

Modelling and Simulation of Dual Unified Power Quality Conditioner for Power Quality Enhancement

Nikhil S. Borse¹, Suhas M. Shembekar²

M.E. Scholar, Department of Electrical Engg, S.S.B.T's C.O.E.T Bambhori, Jalgaon (M.S), India¹

Assistant Professor, Department of Electrical Engg, S.S.B.T's C.O.E.T Bambhori, Jalgaon (M.S), India²

ABSTRACT: This paper introduces dual topology of unified power quality conditioner. This custom power device is similar to the conventional unified power quality conditioner only divergence from the controlled signal is used. In dual unified power quality conditioner, the shunt filter controlled as a sinusoidal voltage source, and series filter controlled as a sinusoidal current source. The conventional UPQC has the drawbacks of complex harmonic extraction of the grid voltage and the load involving complex calculations, voltage and current references with harmonic contents requiring a high bandwidth control, and the leakage inductance of the series connection transformer affecting the voltage compensation generated by the series filter. By using this dual topology of unified power quality conditioner these drawbacks are minimized. In this paper we discuss about the total harmonic distortion in load voltages in case of conventional unified power quality conditioner and dual topology of unified power quality conditioner.

KEYWORDS: Active power filters (APF), Dual Unified Power Quality Conditioner (iUPQC), active and reactive power control, unified power quality conditioner (UPQC).

I. INTRODUCTION

“Power Quality is a set of limits of electrical properties that permits Electrical system to function in their intended manner without loss of performance or life”. Due to use of nonlinear power electronics loads, like static rectifiers, variable speed drives, dc/ac converter, has produce many electric power quality problems such as voltage imbalance high current harmonics, poor power factor and more neutral current, etc.

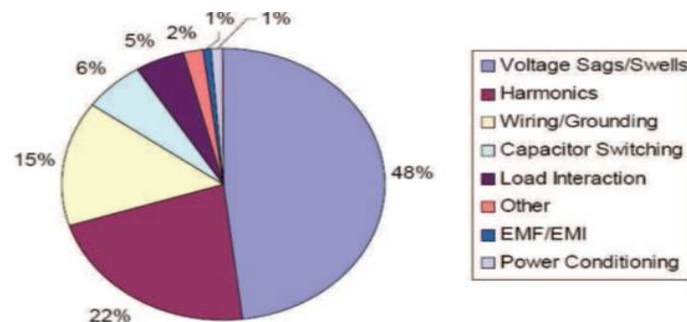


Fig. 1 Power quality problems

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 1, January 2017

Power quality has different meanings. According to institute of electrical and electronics engineer (IEEE) standard IEEE-1100 describe power quality as “the concept of powering and grounding sensitive electronic equipment in a manner suitable for the appliances”. There are number of power quality problems associated with power systems based on time such as long continuation variations, short continuation variations and other some disruption. All electrical appliances are face down to collapse or mal-function when exposed to one or more power quality problems.

Sources of Poor Power Quality are four major groups

a) Unpredictable events b) the electric utility c) the consumer/customer d) the manufacturers

Relatively few power quality problems come from in the transmission power system. The major power quality problems originating in the transmission system are amble (under high-wind conditions resulting in supply interruptions and/or random voltage variations), lightning, insulator flashover, voltage dips, interruptions, transient over voltages, transformer electrifying, imperfect operation of voltage regulation devices, flexible AC transmission system devices and High-voltage DC systems, corona, power line carrier signals, broad band power line communications, and electromagnetic fields.

Typical power quality problems originating in the distribution system are voltage sag, spikes, and interruptions, transient over voltages, transformer energizing, and improper operation of voltage regulating devices, very slow voltage variations, power line carrier Signals.

Customer loads generate a considerable area of power quality problems in today’s electrical power systems. Harmonics is major problem related to end-user; power factor is poor, flicker, transients, irregular grounding, variations in frequency, misapplication in technology, regulation of wiring, and other applicable standards.

