NEURAL NETWORK BASED SOLAR INJECTED DYNAMIC VOLTAGE RESTORER TO MITIGATE POWER QUALITY AND REDUCE THE HARMONICS

Sandra Gabriela Barrazueta Rojas
Escuela Superior Politécnica de Chimborazo (ESPOCH)
sbarrazueta@espoch.edu.ec
0000-0003-2837-8390
Eduardo Francisco García Cabezas
Escuela Superior Politécnica de Chimborazo. Grupo de Investigación & Vinculación AUTOPRO, Riobamba, Ecuador
egarcia@espoch.edu.ec
0000-0002-3547-472X
Jhonny Marcelo Orozco Ramos
Escuela Superior Politécnica de Chimborazo. Grupo de Investigación & Vinculación AUTOPRO, Riobamba, Ecuador
jhonny.orozco@espoch.edu.ec
0000-0003-2016-0426
Juan Carlos Cayán Martínez
Escuela Superior Politécnica de Chimborazo. Grupo de Investigación & Vinculación AUTOPRO, Riobamba, Ecuador
jcayan@espoch.edu.ec
0000-0001-9573-3706

Abstract

One of the most powerful and reliable custom power supplies is the Dynamic Voltage Restaurator (DVR) (the power supply system). This is a collection of powered devices that mitigate the voltage drops and easily recover the pre-default load voltage. Its best advantage of the DVR is to keep users connected and maintain reliable performance stability and consistent quality voltage. A solar photovoltaic failure is given in this dissertation in conjunction with the unbalanced (linear, nonlinear) load voltage reduction in the ANN DVR control unit protecting the critical load.

1. INTRODUCTION

Power efficiency concerns have lately been a big problem for businesses because of time and money loses. Therefore, good power efficiency is often required, and the power quality issues such as voltage decreases, swells, harmony, imbalances and flicks are decreased positively. The best electrical source will preferably be a continuous wave shape in size and frequency. The reactive power injector at the point of the typical link will provide support. Installation of mechanical shunt condensers into the main terminal of the transformer is the common process.

The downside is that transients of slower speed are not compensable. Unbalances are often not corrected inside the short mechanical swapping devices.

This document involves the Complex Voltage Restorer and PV method to mitigate the voltage slump and harmonics in the delivery system as seen in Figure 1. Figure 1. By substituting for a DVR traditional DC source, the proposed dq0-based PI controller along with PV can be used. In order to check the efficacy of the proposed Control injecting real power with PV for DVR over traditional approaches, the models based on MATLAB/SIMULINK were presented here.[1]

PV array output is related to DVR to boost the power efficiency. Photovoltaic solar panels have been used in recent years to utilize sun energy in the electricity generation. To optimize energy due to non-linear PV characteristics PV systems, require full power point tracking technology (MPPT). MPPT methods are the most widely used for disturbance and observation.

