IJERST

International Journal of Engineering Research and Science & Technology

ISSN : 2319-5991
Vol. 4, No. 4
November 2015

www.ijerst.com

Email: editorijerst@gmail.com or editor@ijerst.com

International Journal of Engineering Research and Science & Technology

ISSN 2319-5991 www.ijerst.com
Vol. 4, No. 4, November 2015

Research Paper

ADAPTIVE CONTROL SCHEME FOR A DUAL TOPOLOGY OF UNIFIED POWER QUALITY CONDITIONER

K Spandana[1]* and G Venkata Suresh Babu[2]

*Corresponding Author: K Spandana ✉ spandana.k77@gmail.com

Unified Power Quality Conditioner (UPQC) for harmonic elimination and simultaneous compensation of voltage and current, which improves the power quality offered for other harmonic sensitive loads. UPQC consist of combined series active power filter that compensates voltage harmonics of the power supply, and shunt active power filter that compensates harmonic currents of a non-linear load. In this paper a new control algorithm for the UPQC system is optimized and simplified without transformer voltage, load and filter current measurement, so that system performance is improved. The proposed system can able to compensate the nonlinear load condition and also ensure the sinusoidal voltage for the load in all three phases. This results in the better power quality. It is important to emphasize that the existing UPQC topologies does not have this capability. The simulation result is verified using MATLAB/SIMULINK.

Keywords: Active filters, Control design, Power line conditioning, Unified Power Quality Conditioner (UPQC)

INTRODUCTION

In earlier days the major problem in distribution system occurs with increase of nonlinear loads and the power quality is poor at electrical grid. Due to these there is a high harmonic which is distorted the voltage utility at grid and this affect occurs in critical loads from source to load. To harmonic we regulate voltage from the loads and even though it contents harmonic we can undistorted current from the utility grid. A PAF is a non-sinusoidal reference of current source and SAF is non-sinusoidal voltage sources both of them are compensate the harmonic from utility grid voltage and load current. This reference might be complex method which is obtained by the filters to control harmonics. By using this method of complexity of UPQC control technique for both filters without need of harmonic extraction with a sinusoidal reference. The alternative for power quality conditioners was proposed in which

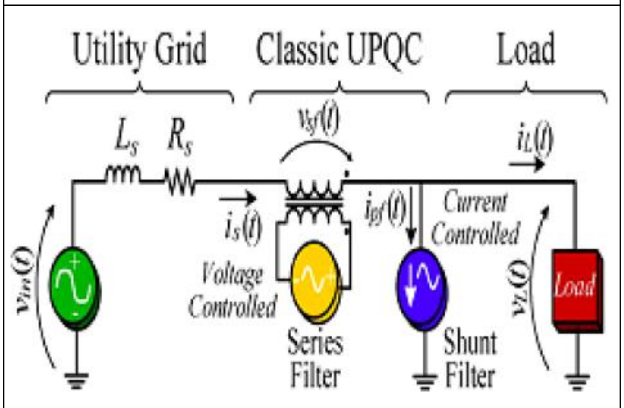
[1] PG Student (EPS), Department of EEE, SITS, Kadapa, India.
[2] Associate Professor & HOD, Department of EEE, SITS, Kadapa, India.

line voltage is regulator/conditioner. This conditioner consists of two single-phase current source inverters where the SAF is controlled by a current loop and the PAF is controlled by a voltage loop and both grid current and load voltage are sinusoidal, and therefore, their references are also sinusoidal. In this concept is called "dual topology of unified power quality conditioner" (iUPQC), and the control schemes use the p-q theory, for a real time of the positive sequence components of the voltages and the currents. The aim of this paper is to propose a simplified control technique for a dual three-phase topology of a unified power quality conditioner (iUPQC) is to be used in the utility grid connection. In ABC reference the proposed control scheme is developed for the classical control theory without the need for coordinate transformers and digital control implementation. The references to both SAF and PAFs are sinusoidal, dispensing the harmonic extraction of the grid current and load voltage.

