{shb}=b_1$, $i^*_{shc}=c_1$

where

$a_1=i^*_{sa}-i_{la}$
$b_1=i^*_{sb}-i_{lb}$
$c_1=i^*_{sc}-i_{lc}$

B .Control of the series active filter

Principle of Control of Series APFs In the series APF, the three load voltages (v_{la}, v_{lb}, v_{lc}) and are subtracted from three supply voltages(v_{sa}, v_{sb}, v_{sc})resulting into three-phase reference voltages (v^*_{la}, $v^*_{lb,}$ v^*_{lc}) to be injected in series with the load. By taking a suitable transformation, the three reference currents(I^*_{sea}, $I^*_{seb,}$ I^*_{sec})of the series APF are obtained from the three-phase reference voltages (v^*_{ia}, v^*_{ib} , v^*_{ic}). The reference currents are fed to a current controller along with their sensed counterparts(i_{sea}, i_{seb}, i_{seb}). Supply voltage and load voltage are sensed and there from the desired injected voltage is computed as

$$V_{inj}=v_s- v_1 \text{ ....(5)}$$

The three-phase reference values of injected voltage are expressed as

$$V^*_{ia} = \sqrt{2}\ V_{inj} \sin(\omega t + \delta_{inj}) \text{ ....(6)}$$
$$V^*_{ib} = \sqrt{2}\ V_{inj} \sin(\omega t + \tfrac{2\pi}{3} + \delta_{inj}) \text{ ....(7)}$$
$$V^*_{ic} = \sqrt{2}\ V_{inj} \sin(\omega t - \tfrac{2\pi}{3} + \delta_{inj}) \text{ ....(8)}$$

Where δ_{inj} is the phase of the injected voltage.

The three-phase reference currents of the series APF are compared as

$$i_{sea} = \frac{V^*_{ia}}{Z_{se}},\ i_{seb} = \frac{V^*_{ib}}{Z_{se}},\ i_{sec} = \frac{V^*_{ic}}{Z_{se}}$$

The impedance Z_{se} includes the impedance of the transformer inserted.

The currents (i^*_{sea}, $i^*_{seb,}$ i^*_{sec})are the ideal currents to be maintained through the secondary winding of the transformer in order to inject voltages(v_{la}, v_{lb}, v_{lc}) there by accomplishing the desired task of voltage sag compensation the currents(i^*_{sea}, i^*_{seb},i^*_{sec}) are compared with series compensating currents in the PWM current (i_{sha}, i_{shb}, i_{shc}) controller for obtaining signals for the switches in inverter.

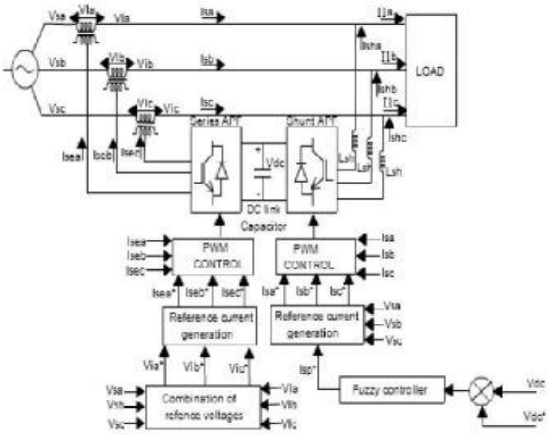

Fig.2 control scheme of three-phase UPQC

IV. SIMULATIONS AND RESULTS

A UPQC simulation model (Fig.3) has been created in MATLAB/Simulink so as to proceded UPQC circuit waveforms, the steady-state and dynamic performance, and voltage and current ratings. The following typical case studies have been simulated and the results are presented .

