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Design and Simulation of OUPQC to Mitigate Harmonics in Distribution Networks for Enhancing the Power Quality

Arti Gosain[1], Shuchi Shah[2] and Virendra Singh Solanki[3]

[1,2,3]MIT, Mandsaur

E-mail: [1]rtgosain@gmail.com, [2]shuchi.shah@mitmandsaur.info, [3]virendra.singh@mitmandsaur.info

Abstract—*With the increase in the complexion of the power distribution system and the loads, it is very possible that several kinds of power quality disturbances are in a distribution system or a power load simultaneously, and it is therefore important to introduce UPQC (Unified Power Quality Conditioner). The Unified power quality conditioner (UPQC) is an effective solid state power device for the enhancement of power quality due to its quick response, high reliability and nominal cost. A UPQC is used to compensate deep voltage sags, voltage unbalances and harmonics. It is efficiently capable of protecting sensitive loads against the voltage variations or disturbances. UPQC employs two converters that are connected to a common DC link with an energy storage capacitor. UPQC is the emerging device of Solid state Power, which combines the functions of series voltage compensator, shunts current compensator. The open unified power quality conditioner (OUPQC), composed of a power-electronic series main unit installed in the medium-voltage/low-voltage (LV) substation, along with several power-electronic shunt units connected close to the end users. The series and parallel units do not have a common dc link, so their control strategies are independent of each other.*

Simulation results are presented to verify the effectiveness and feasibility of the proposed topology.

Keywords*: OUPQC; voltage sags; harmonics; control strategy*

1. INTRODUCTION

Nowadays, with the increasing demand of various types of nonlinear loads in distribution networks become more and more sensitive, so various power quality problems would be likely to occur simultaneously[2,3]. With this it's important to use a scheme which is Fig. out almost any power quality issues. The OUPQC scheme proposed by Morris et al by separating common DC link from the conventional UPQC.

In order to achieve general improvement in power quality for all ends users, with cost effectiveness [1]. Open UPQC is its ability to stabilize the load voltage, without distorting the supply current and load voltage from sinusoidal for and also keeping it balanced [4]. Open UPQC can posses the better compensating characteristics than the conventional UPQC.

OUPQC devices do not allow local distributors to guarantee different quality demand levels to the final costumers, because they improve power quality for all the supplied end users.

In the power quality our object is IEEE 519 rule for voltage as well as current at load end that is why we have not shown supply voltage and current wave. The basic principle is presented and simulation results are given to verify the analysis.

2. SYSTEM DESCRIPTION

The OPEN UPQC structure has consists of two VSI named as CONV_1 and CONV_2 left out common DC link. The sensitive loads are protected by the series VSI and operate as a voltage source against sag and swell while the shunt VSI being the current source eliminates the load current harmonics by limiting linked to international standards of power quality [5].

The shunt converter (CONV_2) is supplied by DC capacitor Cdc and connected to the system in parallel by Coupling inductor to ripple out the switching frequency harmonics.

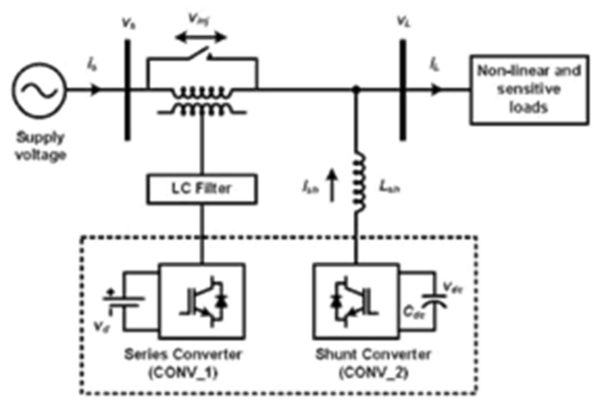

Fig. 1: OPEN Unified power quality conditioner.