DUAL UPQC

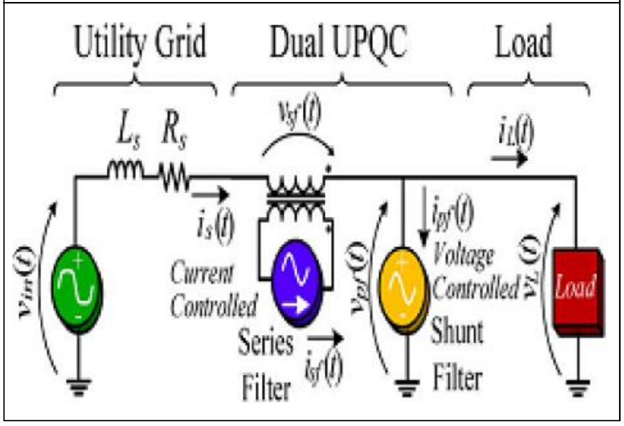
The conventional UPQC structure is composed of a SAF and a PAF, as shown in Figure 1. In this configuration, the SAF works as a voltage source in order to compensate the grid distortion, unbalances, and disturbances like sags, swells, and flicker. Therefore, the voltage compensated by the SAF is composed of a fundamental content and the harmonics. The PAF works as a current source, and it is responsible for compensating the unbalances, displacement, and harmonics of the load current, ensuring a sinusoidal grid current. The series filter connection to the utility grid is made through a transformer, while the shunt filter is usually connected directly to the load, mainly in low-voltage grid applications.

Figure 1: Conventional UPQC



In order to minimize these drawbacks, the iUPQC is investigated in this paper, and its scheme is shown in Figure 2.

Figure 2: Dual UPQC (iUPQC)



The scheme of the iUPQC is very similar to the conventional UPQC, using an association of the SAF and PAF, diverging only from the way the series and shunt filters are controlled. In the iUPQC, the SAF works as a current source, which imposes a sinusoidal input current synchronized with the grid voltage. The PAF works as a voltage source imposing sinusoidal load voltage synchronized with the grid voltage. In this way, the iUPQC control uses sinusoidal references for both active filters. The high-frequency filter transfer function of the PAF is derived by analyzing the circuit is shown in

$$\frac{v_L(s)}{v_{pc}(s)} = \frac{1}{L_{pf}C_{pf}} \cdot \frac{1}{s^2 + s \cdot \frac{1}{C_{pf}R_L} + \frac{1}{L_{pf}C_{pf}}}.$$

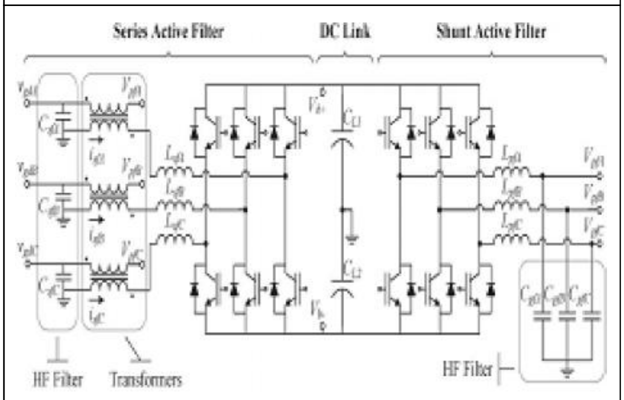
The high-frequency filter transfer function of the SAF is derived by analyzing the circuit is shown in

$$\frac{i_s(s)}{v_{sc}(s)} = \frac{n}{\{sL_{sf} + n^2[sL_{lg} + R_{lg} + \alpha + \beta] \cdot \gamma\}}$$

This is a major point to observe related to the classic topology since the only request of sinusoidal reference generation is that it must be synchronized with the grid voltage. The SAF acts as high impedance for the current harmonics and indirectly compensates the harmonics, unbalances, and disturbances of the grid voltage since the connection transformer voltages are equal to the difference between the grid voltage and the load voltage. In the same way, the PAF indirectly compensates the unbalances, displacement, and harmonics of the grid current, providing a low-impedance path for the harmonic load current. The power circuit of the proposed iUPQC is made up of two four-wire three-phase converters connected back to back and their respective output filters, as shown in Figure 3.

