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Unified Power Quality Conditioner (UPQC) in Alleviation of Power Quality Issues

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Abstract- Due to vast implementation of power electronics based equipment power quality has turned into essential and important factor. The conventional devices or equipment is not sufficient for enhancing the power quality. The UPQC is the new design for improving the power quality and moreover it attends to both voltage deformity and current deformity simultaneously. In this paper new FACTs (flexible Alternating current Transmission) circuit called UPQC (unified power quality conditioner) is developed to compensate the voltage and current imperfections. The two different control strategies are used for it. The voltage sag and swells together with current harmonic compensation are shown.

Index Terms- unified power quality conditioner, flexible ac transmission, power quality.

I. Introduction

The nature of electric supply has a serious impact due to extensive application of power electronics based equipment.Electric power consumers must be provided with smooth uninterrupted or undistorted supply at desired magnitude and frequency. As well as the consumers should draw harmonics free current [1]. Many researchers are made for effective improvement of power quality. For the problems arising in power quality, UPQC is found powerful solution.UPQC is apt and adequate enough to attend supply disturbance like voltage, voltage swell, voltage flickering, voltage and current harmonics.The synonym of UPQC is universal active power line conditioner, universal power quality conditioner and universal active power filter. The shunt and series APF are connected in cascade through a common link dc capacitor. The series APF is coupled through series transformer to the line. The series APF prevents the source side voltage disturbances from entering into the load side to make the load voltage at desired magnitude and frequency [2]. Whereas the shunt APF connected in parallel across the load confines the current related problems to the load side to make the current from the source purely sinusoidal [3]. In this manuscript two different control schemes are used for series and shunt APF. This paper effort has been made to reduce the total harmonics distortion. Comparing paper [5], the distortion is minimized by using SPWM controller.

II. CONTROL STRATEGY

The UPQC configuration is shown in figure A.The UPQC consist of two voltage source inverters connected through a common dc link capacitor. The voltage related problem such as voltage sag, voltage swell, voltage flickering and voltage harmonics are compensated by series inverter connected to the line in series.The current related problems like current harmonics are solved by shunt inverter connect to the transmission line. The DC link capacitor connects the shunt APF and series APF together and facilitates for sharing active power among two inverter.

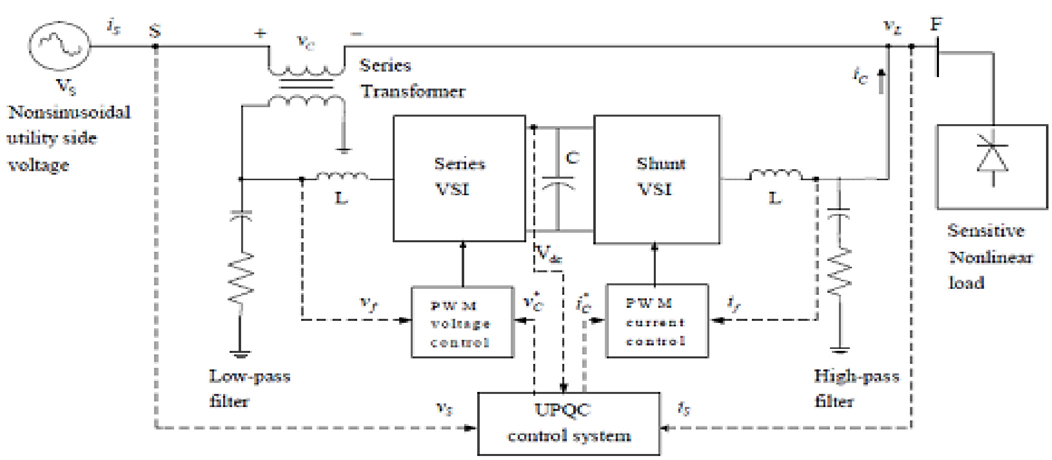

Figure 1: Diagram of UPQC representation.

1.Control Strategy I

The Series filter is controlled by simple algorithm. The unit vector template (UVT) concept is used in this paper as the control scheme [4]. From the distorted supply unit vector template (UVT) istaken. The extraction process is shown in Fig B. objective is to make load voltage completely sinusoidal. To carry this operation the voltage opposite to distortion will be generated and it get cancels with the distorted wave, the resultant voltage will be desired voltage with exact magnitude required at load side, the load voltage will be compared with the load reference voltage and it gives error voltage signal, this signal will be fed into controller, this SPWM gives the required gating pulse to maintain power quality.