There are two different modes of OPEN UPQC operation:

Compensator: when the point of common coupling voltage is within its operation limits, the static switch are closed, the series unit works as a three-phase voltage generator and the shunt units work as current generators.

Back-up: when the point of common coupling voltage is outside of its operation limits, the static switch is open, decoupling the network and the load-compensator system. Each sensitive load is supplied by its shunt unit, which acts as a sinusoidal voltage generator, using the energy stored in the storage system as an energy source.

OPEN UPQC also performs shunt and series compensation in a power distribution system. Since a power transmission line generally operates in a balanced, distortion free environment, an OPEN UPQC must only provide balanced shunt or series compensation [6].

In three phase systems, they could also cause unbalance and draw excessive current. The injected harmonics, reactive power burden, unbalance cause low system efficiency. The power system is subjected to various transients like voltage sags, swell, flickers etc. These transients would affect the voltage at distribution levels which would increase the generating capacity of generating stations and increase the transmission losses in lines[7],[8].

Power quality mainly deals with issues like maintaining a fixed voltage the load ends becomes at the Point of common Coupling (PCC) for various distribution voltage levels irrespective of voltage fluctuations.

Controlling methods has the most significant role in any power electronics based system. The efficiency of a good OPEN UPQC system depends upon its various controlling technique [9].

3. PERFORMANCE OF OPEN UPQC

This section is focused on understanding the OPEN UPQC compensation limits its important to remember that the power absorbed by the loads and the shunt units affect the performance of the whole OPEN UPQC.The OPEN UPQC can better compensate for short duration disturbances [5].

This voltage is derived from a voltage source inverter VSI operated under pulse width modulation (PWM) technique.

OPEN UPQC shown in Fig.2 consists of two VSIs namely VSI_1 and VSI_2. Series inverter (VSI_1) is connected through transformers between the supply and PCC [4]. Shunt inverter (VSI_2) is connected in parallel with PCC through smoothing inductor. VSI_1 operates as a voltage source and protects sensitive loads (Load_1 and Load_2) against voltage sag/swell. VSI_2 operates as a current source and eliminates Load_1 current harmonics [11].

The power circuit of VSI_1 consists of three single-phase H-bridge voltage-source PWM inverters.

The power circuit of VSI_2 consisting of a three-phase voltage-source PWM inverter is supplied from CDC. VSI_2 is directly connected through a boost inductor L_{sm} which can boost up the common DC-link voltage to desired value[9].

Switching devices in VSI_1 and VSI_2 are insulated gate bipolar transistor (IGBT) with anti-parallel diodes. Three-phase uncontrolled diode-bridge rectifier with Load_1.

Load_2 (RL2 and inductive LL2) is another sensitive load connected to PCC [1].