1. Short duration three phase fault conditions.

2. Long duration three phase fault conditions.

3. Dynamic load and three phase fault conditions.

4. Harmonic compensation

5. DC link voltage regulation for the above conditions is also verified.

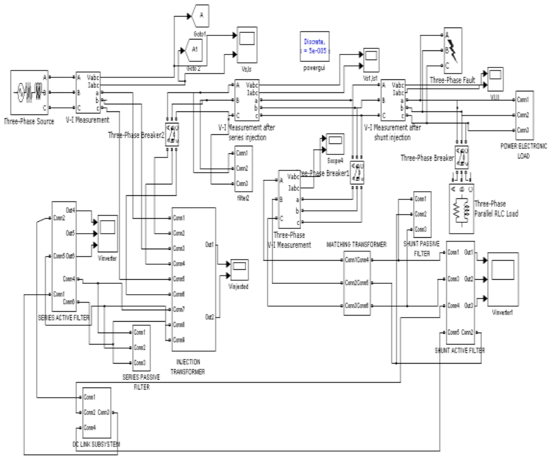

Fig 3. UPQC SIMULATION SYSTEM

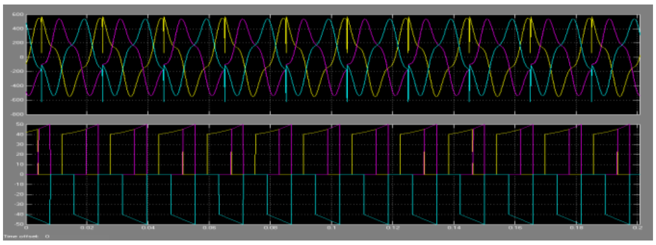

Fig 4 Steady state source voltage and load current waveforms (without UPQC) THD of source voltage:26.01%; THD of load current:94.72%

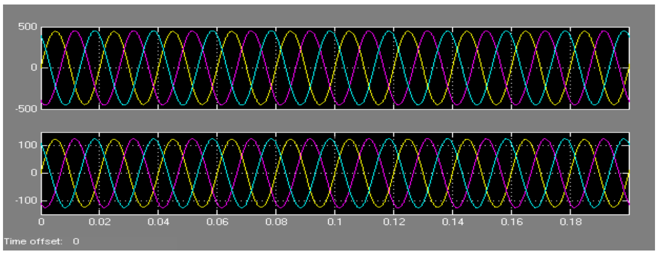

Fig 5.Steady state source voltage and load current waveforms (Fuzzy logic controller) THD of source voltage:1.02%;THD of load current:0.98%

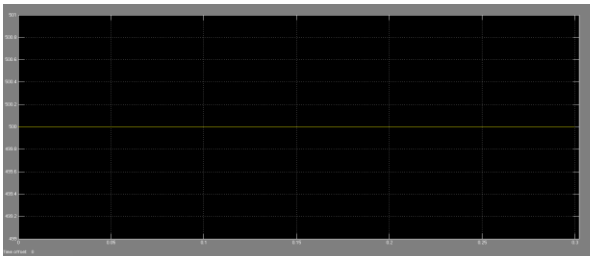

Fig 6.Steady State DC link voltage(500V) Fuzzy logic controller

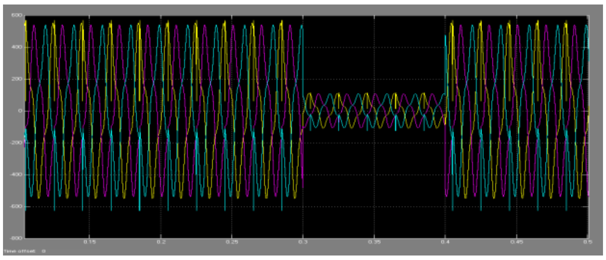

Fig 7 Source voltage when a three phase fault is introduced from 0.3 to 0.4 seconds. (without UPQC) THD of source voltage:27.10%

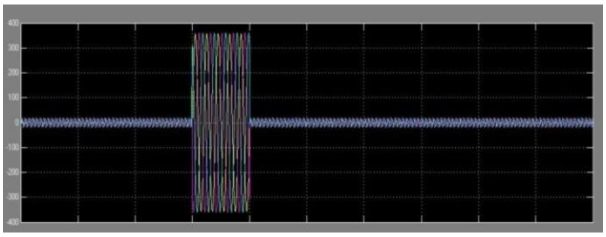

Fig 8. Compensating voltage injected by series active filter.