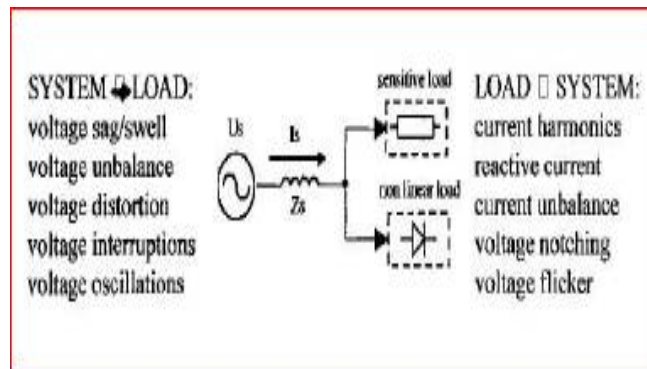


Fig. 2 Power quality difficulty in a typical installation

By using a unified power quality conditioner (UPQC), it is possible to ensure a regulated voltage for the loads, balanced and with low harmonic distortion and at the same time draining undistorted currents from the utility grid, even if the grid voltage and the load current have harmonic contents. The UPQC consists of two active filters, the series active filter (SAF) and the shunt or parallel active filter (PAF). The PAF is usually controlled as a nonsinusoidal current source, which is responsible for compensating the harmonic current of the load, while the SAF is controlled as a nonsinusoidal voltage source, which is responsible for compensating the grid voltage. Both of them have a control reference with harmonic contents, and usually, these references might be obtained through complex methods.

By the use of Dual topology of unified power quality conditioners, these power quality problems can be resolved. The Dual unified power quality conditioner, which is fusion of the shunt and series active filters used to remove harmonics and unbalances.

In iUPQC, the SAF act as a current source, which delivers a sinusoidal input current synchronized with the network voltage. The PAF works such as voltage source, distinguishing sinusoidal load voltage synchronized with the network voltage. Therefore, the pulse width modulation (PWM) controls of the iUPQC deal with a well-known frequency spectrum, since it is controlled by using voltage and current sinusoidal references for both active filters.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 1, January 2017

The SAF acts as high impedance for the current harmonics and indirectly compensates the harmonics, Unbalances, and interference of the network voltage since the connection transformer voltages is equal to the distinction between the grid voltage and the load voltage. Similarly, the PAF indirectly compensate the unbalances, displacement, and harmonics of the network current, provision of a low-impedance path for the harmonic load current. By employing Dual UPQC we can separate the complex harmonic extraction of the load voltage.

II. OBJECTIVES

The main purpose of the Dual UPQC is

- 1) Source current linear concerning with nonlinear load
- 2) Constant load voltage
- 3) Eliminates harmonic load voltage

III. PROPOSED SYSTEM

In the proposed system the power calculation and harmonic extraction are not needed since the harmonics, unbalances, disturbances, and displacement should be compensated. The series active filter has a current loop in order to ensure a sinusoidal grid current synchronized with the grid voltage. The parallel active filter has a voltage loop in order to ensure a balanced regulated load voltage with low harmonic distortion.