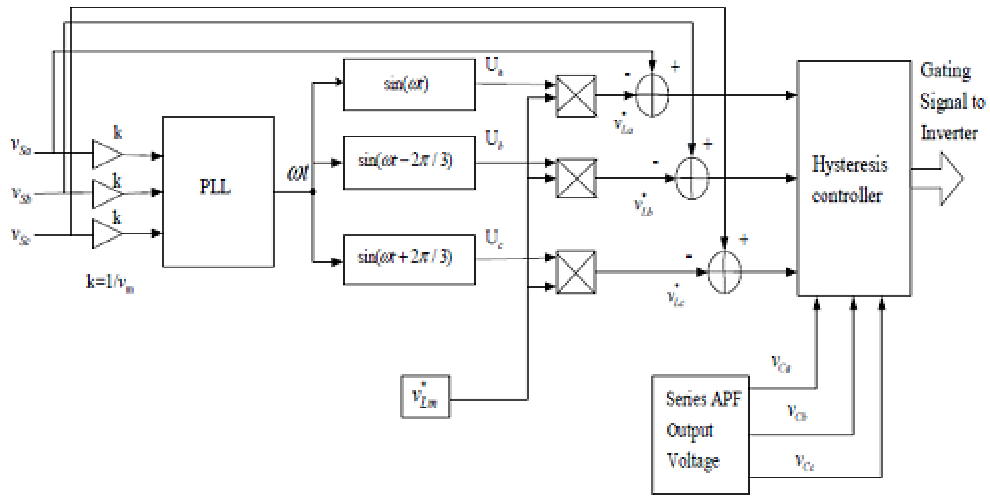

Figure 2: Control block diagram of series APF

2. Control strategy II

In the shunt active power filter uses the Instantaneous reactive power theory or p-q theory [3], to generate the reference signals. The equation (a) and the equation (b) are employed to transverse the three phase currents and voltages to α-β-γ co-ordinates [3]. The shunt APF control scheme is shown in figure C.

$$\begin{bmatrix} Vi\_0 \\ Vi\_\alpha \\ Vi\_\beta \end{bmatrix} = \sqrt{2/3} \begin{bmatrix} 1/\sqrt{2} & 1/\sqrt{2} & 1/\sqrt{2} \\ 1 & -1/2 & -1/2 \\ 0 & 3/\sqrt{2} & -3/\sqrt{2} \end{bmatrix} \begin{bmatrix} Vi\_a \\ Vi\_b \\ Vi\_c \end{bmatrix} \quad ...(a)$$

$$\begin{bmatrix} Ii\_0 \\ Ii\_\alpha \\ Ii\_\beta \end{bmatrix} = \sqrt{2/3} \begin{bmatrix} 1/\sqrt{2} & 1/\sqrt{2} & 1/\sqrt{2} \\ 1 & -1/2 & -1/2 \\ 0 & 3/\sqrt{2} & -3/\sqrt{2} \end{bmatrix} \begin{bmatrix} Vi\_a \\ Vi\_b \\ Vi\_c \end{bmatrix} \quad ...(b)$$

The equation c depicts the computation of real power [P].

$$\begin{bmatrix} P_0 \\ Ps \\ q_s \end{bmatrix} = \begin{bmatrix} Vi\_0 & 0 & 0 \\ 0 & Vi\_0 & 0 \\ 0 & 0 & Vi\_0 \end{bmatrix} \begin{bmatrix} Io \\ Ii\_\alpha \\ Ii\_\beta \end{bmatrix} \quad ...(c)$$

ps=real power
qs=imaginary power.

The equation below depicts the presences of average and oscillating components of instantaneous power.

$$Ps=\overline{Ps}+\widetilde{ps}\ ,\ qs=\overline{qs}+\widetilde{qs} \quad ...(d)$$

$\overline{Ps}$= is the average component of real power
$\widetilde{ps}$ =is the oscillating component of real power
$\overline{qs}$=is the average component of imaginary power
$\widetilde{qs}$ =is the oscillating component of real power.