It can be noted that the filter response has a low cutoff frequency that can reduce the bandwidth of the SAF, decreasing its effectiveness under operation with harmonic contents on the grid voltage. This characteristic of low-frequency attenuation is undesirable and intrinsic to the structure due to the leakage impedance of the coupling transformers.

Figure 3: Power Circuit of the iUPQC



An important contribution of this paper and different from what it was stated in some previous articles, which deal with the same iUPQC control strategy, is that, in spite of the SAF operates with sinusoidal reference, the control of this filter needs to deal with high frequency since the current imposed by the SAF is obtained through the voltage imposition on this filter output inductor. The voltage imposed on these inductors is complementary to the utility grid voltage harmonics so that it guarantees a sinusoidal current through the filter. Different from the conventional UPQC whose narrow-band frequency control may distort the load voltage, in the iUPQC, the narrowband frequency control may distort the current drained from the utility grid. The usage of high-power coupling transformers, with low leakage inductance, and the design of higher voltage dc link, allowing the imposition of higher current rate of change on the filter output inductor, is solutions to change the characteristics of the filter attenuation in low frequencies. The average charge current of the dc link is given by

$$\overline{I_{eq}} = \frac{3}{2} \cdot \frac{n \cdot V_{gdpk} \cdot I_{sfpk}}{V_b}.$$

Through the voltage loop transfer function is obtained and is represented by

$$Gv_{sf}(s) = \frac{V_b(s)}{I_{sf}(s)} = \frac{3}{2} \cdot n \cdot \frac{V_{gdpk}}{V_b} \cdot \frac{1}{\frac{1}{R_b} + sC_b}$$

The proposed iUPQC control structure is an ABC reference frame based control, where the

SAF and PAF are controlled in an independent way. In the proposed control scheme, the power calculation and harmonic extraction are not needed since the harmonics, unbalances, disturbances, and displacement should be compensated. The SAF has a current loop in order to ensure a sinusoidal grid current synchronized with the grid voltage. The PAF has a voltage loop in order to ensure a balanced regulated load voltage with low harmonic distortion. 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 (DSP), which ensure the grid voltage synchronism using a phase locked loop.

SIMULATION RESULTS

The precharge method and the precharge sequence are an important and not trivial design step of the iUPQC due to the power flow characteristics of the system. During the startup, the voltage supplied to the load cannot be distorted, and the iUPQC coupling in the circuit shall not affect the load. The precharge method developed allows the startup of the iUPQC with no need of load power disconnection. The used precharge sequence is shown in Figure 4. The precharge circuit has three

Figures 5a-5d shows the currents and voltages in the source and load. It is possible to see that the currents drained from the source are sinusoidal, balanced, and synchronized with the source voltage, with power factors of 0.980,

Figure 4: Precharge Sequence of the iUPQC

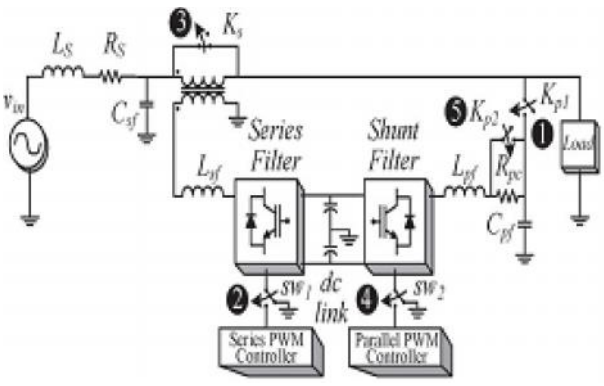
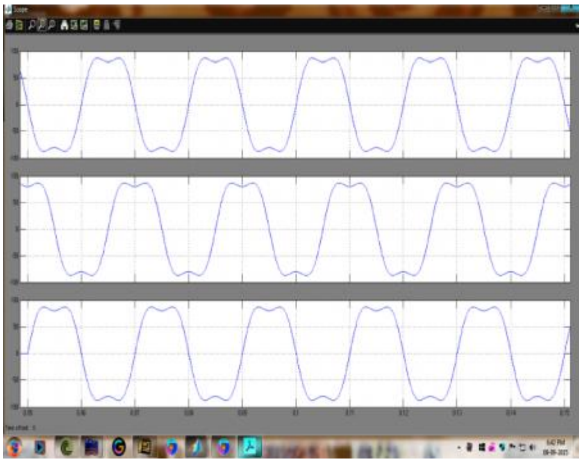