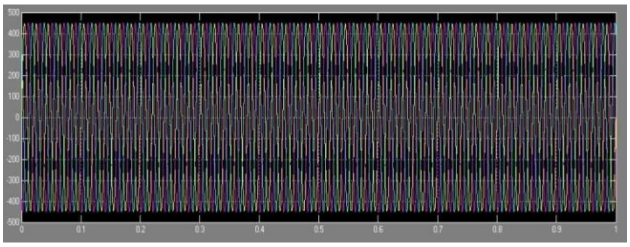

Fig 9 Source voltage when a three phase fault is introduced from 0.3 to 0.4 seconds. (Fuzzy logic controller) THD of source voltage:0.37%

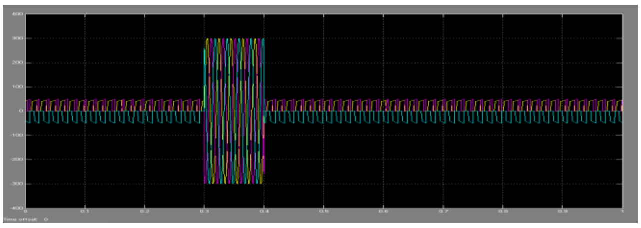

Fig 10. Load current when a three phase fault is introduced from 0.3 to 0.4 seconds. (without UPQC)

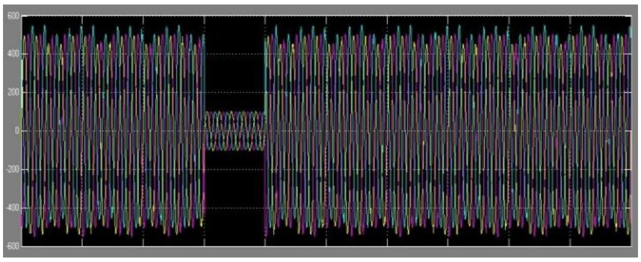

Fig 11. Compensating current injected by shunt active filter

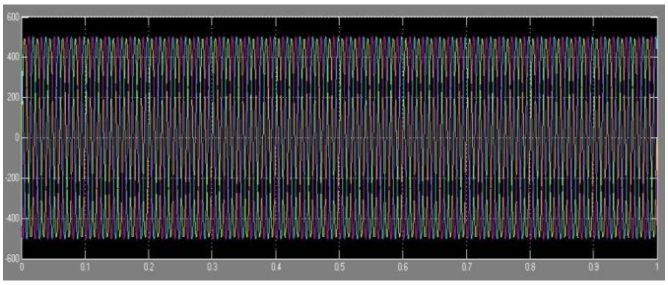

Fig 12.Load current when a three phase fault is introduced from 0.3 to 0.4seconds. (Fuzzy logic controller)

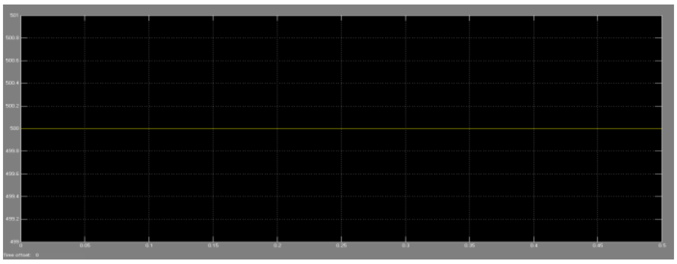

Fig 13.DC link voltage when a three phase fault is introduced from 0.3 to 0.4 seconds. (Fuzzy logic controller)

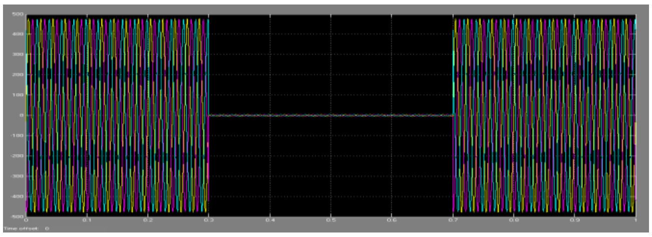

Fig 14. Source voltage when a three phase fault is introduced from 0.3 to 0.7 seconds. (without UPQC) THD of source voltage:7.97%