Two different modes of OPEN UPQC operation

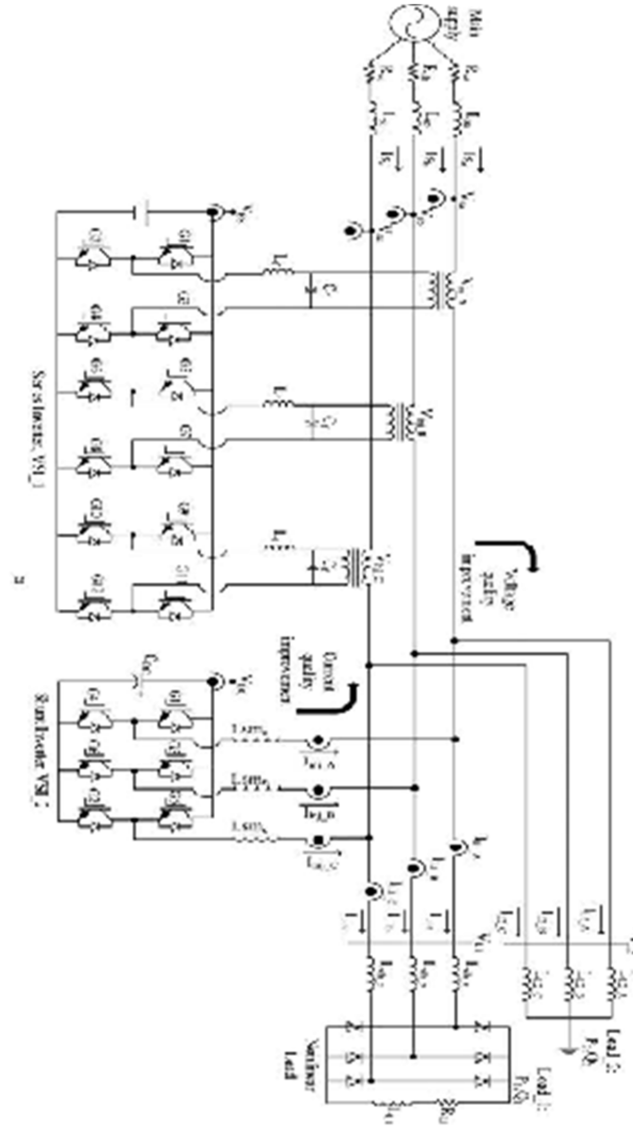

Fig. 2: Schematic diagram of OPEN UPQC.

VSI_1 OFF and VSI_2 ON: When the PCC voltage is within its operation limits, VSI_1 is closed and VSI_2 works as current generators VSI_2 suppresses the Load_1 current harmonics and regulates DC-link voltage during this mode of operation [12].

VSI_1 ON and VSI_2 ON: When the PCC voltage is outside of its operation limits, both VSI_1 and VSI_2 are open. VSI_1 starts to mitigate sag/swell using the energy stored in energy storage device (V_{ES}) and keeps Load_1 and Load_2 voltages at prefault values. Meanwhile, VSI_2

Continues to suppress the Load_1 current harmonics and to regulate DC-link voltage [4].

4. CONTROL STRATEGY

The control strategy for OUPQC is based on PI controller based PWM technique for non linear load.

In the new scheme, three-phase sinusoidal supply voltage is applied to the non-linear load (static load), which is used to injecting current and voltage harmonics into the system [8].

System parameters of test system, load voltage in three-phase after compensation total harmonics distortion (THD) level for compensated load voltage for distribusation system,

New Simulation model of OUPQC using PI controller and non linear load.

DTC (Direct Torque Control) Induction Motor Drive

Induction motor drives controlled by Field Oriented control (FOC) has used in high performance industrial applications, has achieved a quick torque response, and has been applied in various industrial applications instead of dc motors [7,8]. During the last decade a new control method called DTC (Direct Torque Control) has been developed for electrical machines. In this method, Stator voltage vectors is selected according to the differences between the reference and actual torque and stator flux linkage. The DTC technique is characterized by its simple implementation and a fast dynamic response. There are different types of control strategies used for DTC (Direct Torque Control) like ANN control, GA control, Fuzzy Logic control.

Simulation Model for DTC induction motor (Dynamic) load with OUPQC using PI controller based PWM Technique.

An ideal three-phase sinusoidal supply voltage is applied to the non-linear dynamic load (Direct torque control Induction motor drive) injecting so many of current and voltage harmonics into the distribution system. Fig. shows load 1 voltage in three-phase after compensation. shows THD level for compensated load voltage.

5. SIMULATION RESULTS

To demonstrate the effectiveness of the proposed topology scheme. The corresponding parameters of grid and compensation units are seen in Table. I.

Parameters of Test System:

New Simulation model of OUPQC using PI controller and non linear load drive as load is shown in Table I.