Figure 5: (a), (b), (c) and (d) Source and Load Voltages and Currents

(a)



(b)

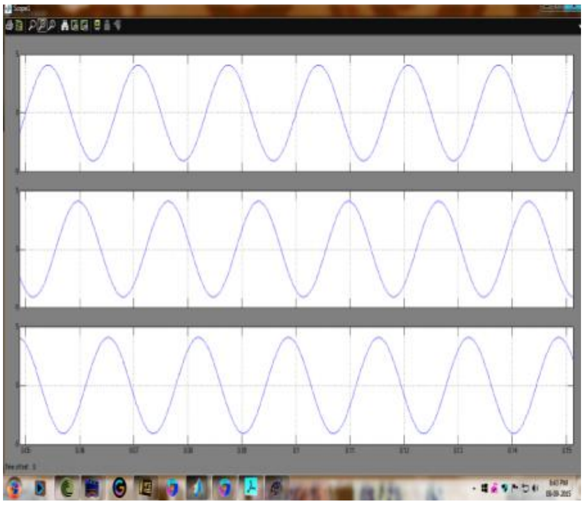
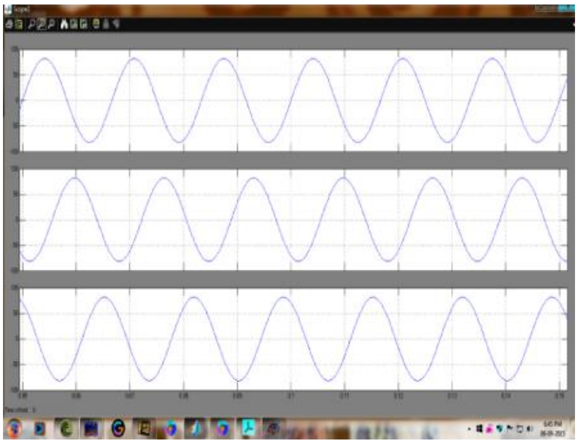


Figure 5 (Cont.)

(c)



(d)

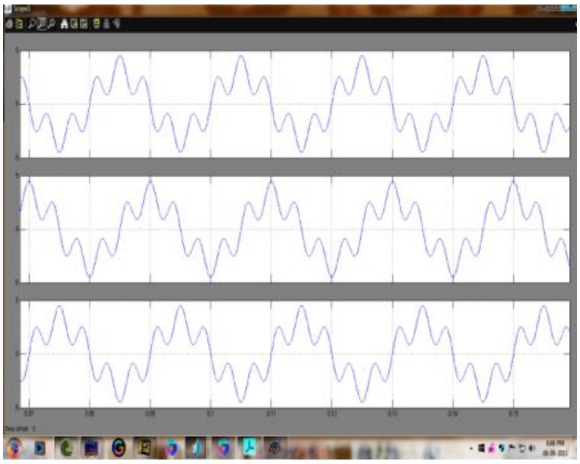


Figure 6: (a) and (b) PAF Currents

(a)