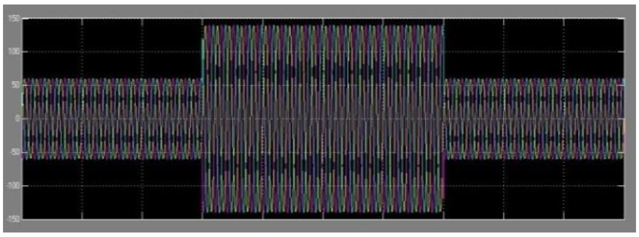

Fig 15. Compensating voltage injected by series active filter

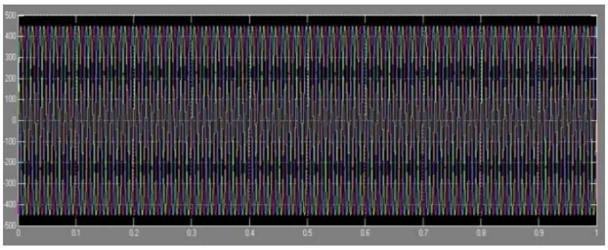

Fig 16.Source voltage when a three phase fault is introduced from 0.3 to 0.7 seconds. (Fuzzy logic controller) THD of source voltage:0.37%

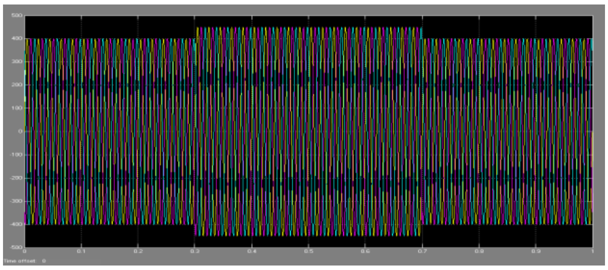

Fig 17. Load current when a three phase fault is introduced from 0.3 to 0.7 seconds. (without UPQC)

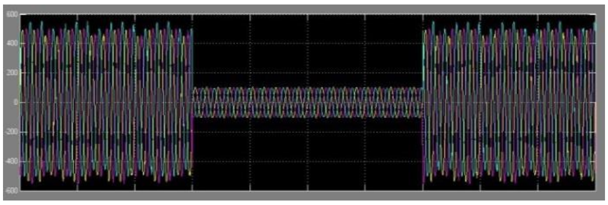

Fig 18.Compensating current injected by shunt active filter .

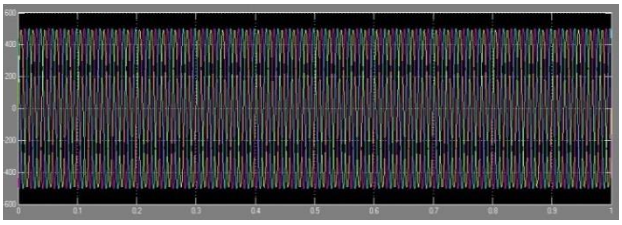

Fig 19. Load current when a three phase fault is introduced from 0.3 to 0.7 seconds. (Fuzzy logic controller)

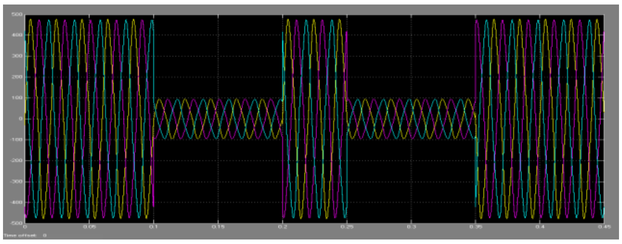

Fig 20.Source voltage when a three phase fault is introduced from 0.1 to 0.2 seconds and an RLC load from 0.25 to 0.35 seconds. (without UPQC)