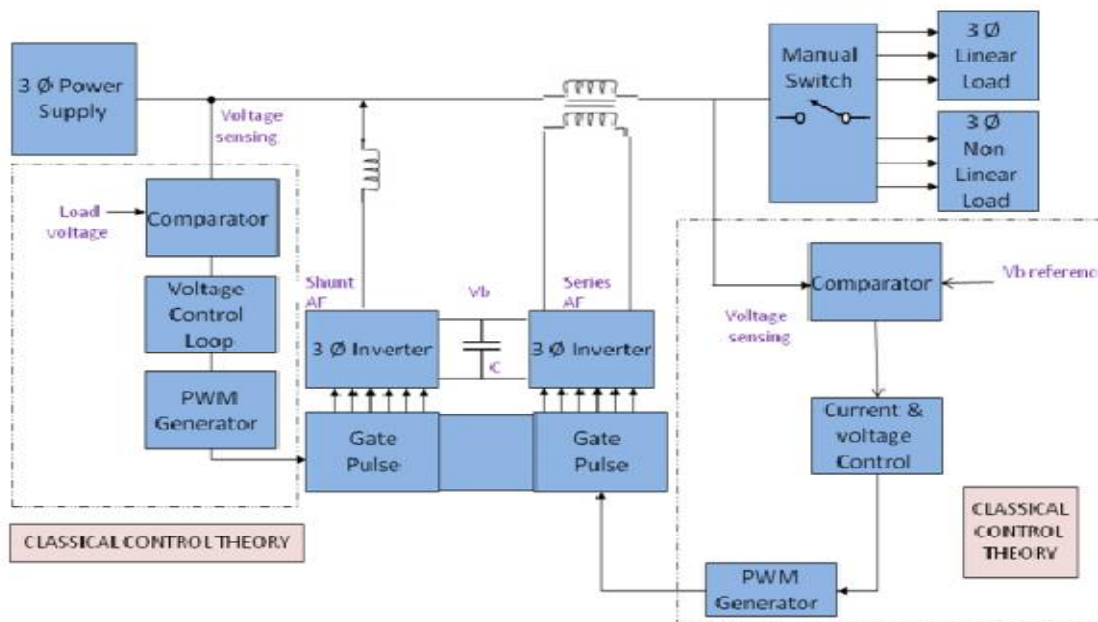


Fig.3 Control of Dual UPQC

These control loops are independent from each other since they act independently in each active filter. The dc link voltage control is made in the SAF, where the voltage loop determines the amplitude reference for the current loop, in the same mode of the power factor converter control schemes. The sinusoidal references for both SAF and PAF controls are generated by a digital signal processor, which ensure the grid voltage synchronism using a phase locked loop.

IV. SAF CONTROL

The SAF control scheme consists of three identical grid current loops and two voltage loops. The current loops are responsible for tracking the reference to each grid input phase in order to control the grid current independently. One voltage loop is responsible for regulating the dc link voltage, and the other is responsible for avoiding the unbalance between the dc link capacitors shown in the Fig. 4. The total dc voltage control loop has a low-frequency response and determines the reference amplitude for the current loops. Thus, when the load increases, overcoming the input grid current, the dc link supplies momentarily the active power consumption, resulting in a decrease of its voltage. This voltage controller acts to increase the grid current reference, aiming to restore the dc link voltage. In the same way, when the load decreases, the voltage controller decreases the grid current reference to regulate the dc link voltage. Considering the three phase input current, sinusoidal and balanced, the voltage loop transfer function is obtained through the method of power balance analysis.