For the power reference and current reference total imaginary power and oscillating real power are considered and used in equation (e).

$$\begin{bmatrix} I^*_{c\alpha} \\ I^*_{c\beta} \end{bmatrix} = \frac{1}{vi\_\alpha + vi\_\beta} \begin{bmatrix} Vi\_\alpha & -Vi\_\beta \\ Vi\_\beta & Vi\_\alpha \end{bmatrix} \begin{bmatrix} -Ps+Ploss \\ -qs \end{bmatrix} \quad ...(e)$$

The compensating current (Icα, Icβ) which are in α-β co-ordinate are converted into a-b-c again using the equation (f).

$$\begin{bmatrix} I^*_{ca} \\ I^*_{cb} \\ I^*_{cc} \end{bmatrix} = \sqrt{2/3} \begin{bmatrix} 1 & 0 \\ -1/2 & 3/\sqrt{2} \\ -1/2 & 3/\sqrt{2} \end{bmatrix} \begin{bmatrix} I^*_{c\alpha} \\ I^*_{c\beta} \end{bmatrix} \quad ...(f)$$

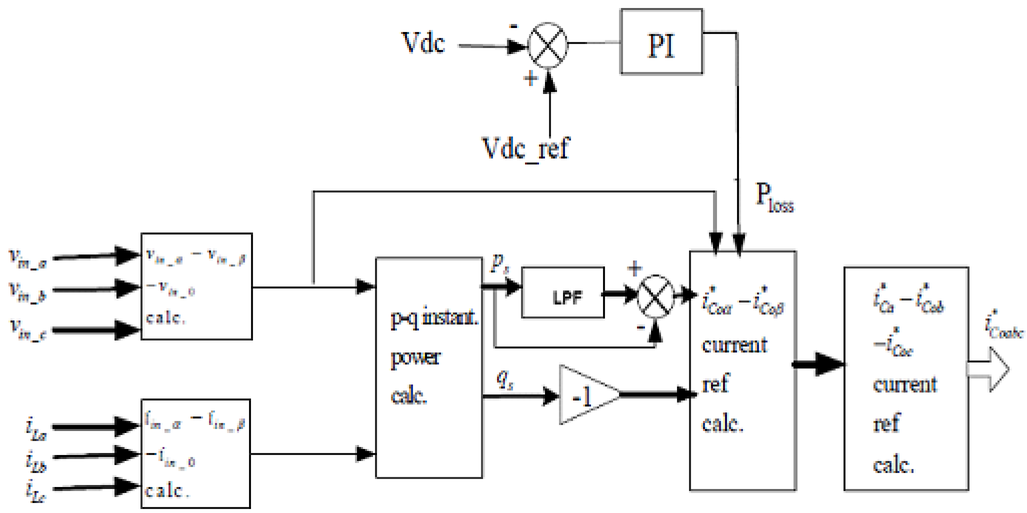

Figure 3: Control block diagram of shunt APF

III. SIMULATION RESULTS

Simulation is developed using the MATLAB/SIMULINK. To introduce the nonlinear load the three phase diode bridge is inserted in Simulink. The simulation result for voltage sag, voltage swell and current harmonics are presented.