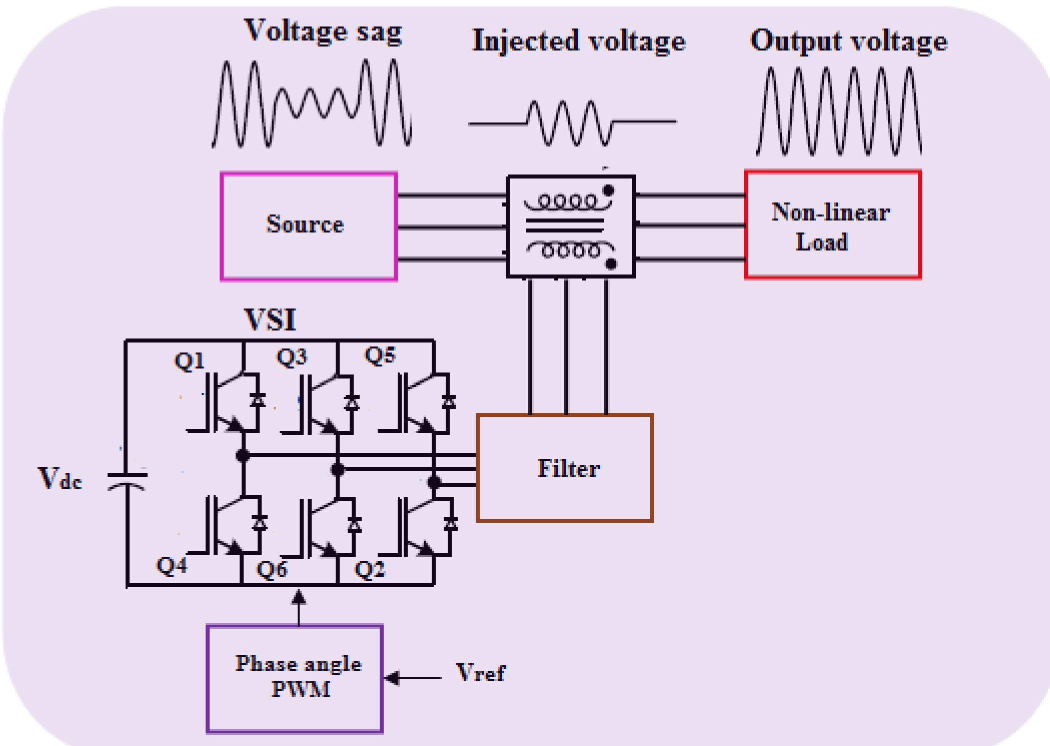


Figure 1 Block diagram of proposed DVR system

And decrease the impedance imbalance problem created by high solar thermal devices penetration by one-phase energy storage unit into low power delivery systems. The voltage imbalance with photovoltaic rooftop cells can be improved by DVR on this proposed system. MPPT technology is introduced in this device to increase the performance of the photovoltaic cell

2. Dynamic Voltage Restorer/ Regulator (DVR)

A series-related system similar to an SSSC is the Dynamic Voltage Restaurant (DVR). The key feature of DVR is that responsive loads like the semiconductor manufacturing plant or IT industry as seen in Figure 2 will remove or reduce the voltage slopes. The built DVRs with a rating of 2 MVA per module are modular.

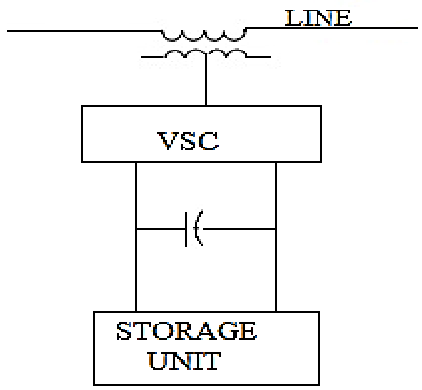


Figure 2.Dynamic Voltage Restorer

It was planned to offset three phase voltage sales up to 35 percent for less than half a second (depending on the requirement). When the stress drop happens in just one step (caused by SLG defects) the DVR can be built to compensate for the decreases above 50 per cent. Usually, the energy stock available in condensers is between 0.2 and 0.4MJ per MW served load. [2]

3. PV SYSTEM

PV is a way to transform solar energy to direct power by means of semiconductor materials that display the photovoltaic effect. PV is a means of transforming solar energy. Solar panels consisting of a variety of solar cells provide a solar energy plant with a photovoltaic system. The system's inputs are irradiance and temperature. The voltage varies from 0 to 0 CV (Voc) and refers to the current fluctuation from 0 to zero CV (Isc) current. With the solar radiation, the sum of solar incidents on the pv cord increases and thus the power with the same voltage value increases. In return, the temperature rise decreases open circuit Voltage and thus improves PV cell performance