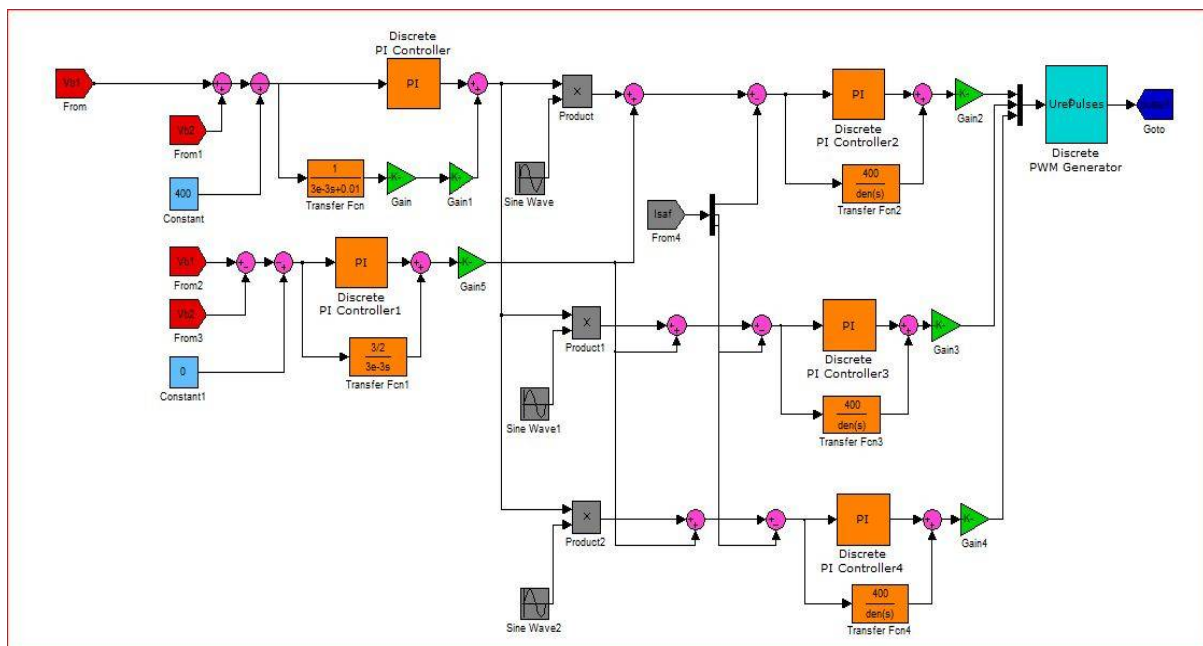


Fig. 4 Control of Series Active Filter

V. PAF CONTROL

The PAF control scheme is formed by three identical load voltage feedback loops, except for the 120° phase displacements from the references of each other. The voltage loops are responsible for tracking the sinusoidal voltage reference for each load output phase in order to control the load voltages independently shown in Fig. 5. The dynamic model is obtained through the circuit analysis using average values related to the switching period and through small signal analysis by using Laplace Transformation.

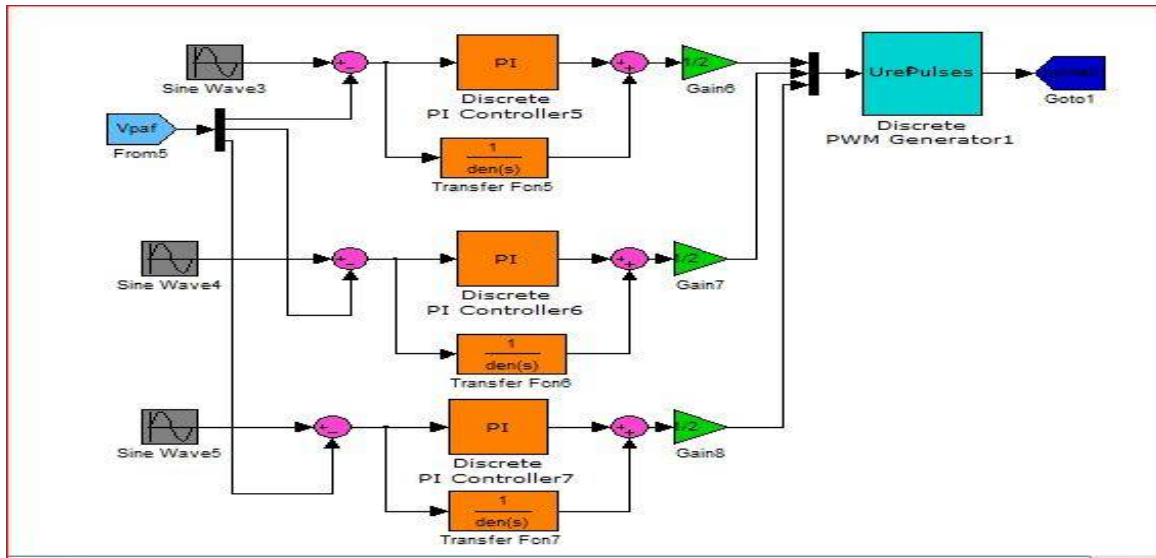


Fig. 5 Control of Parallel Active Filter

VI. SIMULATION AND EXPERIMENTAL RESULT

The Simulink developed by Math Works, is a data flow graphical programming language tool for modelling, simulating and analysing multi domain dynamic systems. Its primary interface is a graphical block diagramming tool and a customizable set of block libraries. It offers tight integration with the rest of the MATLAB environment and can either drive MATLAB or be scripted from it. Simulink is widely used in control theory and digital signal processing for multi domain simulation and Model-Based Design.