Table I: PARAMETERS OF NON LINEAR LOAD (STATIC)

Source 3-phase	13 kV, 50 Hz
Inverter IGBT based	3 arm, 6 Pulse
Carrier Frequency	1080 Hz
Sample Time	5 µs
PI Controller Series Control	K_p=0.5,K_i=100
Shunt Control(I)	K_p=1000,K_i=1000
Shunt Control(II)	K_p=0.5,K_i=100 , 50 µs
RL Load Active Power	1 kW
Inductive Reactive Power	400 VAR
Non Linear Load Rs,Cs,Ron	1 e5,100,1 e-3
Transformer 1 Y/Δ/Δ	13/115/115KV
Transformer 2Δ/Y	115/11 KV

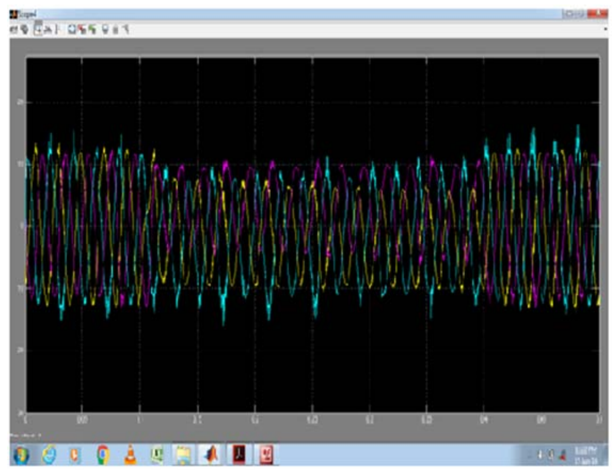

Fig. 5.1 (a) shows load 1voltage in three-phase after compensation

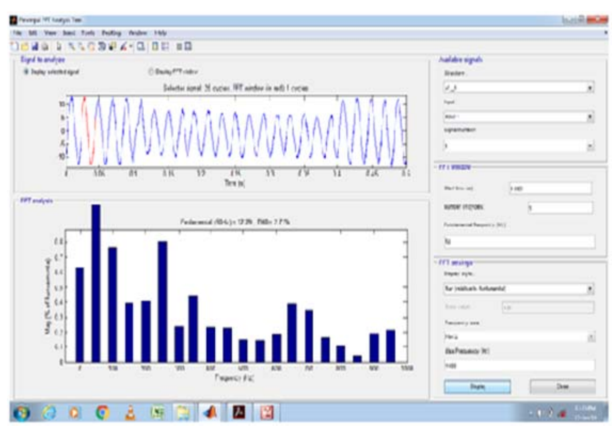

Fig. 5.2(a): Waveform of Current Load 1 with open UPQC

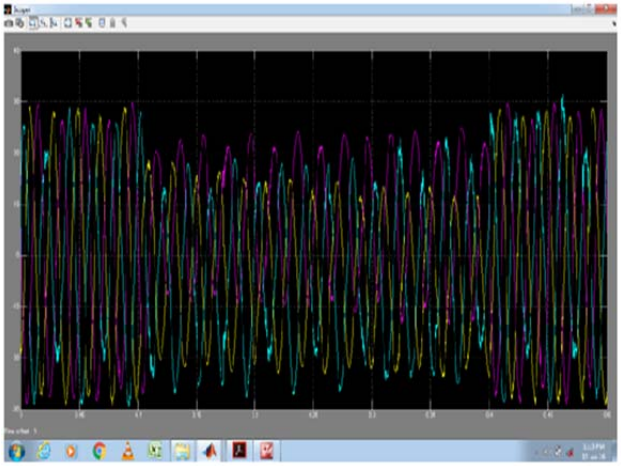

Fig. 5.2(a): Waveform of Current Load 1 with open UPQC

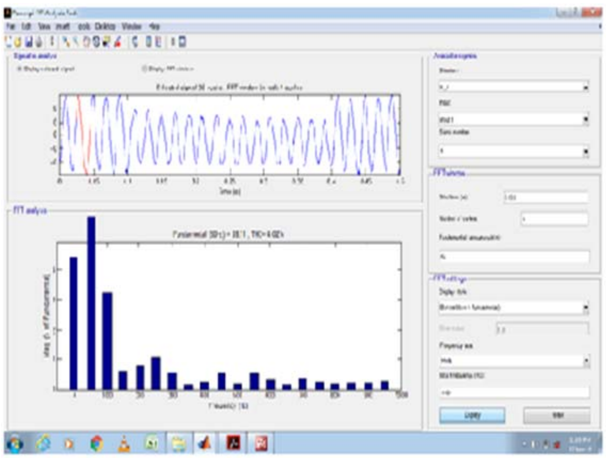