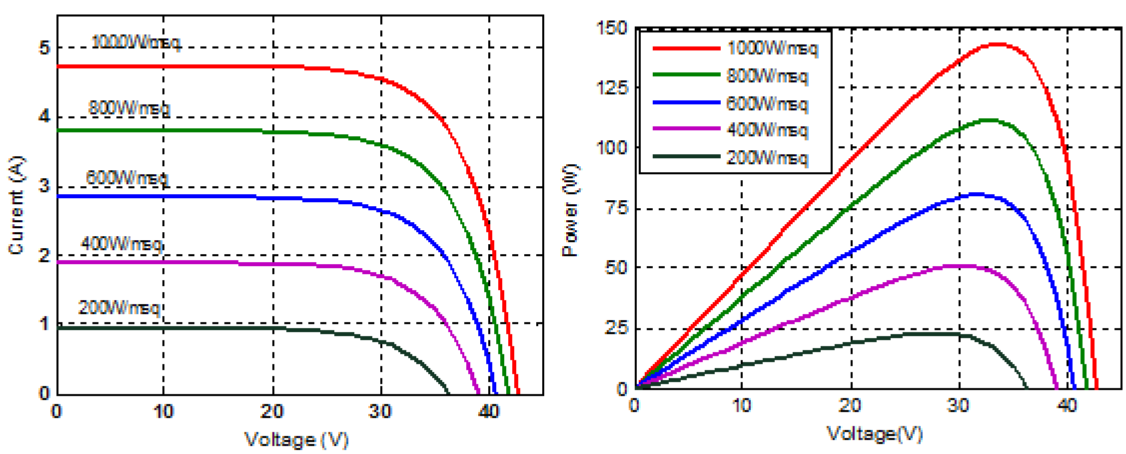
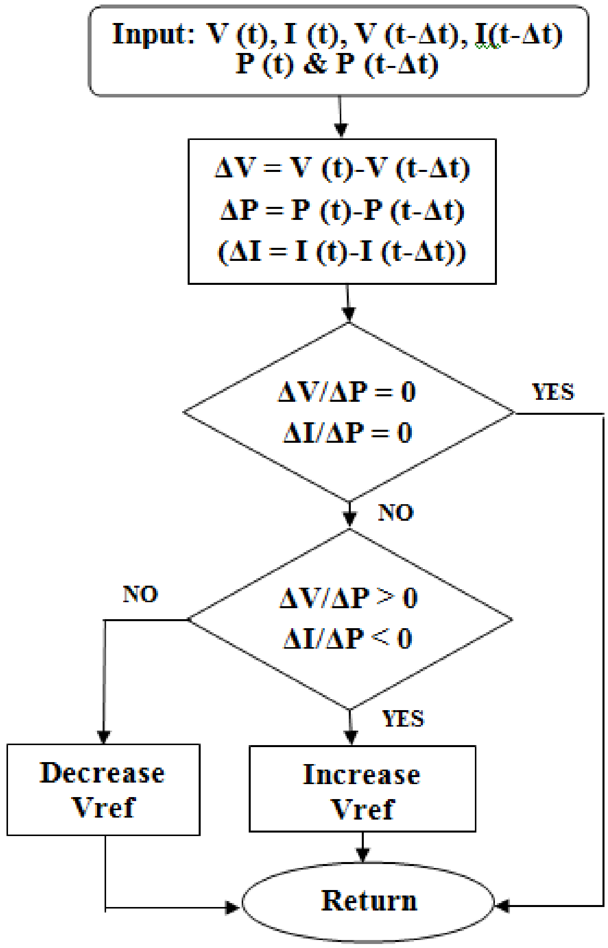


Figure 3 IV and PV characteristics' of solar panel

4. INC MPPT Algorithm

A number of scholars, Liu et al (2008) Safari et al. (2011) and Mai et al. discussed the incremental conductance technique (INC) (2011). This approach tracks the ultimate power point by comparing the gradual (AlG) and the instantaneous (G) solar panels, which are illustrated in [3]figure 4 in the flow diagramBy monitoring MPPs under different atmospheric conditions, the



as shown in Equation (1).