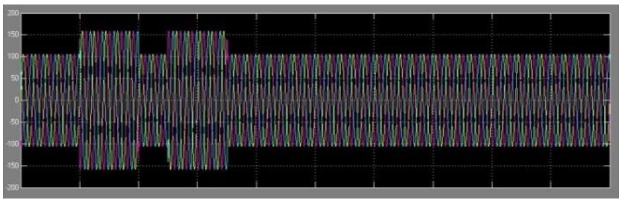

Fig 21.Compensating voltage injected by series active filter

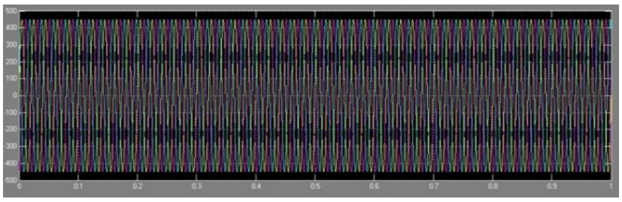

Fig 22.Source voltage when a three phase fault is introduced from 0.1 to 0.2 seconds and an RLC load from 0.25 to 0.35 seconds. (Fuzzy logic controller)

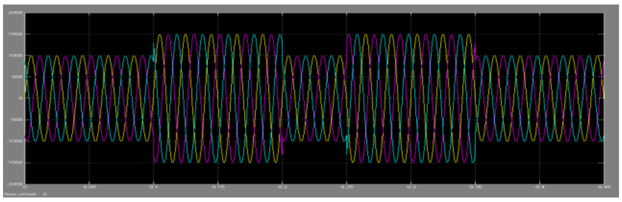

Fig 23.Load current when a three phase fault is introduced from 0.1 to 0.2 seconds and an RLC load from 0.25 to 0.35 seconds. (without UPQC)

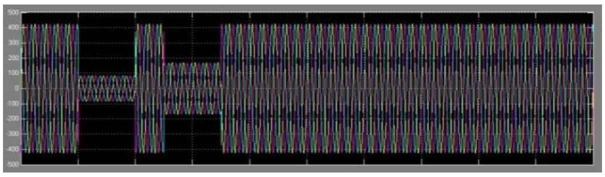

Fig 24 .Compensating current injected by shunt active filter

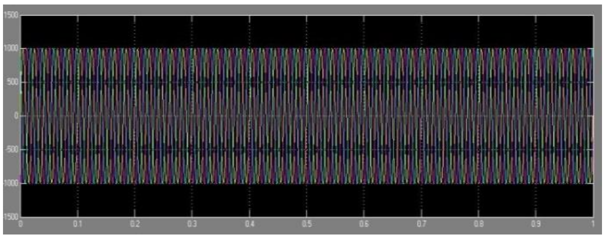

Fig 25. Load current when a three phase fault is introduced from 0.1 to 0.2 seconds and an RLC load from 0.25 to 0.35 seconds.(Fuzzy logic c ontroller **)**

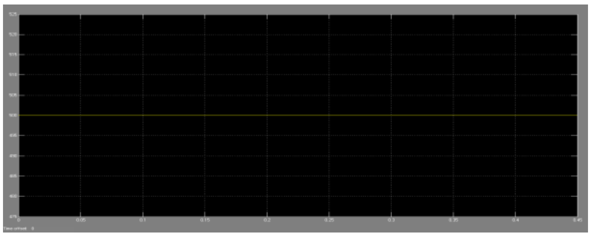

Fig 26. DC link voltage when a three phase fault is introduced from 0.1 to 0.2 seconds and an RLC load from 0.25 to 0.35 seconds.(Fuzzy logic controller).

V.CONCLUSIONS

The main objective of this project is to develop a UPQC control scheme for reduction of short and long duration faults in three phase –three wire system. This project investigated the development of UPQC control schemes for reduction of short and long duration faults in three phase–three wire system to implementation of a flexible control strategy to enhance the performance of UPQC.

The objectives laid down have been successfully realized through software implementation in MATLAB/SIMULINK. and Simulation results shows that, this control strategy is used for the compensation of the nonlinear/unbalance load conditions in three-phase three-wire system, the harmonic reduction is better unbalance/distortion of load current and source voltage are compensated well and dc voltage gets regulated all of which verifies the effectiveness of applying such a flexible control strategy in UPQC.

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