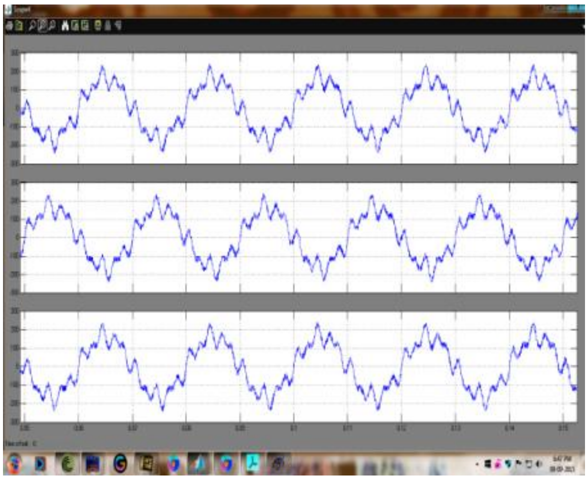
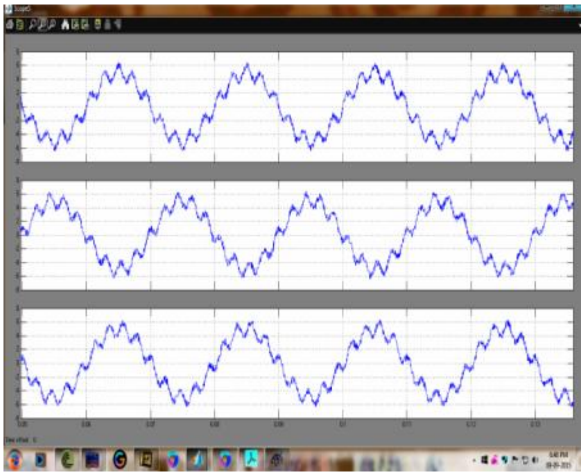


Figure 6 (Cont.)

(b)



0.994, and 0.994 for phases A, B, and C, respectively.

Figures 6a and 6b shows the currents through the PAF. The PAF indirectly supplies the load harmonic currents because the SAF only drains the fundamental current component from the source.

Figures 7a-7d shows the source and load voltages during a voltage interruption in phase A,

Figures: 7: (a), (b), (c) and (d) Source Voltages and Currents and Load Voltages

(a)

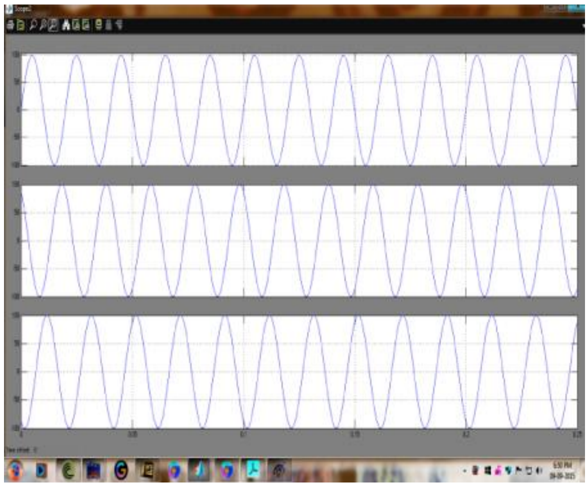
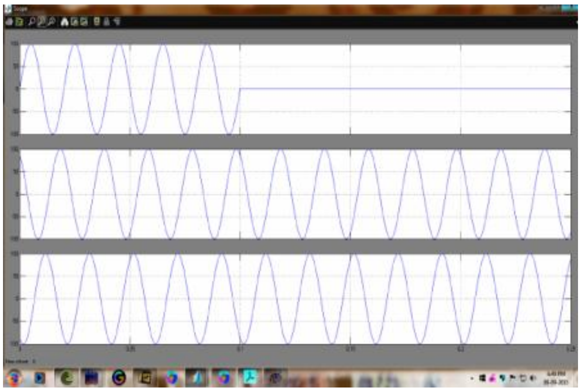
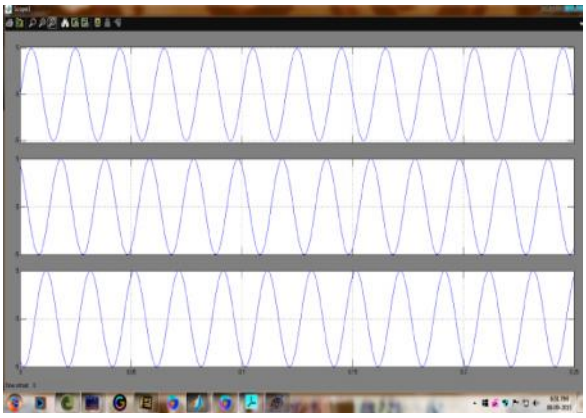


Figure 7 (Cont.)