Figure 4 Incremental conductance algorithms

The purpose of this algorithm is to monitor the point where the voltage operates equal to exponential conductance. It thus performs in different illumination and temperatures. More measurements than the P&O approach are required in the INC approach and slower diffusion. The INC approach was used to incorporate complicated analog devices, but with the framework for microcontrollers today it becomes simpler. [4]

5. CONTROL SCHEME

The output from the controller is the optimal firing sequences relative to the PWM signal generator.

$$VA = \sin(\omega t + \delta) \quad (5)$$

$$VB=\text{Sin}\,(\omega t+\delta-2\pi/3) \quad (6)$$
$$VC = \text{Sin}\,(\omega t +\delta+2\pi/3) \quad (7)$$

5.1. ANN Controller

ANN is the human brain paradigm that seeks to mimic the method of learning. .The ANN paradigm is made up of input, secret and output layers of three layers of neurons. External information stimulates the input layer, while the output layer passes information to an external computer. [5]

The data collection for ANN is derived from traditional effects of regulation. which illustrates how the block diagram and structure functions.

$$y_j = f\left[\left(w_{ij}x_{ij}\right)+b_j\right] \quad (1)$$

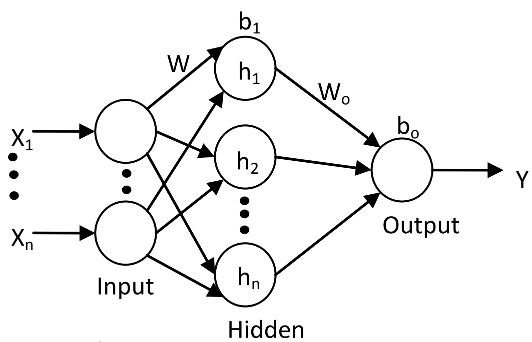


Figure 5. Exploded diagram of the artificial neural network.

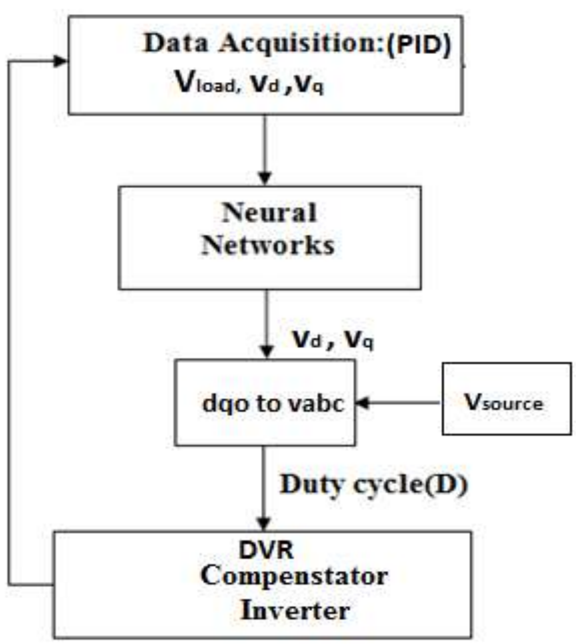


Figure 6. ANN systems

The ITC system Figure 6 ANN DVR, which included a list of 1250, separated into two subdatabases, system input and power output versions, 70% of the ANN instruction was used, the remaining 30% were used for second hand research and evaluation of networks.[6] The efficiency is determined by calculating medium-square errors , as seen in figure 7 and equation (2).

$$e = \frac{1}{p}\sum_{i=1}^{p}\left\| y^{(i)} - v^{(i)} \right\|^2 \qquad (2)$$

Where, p= number of training data entries; y = ANN output vector; v = desired output

A well-trained ANN will give the reference stress as a result of a variety of input parameters very similar to the target value and give an error of approximately zero. [7]A weighted total of n inputs Vk, K=1, 2 is determined for each neuron aj. n and the output is generated according to Equation (3).

$$a_j = \tan sig\left(\sum_{k=1}^{n} w_k v_k + bias \right) \qquad (3)$$

In Equation (3), w_k represents the synapse weight linked with each one of the n inputs.