1) The main objective of dual unified power quality conditioner is to regulate load voltage with low harmonic content. Fig. 6 shows the MATLAB Simulation of conventional unified power quality conditioner

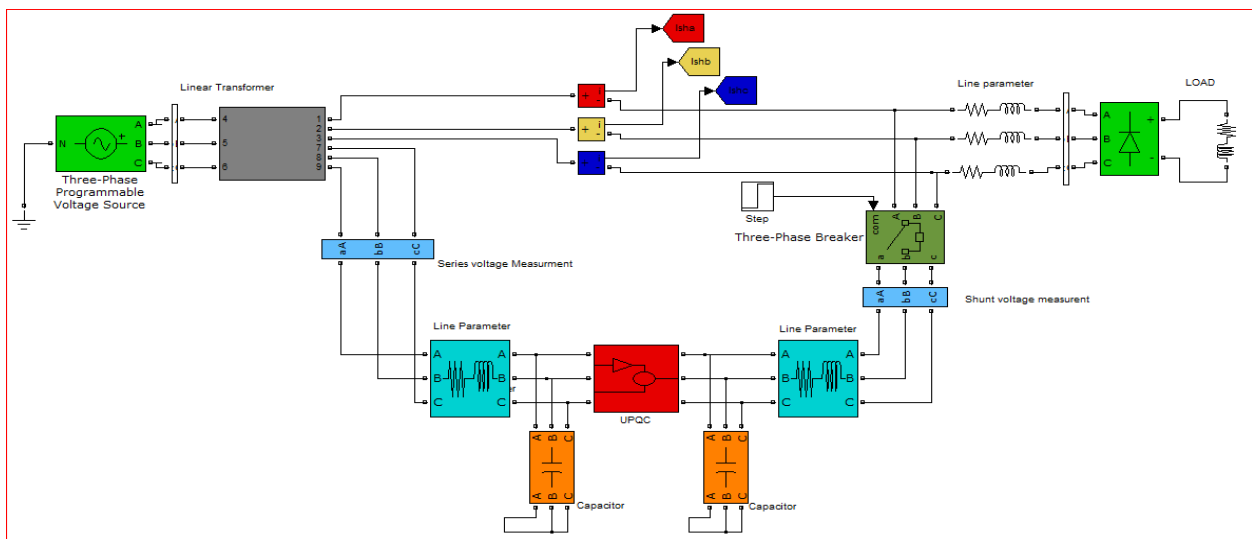


Fig. 6 Simulation of conventional UPQC

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 1, January 2017

Fig. 7 shows harmonic content in load side voltage. The total harmonic distortion in load side voltage is 10.22 % in conventional unified power quality conditioner. But according to IEEE standard the total harmonic distortion is not necessarily greater than 10%. Hence this high distortion in load voltages is minimized with the help of dual topology of unified power quality conditioner

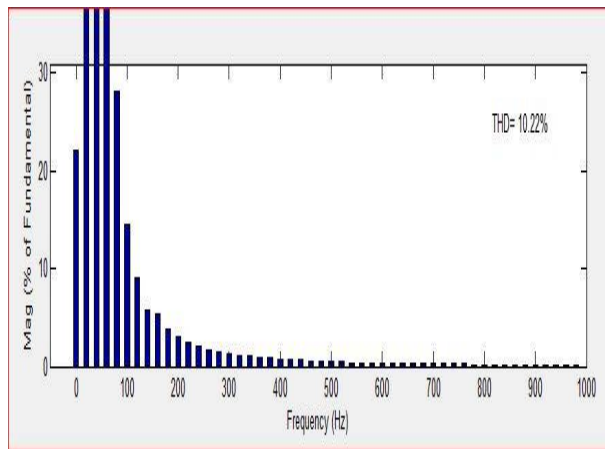


Fig. 7 Load Voltage THD for Conventional UPQC

Fig. 8 shows the MATLAB Simulation of Dual unified power quality conditioner. Having series and shunt active power filters with IGBTs.