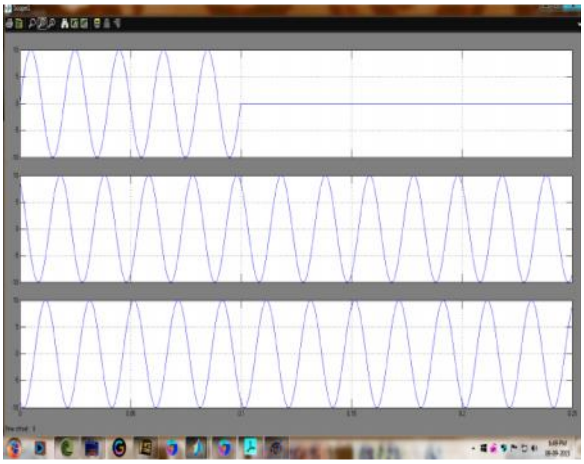
(b)



(c)



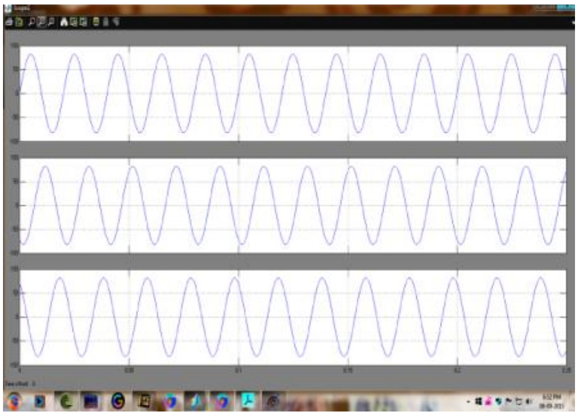
(d)



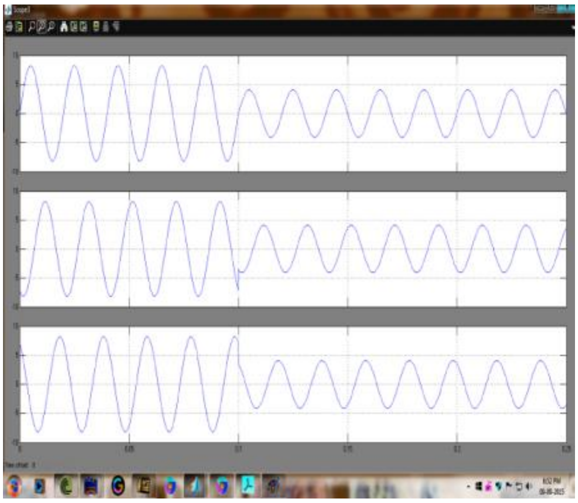
it shows the source currents during a fault in phase A. It is possible to see that the source currents in the other phases have the amplitudes increased in order to keep the nominal power of the load.

Figure 8: (a) and (b) Load Voltages and Currents

(a)



(b)



The load voltages and the load currents are shown in Figures 8a and 8b during a load step from 100% to 50%.

CONCLUSION

In this study, a new simplified control algorithm is proposed for UPQC system in order to compensate power quality problems such as, unbalanced voltages, harmonics, reactive power and neutral current of the nonlinear loads. The proposed control algorithm simulation results are given in PSIM simulation. In literature, conventional UPQC control algorithms require measurements of load, filter and mains currents and Voltages and also DC bus voltage in order to regulate DC bus. The proposed control algorithm, the number of measurement is decreased. The results validate the proposed iUPQC control scheme, proving that the power quality can be meaningfully better with a simple control method which uses only synchronized sinusoidal references.