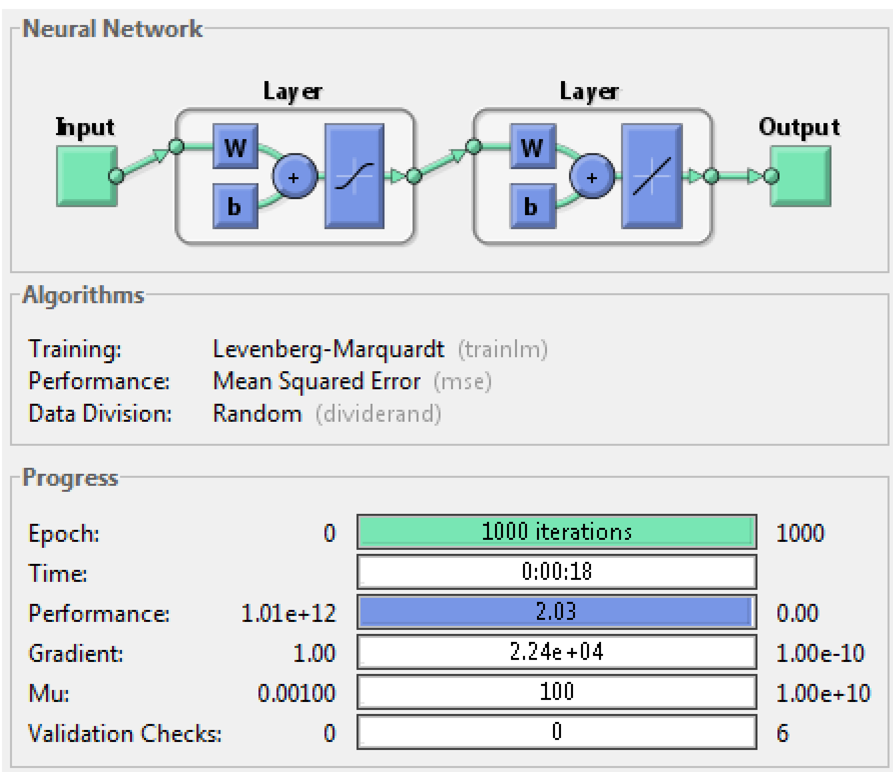


Figure 7 ANN training structure

ANN controller as seen in figure 8 is the basis for operation of the proposed DVR. The generator of the PWM signal which controls a DVR inverter to produce the injected voltage needed.

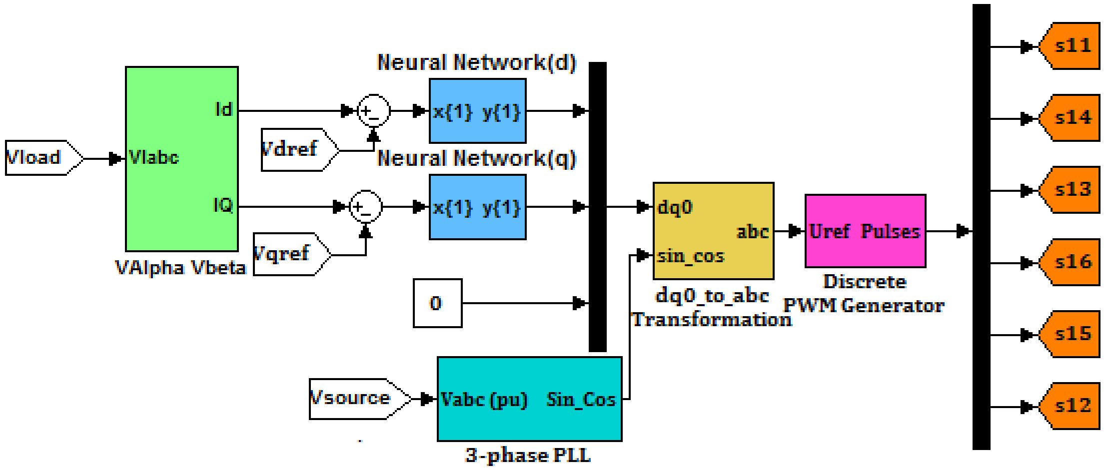


Figure.8 ANN controller

For improving both transient and stable state efficiency, the ANN controller's performance is well known. The ANN controller function is very useful because it does not need the same mathematical model. [6]