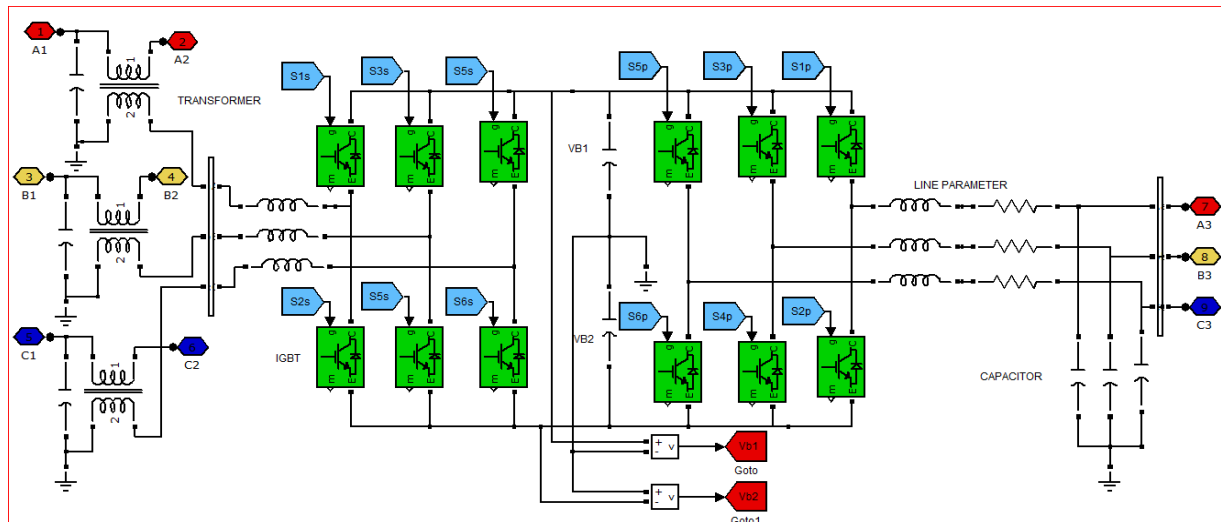


Fig. 8 Simulation of Dual UPQC

Fig. 9 shows harmonic content in load side voltage. The total harmonic distortion in load side voltage is reduced to 0.72 % in Dual topology of unified power quality conditioner. This decrease in distortion gives the quality of power system

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 1, January 2017

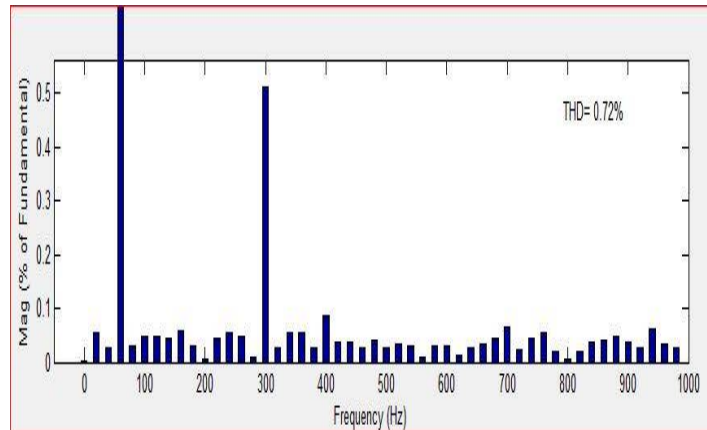


Fig. 9 Load Voltage THD for Dual UPQC

2) The second objective of the Dual unified power quality conditioner is to maintain the grid current and load voltage constant. Figure 10 shows the distortion in source or grid voltage.

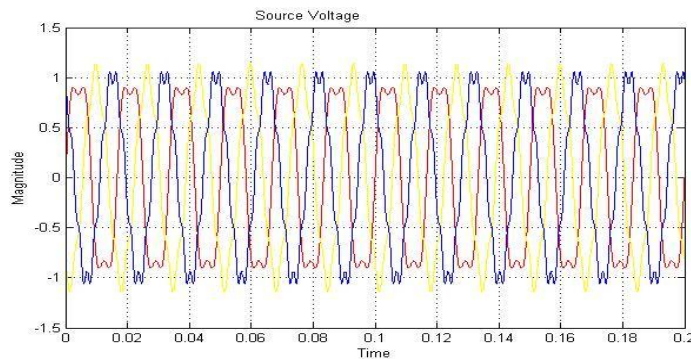


Fig. 10 Distorted Source Voltage

But by using Dual unified power quality compensation the constant load voltage is taken out and to maintain the load side power quality problem. Figure 11 indicates the compensated load voltage.