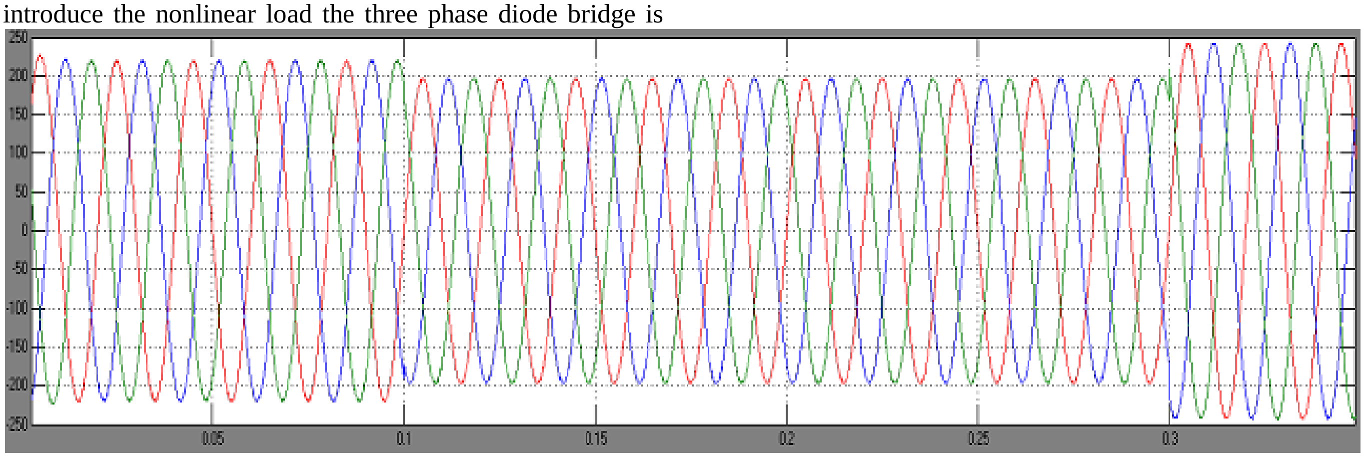

figure 4: Simulation results for UPQC at source voltage.

In the above graph, it is shown that the voltage till the 0.1 sec is normal. From 0.1 sec to 0.3 sec the voltage sag is seen, after 0.3 sec voltage swell is seen

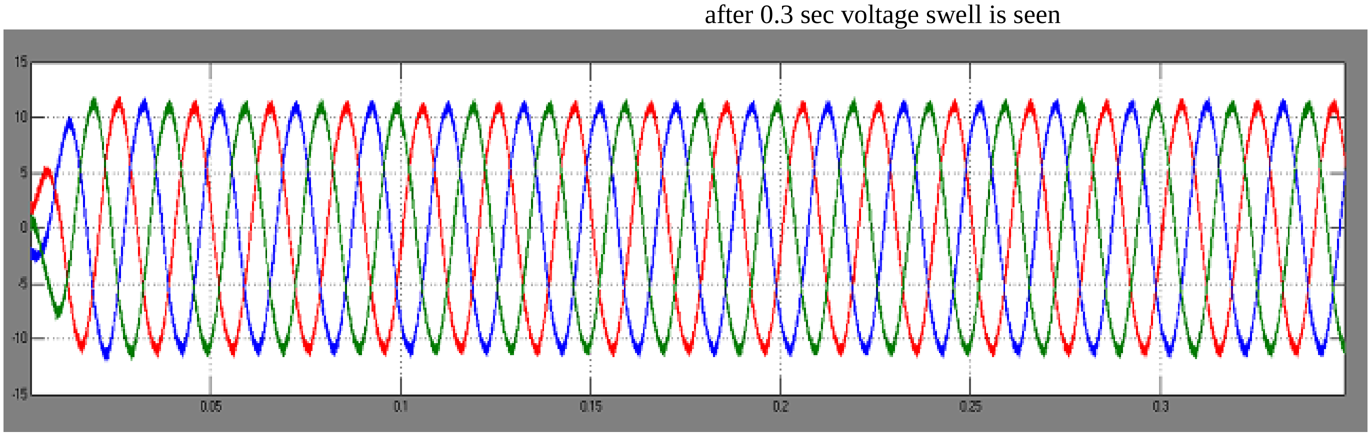

Figure 5: Simulation results UPQC for source current

In the above graph the source current is shown, the source current will not have any distortion, the current harmonics problem occurs at load side, that is current harmonics is seen in load current.