Fig. 5.2(b): Total harmonic distortion with open UPQC for Current Load 1

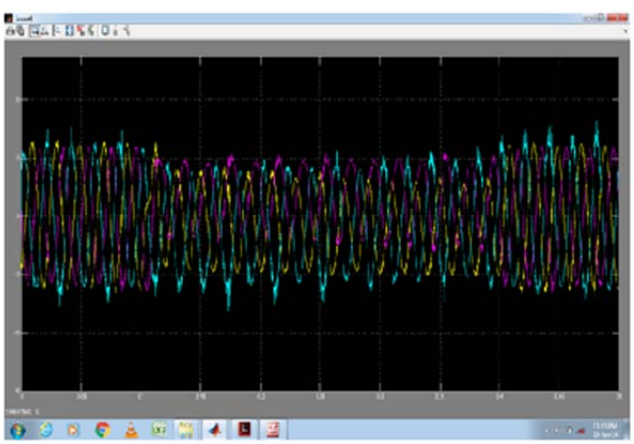

Fig. 5.3(a): Waveform of Voltage Load 2 with open UPQC

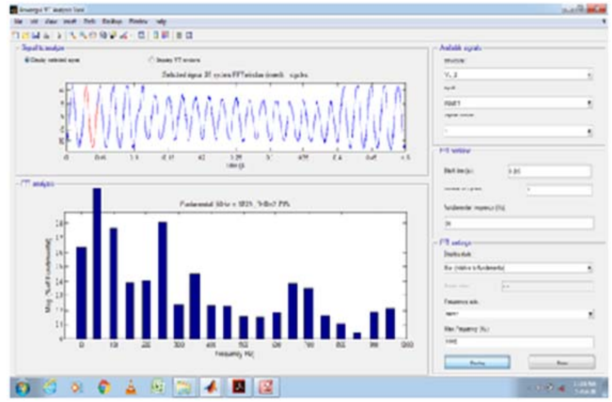

Fig. 5.3(b): THD with open UPQC for voltage Load 2

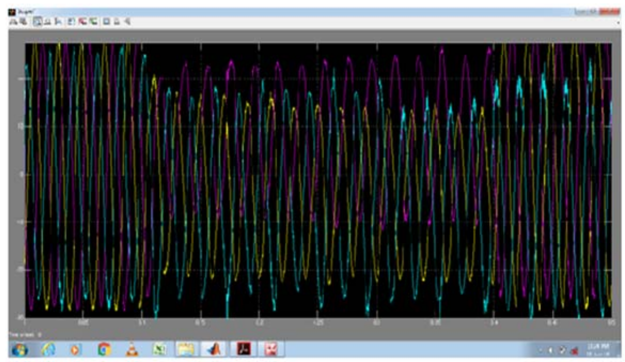

Fig. 5.4(a): Waveform of Current Load 2 with open UPQC

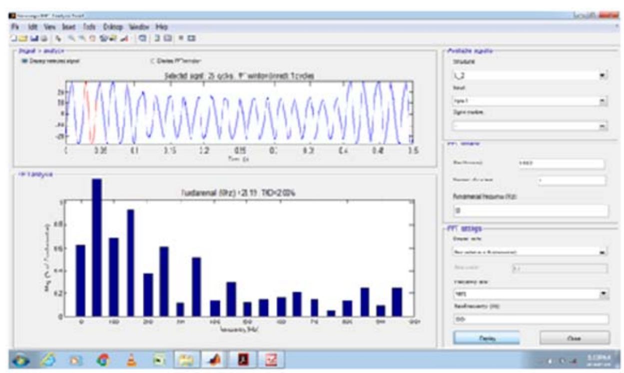

Fig. 5.4(b): Total harmonic distortion with open UPQC for Current Load 2

Simulation model of UPQC using PI control and Direct torque control induction motor drive as load is shown in Table II System parameters of test system.

Table Ii: Parameters of Dynamic Load

Source 3-phase	13 kV, 50 Hz
Inverter IGBT based	3 arm, 6 Pulse

Carrier Frequency	1080 Hz
Sample Time	5 μs
PI Controller Series Control	K_p=0.5,K_i=100