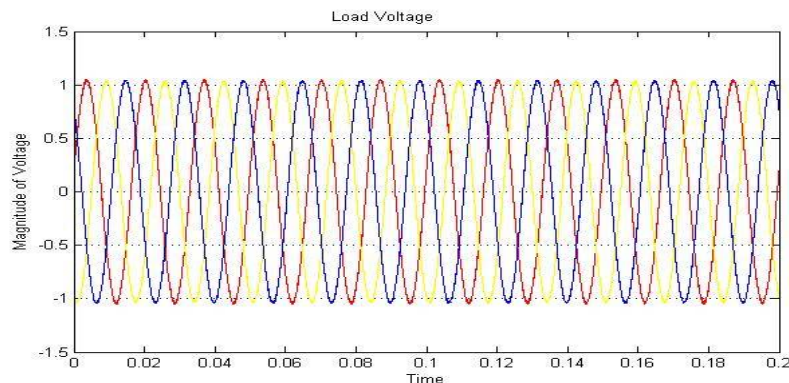


Fig. 11 Compensated Load Voltage

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 1, January 2017

3) The third objective of the dual topology of unified power quality conditioner is to maintain load voltage constant with respect to sudden change in load or supply system. In this paper we consider only sudden load changes.

A) Consider three phase source voltages. Out of those three phases voltage lower occurs in phase A after two cycles and its magnitude goes to zero. But by Dual UPQC compensation modulated load voltage is taken out. Figure 12 shows the source voltage with rapid voltage dip in phase A and modulated load voltage after compensation.

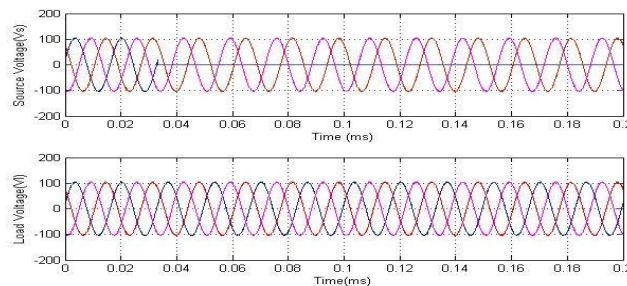


Fig 12 Source Voltage and Load Voltage during Voltage Dip in phase

B) Consider a three phase source current. Out of those three phases, phase A has dip after two cycles. But by Dual UPQC compensation modulated load voltage is taken out. Figure 8 shows the load voltage and source current by considering dip in source current and modulated load voltage.

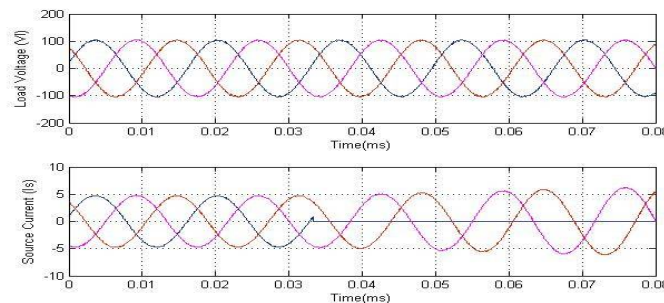


Fig 13 Load voltage and source current dip

C) Consider a three phase load current. There is immediate increase in a magnitude of current. But by Dual UPQC compensation modulated load voltage without change in magnitude is taken out. Figure 9 shows the load voltage and load current by considering load current step from 50% to 100%