7. PARAMETERS OF DVR TEST SYSTEM

Table 1 lists device parameters. Load voltage is felt and the sequence analyzer is pushed along. Compared to Vref, its magnitude. Device contains 11 kV, 50 Hz generator, three-stage transformer feeding transmission lines, linked in /Y/Y, 11000/400/400V. Two related loads are considered in this test system with separate feeders.[7] One feeder is attached to DVR and the other is preserved as it is. This test device is checked in the state of SLG fault. The proposed DVR setup system consists of a generating system of 100 V, 60 Hz, which feeds two transmission lines through a three-wind inductive filter. The output of the MTG device is corrected further with the three-part voltage and is given to the DVR DC connection. Both linear and non-linear charge is connected at distribution end to check the function of DVR for voltage compensation. DVR can only operate for high load environments. It is virtual. Therefore, DVR is placed into the charging sequence to increase the voltage of supply before load is given.

A comprehensive structure was modeled in order to determine the utility of the control strategy suggested by MATLAB/SIMULINK. [8]

8. SIMULATION MODELS AND RESULTS

Systems with two parallel feeders are shown in this SIMULINK model. Different loads are attached to both feeders.[9] Detailed control scheme shown in Figure 8 for ANN controller simulation. DVR is attached in a sequence to one feeder and the other feeders are maintained as they are. Simulation is carried out with MATLAB/SIMULINK on the DVR evaluation system .:

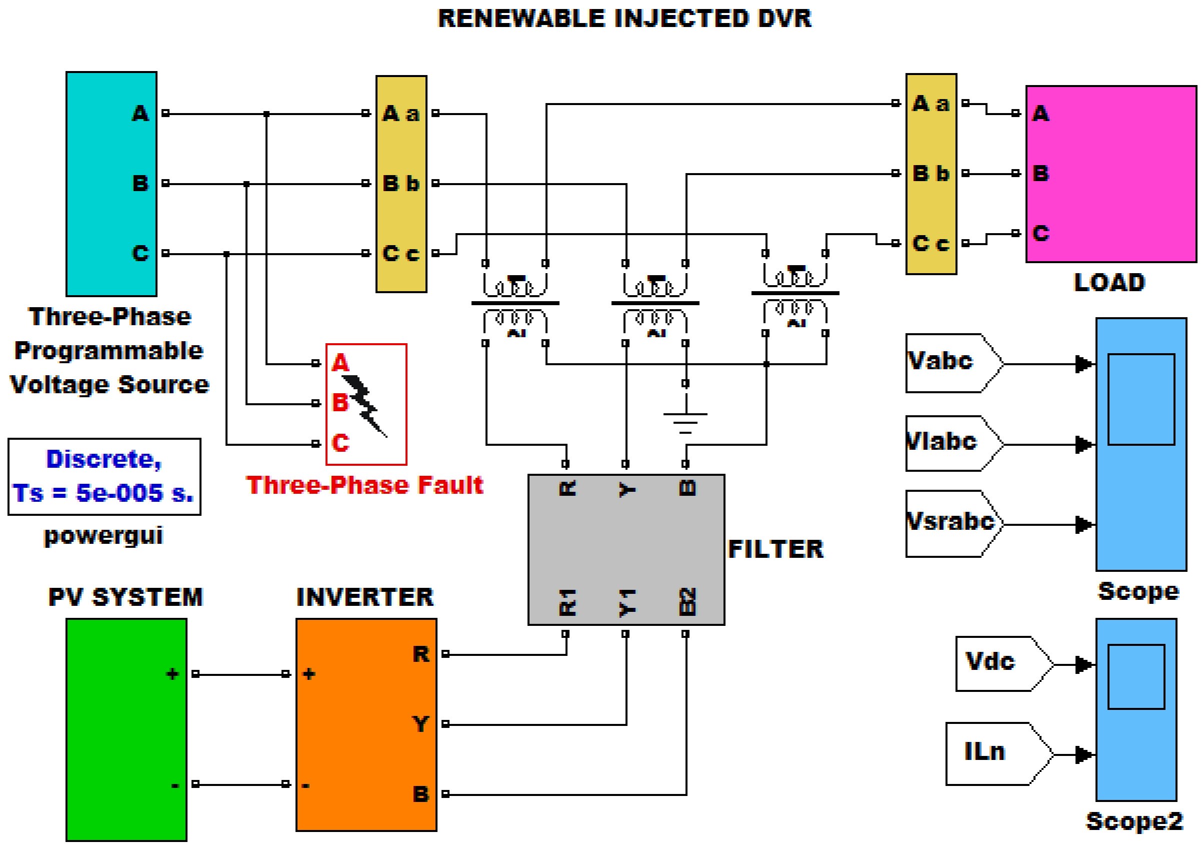


Figure 9: Simulation Model of DVR Test System

8.1 SIMULINK MODEL OF THE TEST SYSTEM WITH NON-LINEAR LOAD

CASE1:

For the test device supplying nonlinear load, SLG error is considered. Here the resistance to fault is 0.001 ohm and the resistance of the field is 0.001 ohm. This defect is generated between 0,254s and 0,3s . The output waves for the load voltage without or with compensation appear on the Diagram.10(a)–(c), single phase voltage and current harmonic, sag and malfunction simulation output as seen in Figure 11. [10-11]The output waves for the load voltage without and at compensation. Actual power frequency range of source voltage was pumped into the regulated ANN PV. Figure.12-14 indicates injected voltage and load voltage with compensation. The output wave shapes here indicate that the voltage during the fault generation process in the uncompensated feeder rises. The disparity is minimized when DVR is attached to the device