Shunt Control(I)	K_p=1000,K_i=1000
Shunt Control(II)	K_p=0.5,K_i=100 , 50 μs
RL Load Active Power	1 kW
Inductive Reactive Power	400 VAR
Non Linear Load Rs,Cs,Ron	1 e5,100,1 e-3
Transformer 1 Y/Δ/Δ	13/115/115KV
Transformer 2Δ/Y	115/11 KV
Motor load Vrms,Frequency	220 V, 50 Hz

Simulation Model for DTC induction motor (Dynamic) load with OUPQC using PI controller based PWM Technique.

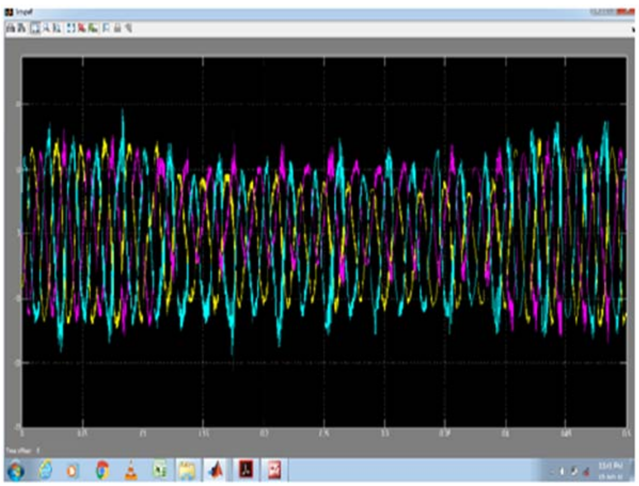

Fig. 5.5 (a) shows load 1 voltage in three-phase after compensation.

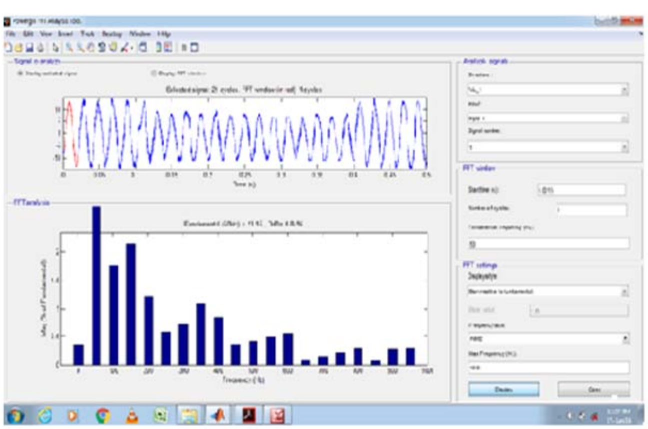

Fig. 5.5(b) Total harmonic distortion with open UPQC for voltage Load 1

An ideal three-phase sinusoidal supply voltage is applied to the non-linear dynamic load (Direct torque control Induction motor drive) injecting so many of current and voltage harmonics into the distribution system.