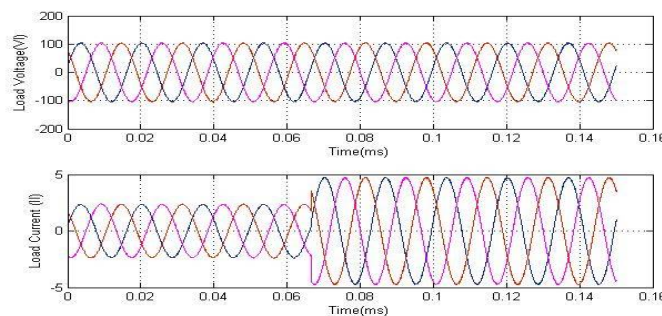


Fig 14 Load voltage and load current step

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 1, January 2017

D) Consider a three phase load current. There is a rapid decrease in a magnitude of current. But by Dual UPQC compensated modulated load voltage without change in magnitude is separated. Figure 10 shows the load voltage and load current by considering load current step from 100% to 50%.

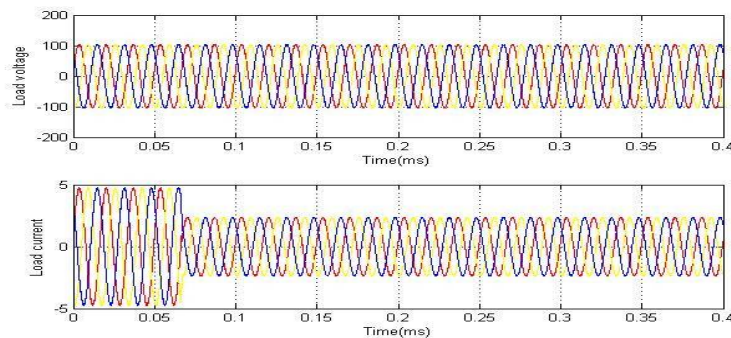


Fig 15 Load voltage and load current step

VII. CONCLUSION

The proposed Dual unified power quality was able to compensate the nonlinear load currents and also ensure the sinusoidal voltage for the load in all three phases. The control also had a great performance during the load steps and voltage disturbances at the source. The main advantage of the proposed control in relation to other proposed schemes were the utilization of sinusoidal references for both series and shunt active filter controls without the need for complex calculations or coordinate transformations. It minimizes the total harmonic content in load voltages to maintain the power quality within IEEE-519 standards.

REFERENCES

- [1] Rodrigo Augusto Modesto, Sergio Augusto Oliveira da Silva, Azauri Albano de Oliveira Junior and Vinicius Dario Bacon, "Versatile Unified Power Quality Conditioner Applied to Three-Phase Four Wire Distribution Systems using a Dual Control Strategy" IEEE Transactions on Power Electronics TPEL-Reg-2015-06-0923.R1.
- [2] Yash Pal, A. Swarup, and Bhim Singh, "A Review of Compensating Type Custom Power Devices for Power Quality Improvement" 2008 Joint International Conference on Power System Technology and IEEE Power India Conference New Delhi, India, pp. 1 - 8, October 2008
- [3] Raphael J. Millnitz dos Santos, Jean Carlo da Cunha and Marcello Mezaroba, "A Simplified Control Technique for a Dual Unified Power Quality Conditioner" IEEE Transaction on Power Industrial Electronics, vol.61, no.11, November 2014.
- [4] Luis A. Moran. Juan W. Dixon, Jose R. Espinoza and Rogel R. Wallace, "Using active power filters to improve power quality" International conference on recent advancement in electrical, electronics and control engineering, IEEE 2011.
- [5] Raju Pandey, A.K.Kori, "Enhancement of Power Quality in Transmission line using Flexible AC Transmission System" IJSETR, vol.2, issue 8, August 2013.
- [6] Luis A. Moran. Juan W. Dixon, Jose R. Espinoza and Rogel R. Wallace, "Using active power filters to improve power quality" International conference on recent advancement in electrical, electronics and control engineering, IEEE 2011.
- [7] Sung-Hun Ko, Seong R.Lee, Hooman Dehbonej and Chemmangot V. Nayar, "Application of Voltage and current controlled voltage source inverters for distributed generation systems" IEEE transactions on energy conversions, vol.21, no.3, September 2006.
- [8] Vinod Khadkikar, "Enhancing electric power quality using UPQC: A comprehensive overview," IEEE Transaction on power electronics, vol.27, no. 5, pp.2284-2297, May 2012.