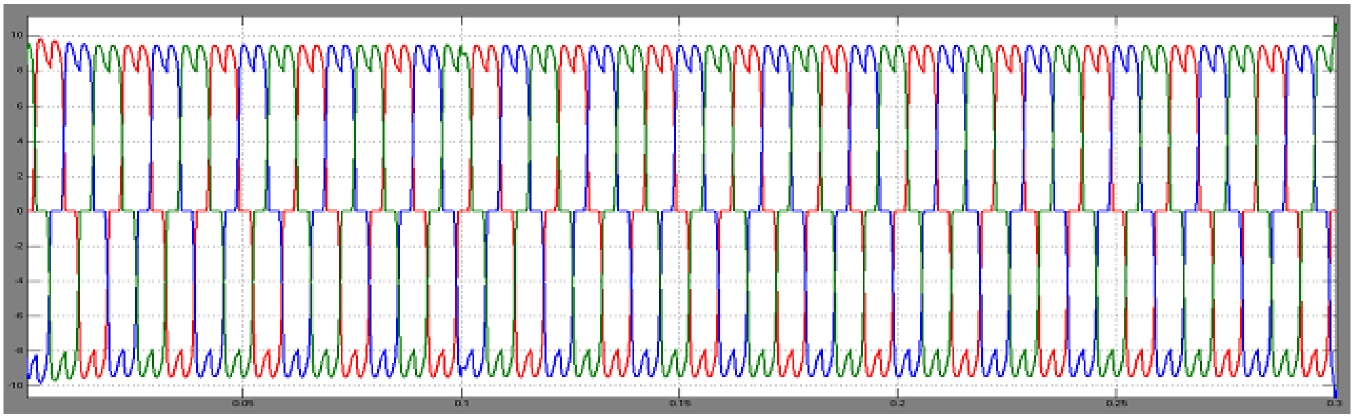

Figure 6: Load current simulation results of UPQC

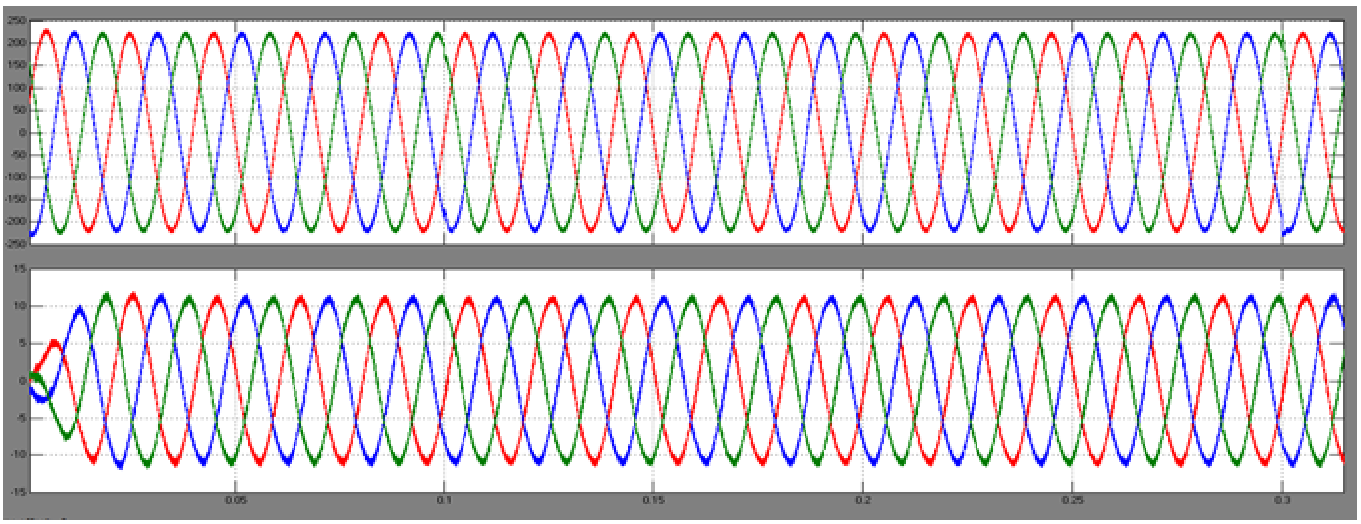

Figure 7: a) Voltage at the grid without any distortion.
b) Current at the grid without any harmonics.

The graphs shown above is the grid voltage and current when UPQC is connected to it.