In order tto achieved the required result in we are showing the necessary waveform of the simulations that is waveforms of the load voltage,load current and showing the parameters so follow with the standards value as per the IEEE 519 rule our result is as per the desired value in dynamic load.

6. CONCLUSION

The performance of OPEN UPQC for power quality improvement is evaluated for non linear load. It has been proved that for distribution network having non-linear load both static and dynamic the open UPQC has wide range for enhancing the power quality. The simulation result of load-voltage and load-current as per the IEEE 519 rule is satisfactory. We are focusing on mitigate or eliminated uneven oscillations in distribution line with in desired value. The OPEN UPQC for non-linear load are analyzed and its suitable for the sensitive loads, which posses high reliability due to independent operations along with high flexibility. It has been concluded that OPEN UPQC can posses the better compensating characteristics for non-linear loads. Voltage qualities within large supply region are also improved.

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REFERENCES

[1] BRENNA MORRIS, FARANDA ROBERTO, TIRONI ENRICO. A new proposal for power quality and custom power improvement: OPEN UPQC [J]. *IEEE Transactions on Power Delivery*, 2009, 24 (Compendex): 2107-2116.

[2] BOLLEN M, H J. Understanding Power Quality Problems: Voltage Sags and Interruptions [M]. *IEEE Press*, 2000.

[3] Lin Haixue. Main problems of modern power quality [J].*Power System Technology*, 2001, 25 (10) : 5-12 (in Chinese) .

[4] Teke, A., Saribulut, L., Tümay, M.: 'A novel reference signal generation method for power-quality improvement of unified power-quality conditioner', *IEEE Trans. Power Deliv.*, 2011, 26, pp.2205–2214

[5] Jindal, A.K., Ghosh, A., Joshi, A.: 'Interline unified power quality conditioner', *IEEE Trans. Power Deliv*., 2007, 22, (1), pp. 364– 372.

[6] A. Agustoni, E. Borioli, M. Brenna, G. Simioli, E. Tironi, and G. Ubezio, 'LV DC distribution network with distributed energy resources : Analysis of possible structures ," presented at the 18th *Int. Conf. Electricity Distribution CIRED* 2005,Turin, Italy, Jun. 6-9, 2005.

[7] M. R. Banaei, S. H. Hosseini, and M. D. Khajee, "Mitigation of voltage sag using adaptive neural network with dynamic voltage restorer," inProc. 5th *Int. CES/IEEE Power Electronics and Motion Control Conf*., Shanghai, China, Aug. 14–16, 2006, vol. 2, pp. 1–5.

[8] A. Ghosh and G. Ledwich, "Compensation of distribution system voltage using DVR," *IEEE Trans. Power Del*., vol. 17, no. 4, pp. 1030–1036, Oct. 2002.

[9] Teke, A., Tümay, M.: 'Unified power quality conditioner: a literature survey', *J. Electr. Syst*., 2011, 7, (1), pp. 122–130.

[10] Teke, A., Bayindir, K.Ç., Tümay, M.: 'Fast sag/swell detection method for fuzzy logic based dynamic voltage restorer', *IET Gener. Transm. Distrib*., 2009, 4, (1), pp. 1–12.

[11] Basu, M., Das, S.P., Dubey, G.K.: 'Comparative evaluation of two models of UPQC for suitable interface to enhance power quality',*Electr. Power Syst.* Res., 2007, 77, pp. 821–830.

[12] Ghosh, A., Ledwich, G.: 'A unified power quality conditioner (UPQC) for simultaneous voltage and current compensation', *Electr. Power Syst*. Res., 2001, 59, pp. 55–63.

[13] Brenna, M., Faranda, R., Tironi, E.: 'A new proposal for power quality and custom power improvement OPEN UPQC', *IEEE Trans. Power Deliv*., 2009, 24, (4), pp. 2107–2116.