REFERENCES

1. Axente I, Ganesh J, Basu M, Conlon M and Gaughan K (2010), "A 12-Kva DSP-Controlled Laboratory Prototype UPQC Capable of Mitigating Unbalance in Source Voltage and Load Current", *IEEE Trans. Power Electron.*, Vol. 25, No. 6, pp. 1471-1479.
2. Axente I, Basu M, Conlon M and Gaughan K (2010), "Protection of Unified Power Quality Conditioner Against the Load Side Short Circuits", *IET Power Electron.*, Vol. 3, No. 4, pp. 542-551.
3. Franca B and Aredes M (2011), "Comparisons Between the UPQC and its Dual Topology (iUPQC) in Dynamic Response and Steady-State", in Proc. 37th IEEE IECON/IECON, November, pp. 1232-1237.
4. Karanki S, Mishra M and Kumar B (2010), "Particle Swarm Optimizationbased Feedback Controller for Unified Power-Quality Conditioner", *IEEE Trans. Power Del.*, Vol. 25, No. 4, pp. 2814-2824.
5. Kesler M and Ozdemir E (2011), "Synchronous-Reference-Frame-Based Control Method for UPQC Under Unbalanced and Distorted Load Conditions", *IEEE Trans. Ind. Electron.*, Vol. 58, No. 9, pp. 3967-3975.
6. Khadkikar V (2012), "Enhancing Electric Power Quality Using UPQC: A Comprehensive Overview", *IEEE Trans. Power Electron.*, Vol. 27, No. 5, pp. 2284-2297.
7. Khadkikar V and Chandra A (2011), "UPQC-S: A Novel Concept of Simultaneous Voltage Sag/Swell and Load Reactive Power Compensations Utilizing Series Inverter of UPQC", *IEEE Trans. Power Electron.*, Vol. 26, No. 9, pp. 2414-2425.
8. Khadkikar V, Chandra A, Barry A and Nguyen T (2011), "Power Quality Enhancement Utilising Single-Phase Unified Power Quality Conditioner: Digital Signal Processor-Based Experimental Validation", *IET Power Electron.*, Vol. 4, No. 3, pp. 323-331.
9. Kinhal V, Agarwal P and Gupta H (2011), "Performance Investigation of Neural-Network-Based Unified Power-Quality Conditioner", *IEEE Trans. Power Del.*, Vol. 26, No. 1, pp. 431-437.
10. Kwan K H, So P L and Chu Y C (2012), "An Output Regulation-Based Unified Power Quality Conditioner with Kalman Filters", *IEEE Trans. Ind. Electron.*, Vol. 59, No. 11, pp. 4248-4262.
11. Lee W C, Lee D M and Lee T-K (2010), "New Control Scheme for a Unified Power-Quality Compensator-Q with Minimum Active Power Injection", *IEEE Trans. Power Del.*, Vol. 25, No. 2, pp. 1068-1076.
12. Leon A, Amodeo S, Solsona J and Valla M (2011), "Non-Linear Optimal Controller for Unified Power Quality Conditioners", *IET Power Electron.*, Vol. 4, No. 4, pp. 435-446.

13. Li G, Ma F, Choi S and Zhang X (2012), "Control Strategy of a Cross-Phaseconnected Unified Power Quality Conditioner", *IET Power Electron.*, Vol. 5, No. 5, pp. 600-608.
14. Munoz J, Espinoza J, Moran L and Baier C (2009), "Design of a Modular UPQC Configuration Integrating a Components Economical Analysis", *IEEE Trans. Power Del.*, Vol. 24, No. 4, pp. 1763-1772.

International Journal of Engineering Research and Science & Technology
Hyderabad, INDIA. Ph: +91-09441351700, 09059645577
E-mail: editorijlerst@gmail.com or editor@ijerst.com
Website: www.ijerst.com

ISSN 2319-5991