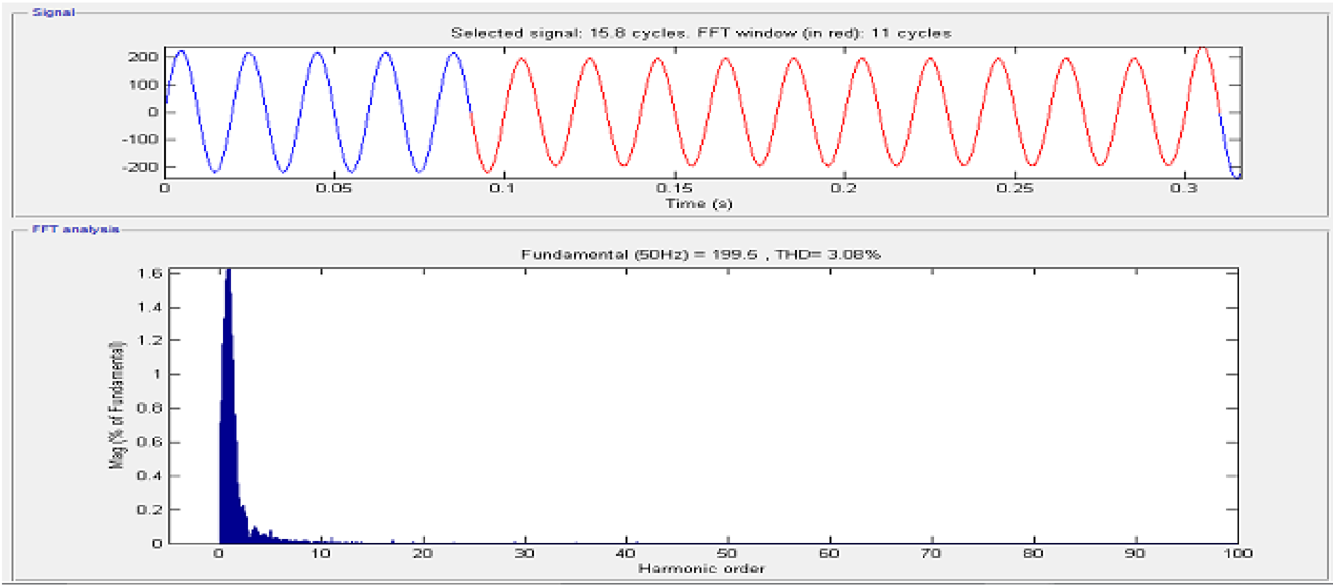

Figure 8: Total harmonics distortion analysis of source voltage

The total harmonic distortion value of the source voltage is appearing as 3.08% for 11 cycles from the start time of 0.09 sec.

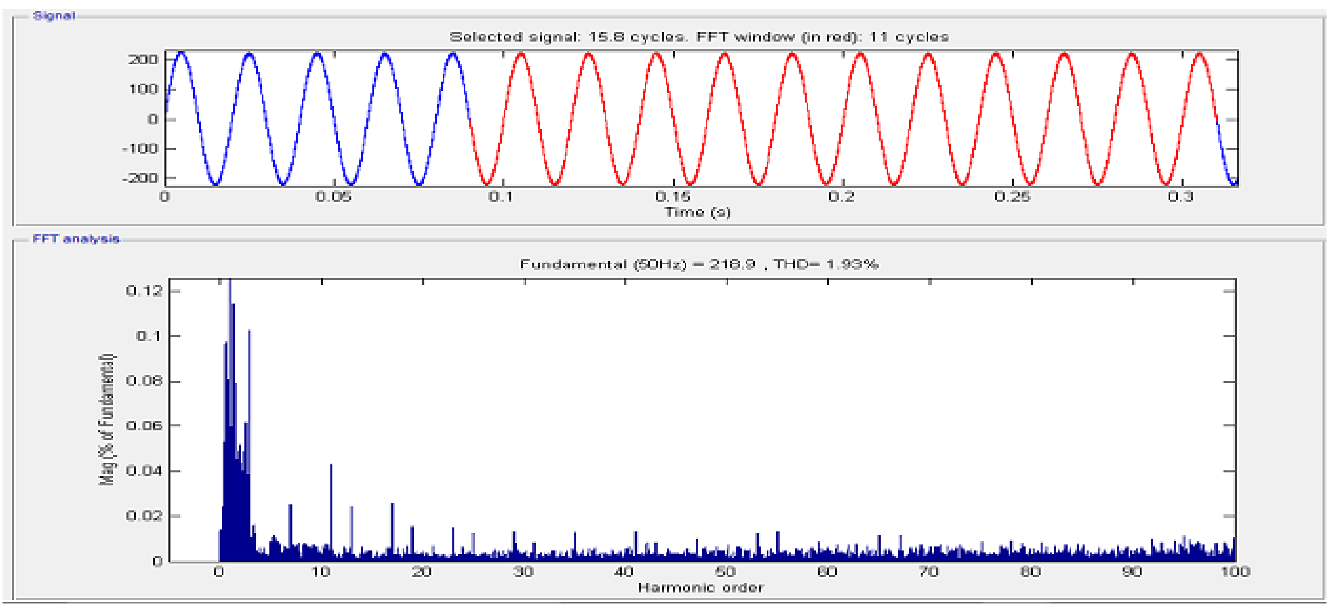

Figure 9: Total harmonic distortion analysis of line voltage

The total harmonics distortion value of load voltage is 1.93% for 11cycles from the start time of 0.09 sec. Therefore the THD of line voltage is lesser than the source voltage and it's proved that UPQC has improved the power quality.

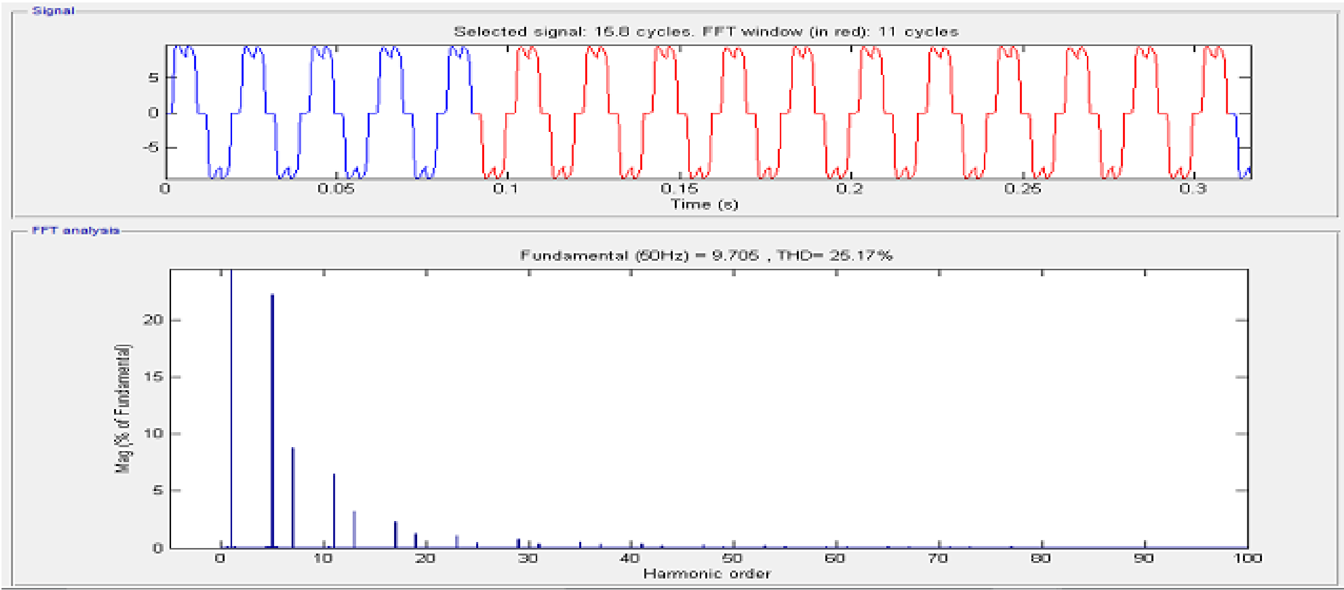

Figure 10: Total harmonic distortion of load current

The Total Harmonic Distortion value of load current is 25.17% of 11cycles from the start time of 0.09 sec.

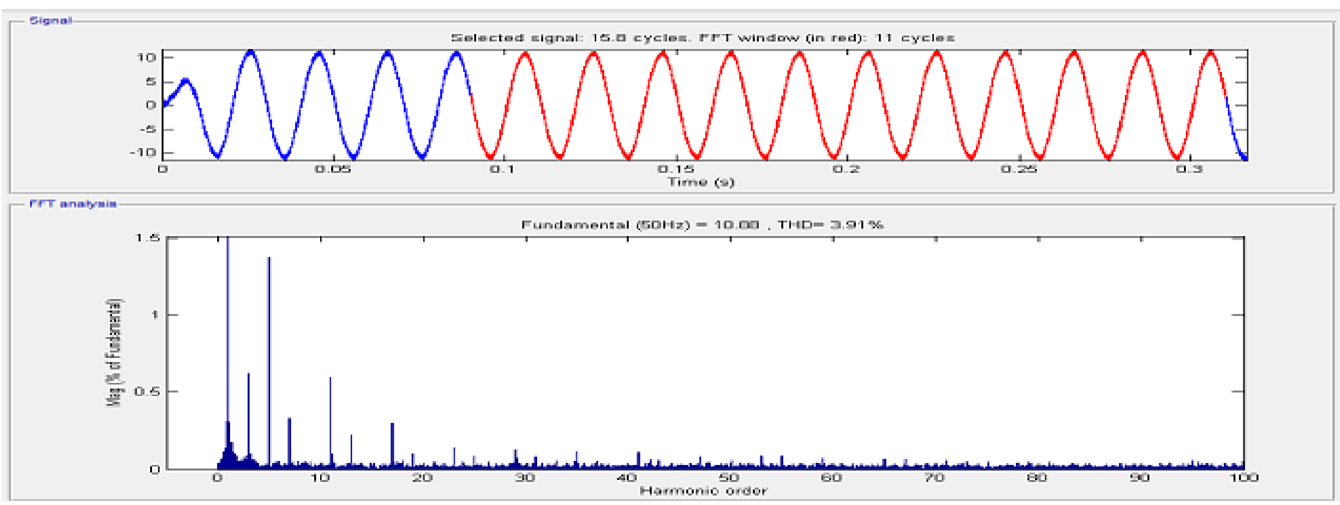

Figure 11: Total harmonic distortion of line current.

The total harmonics distortion value of line voltage is 3.91% for 11cycles from the start time of 0.09 sec. Therefore the THD of line current is lesser than the source current and it's proved that UPQC has improved the power quality.

IV. CONCLUSION

This paper proposes a control algorithm for UPQC based on SPWM voltage and current controller. In this scheme the series APF and the shunt APF of the UPQC are controlled by the combination of UVT and instantaneous p-q theory. The UPQC model is developed and simulated.It is observed from the results obtained through simulation that the supply side voltage sag/swell, harmonic along with the load side current harmonics are easily taken care of by the use of the proposed control scheme.

REFERENCES

[1] H. Awad, M. H.J Bollen, "Power Electronics for Power Quality Improvements," IEEE Symp. On Industrial Electronics, 2003, vol.2, pp.1129-1136.

[2] Aredes M., Heumann K., Watanabe E.H., "An universal active power line conditioner", IEEE Transactions on Power Delivery, 1998, vol. 13, pp. 545-551.

[3] Metin Kesler and Engin Ozdemir, "A Novel Control Method for Unified Power Quality Conditioner (UPQC) Under Non-Ideal Mains Voltage and Unbalanced Load Conditions," IEEE Conference on Applied Power Electronics, Feb. 2010, pp. 374-379.

[4] V. Khadkikar, P. Agarwal, A. Chandra, A.O. Bany and T.D.Nguyen, "A Simple New Control Technique for Unified Power Quality Conditioner

(UPQC)," IEEE International Conference on Harmonics and Quality of Power, Sept. 2004, pp. 289 – 293.

[5] Hembram, Mihir, and Ayan Kumar Tudu. "Mitigation of power quality problems using unified power quality conditioner (UPQC)", Proceedings of the 2015 Third International Conference on Computer Communication Control and Information Technology (C3IT),

2015

[6] F. A. Jowder, "Modeling and Simulation of Dynamic Voltage Restorer (DVR) Based on Hysteresis Voltage Control," The 33rd Annual Conference of the IEEE Industrial Electronics Society (IECON) Nov. 2007, pp. 1726-1731.

[7] Mehmet Ucar and Engin Ozdemir, "Control of a 3-phase 4-leg active power filter under non-ideal mains voltage condition," Electric Power Systems Research 78 (2008) 58–73.

[8] Shankar, Sai, Ashwani Kumar, and W. GAO. "Operation of unified power quality conditioner under different situations", IEEE Power and Energy Society General Meeting, 2011, pp. 1-10

[9] V.Khadkikar, A.Chandra, A.O. Barry and T.D.Nguyen, "Conceptual Study of Unified Power Quality Conditioner (UPQC)," IEEE International Symposium on Industrial Electronics, vol.2, July 2006, pp. 1088-1093.

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