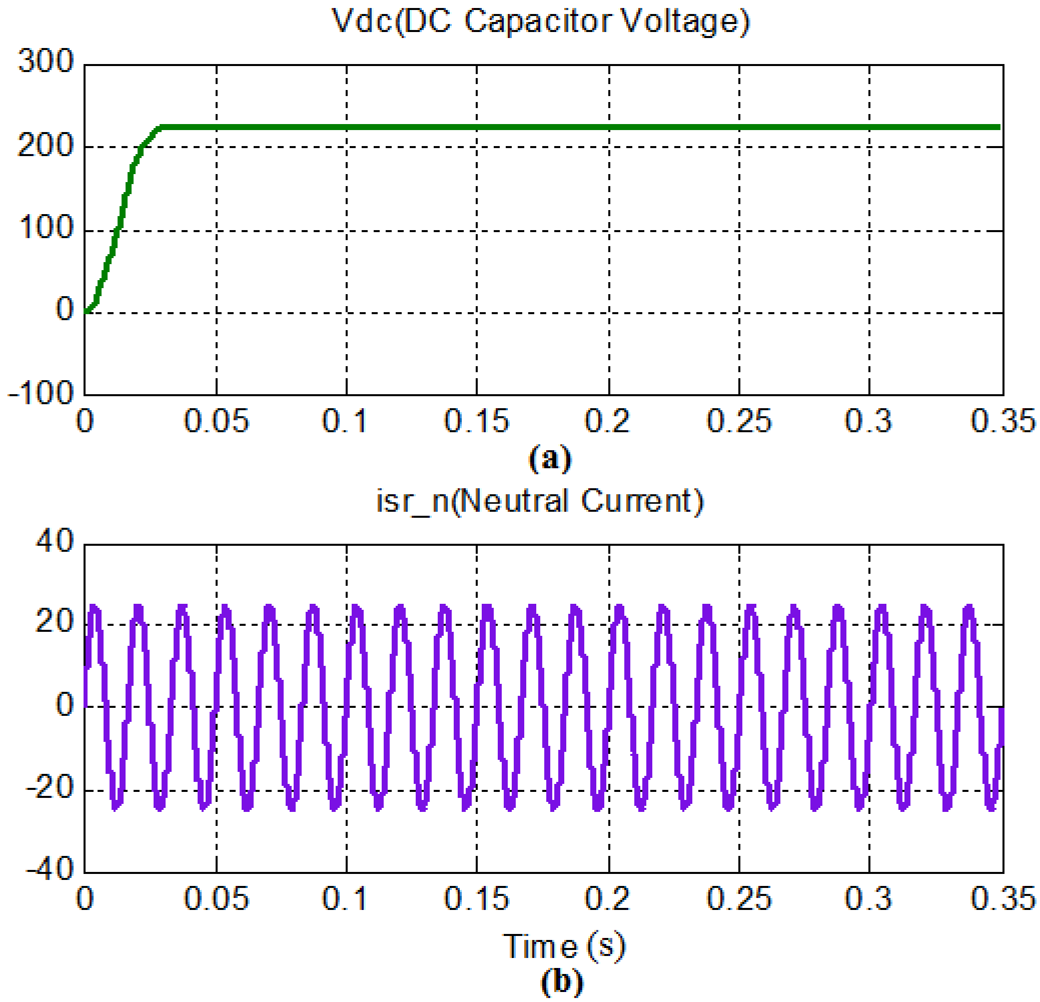


Figure 10 (a) PV voltage (V), (b) load current (A)

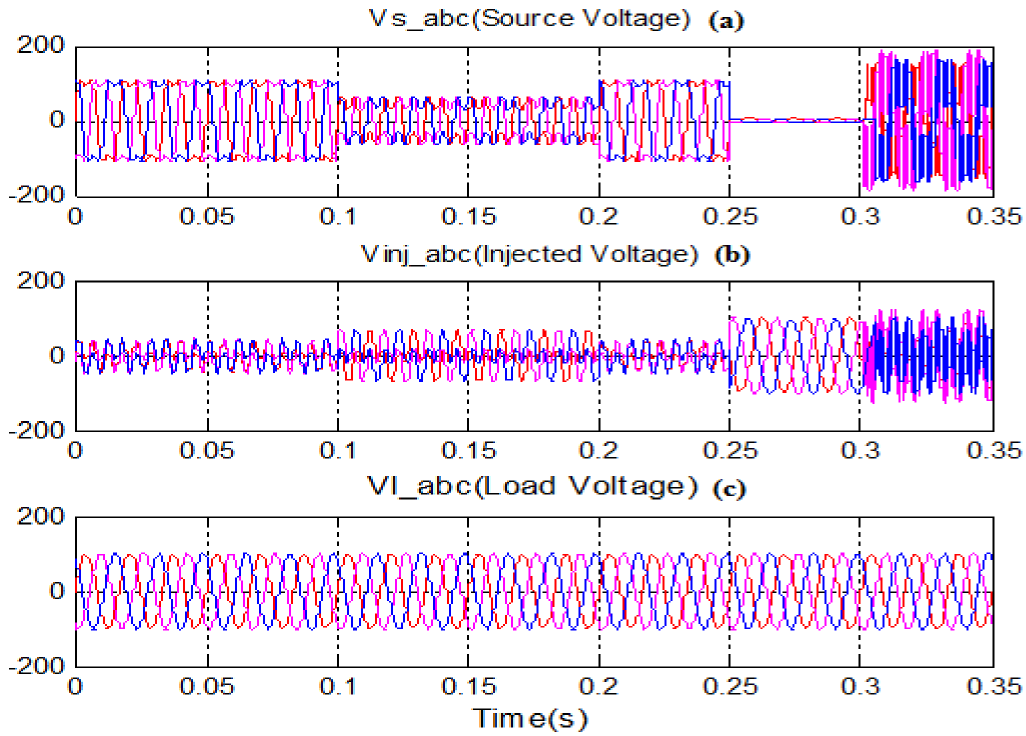


Figure 11. (a): source voltage, (b) injected voltage (c) load voltage

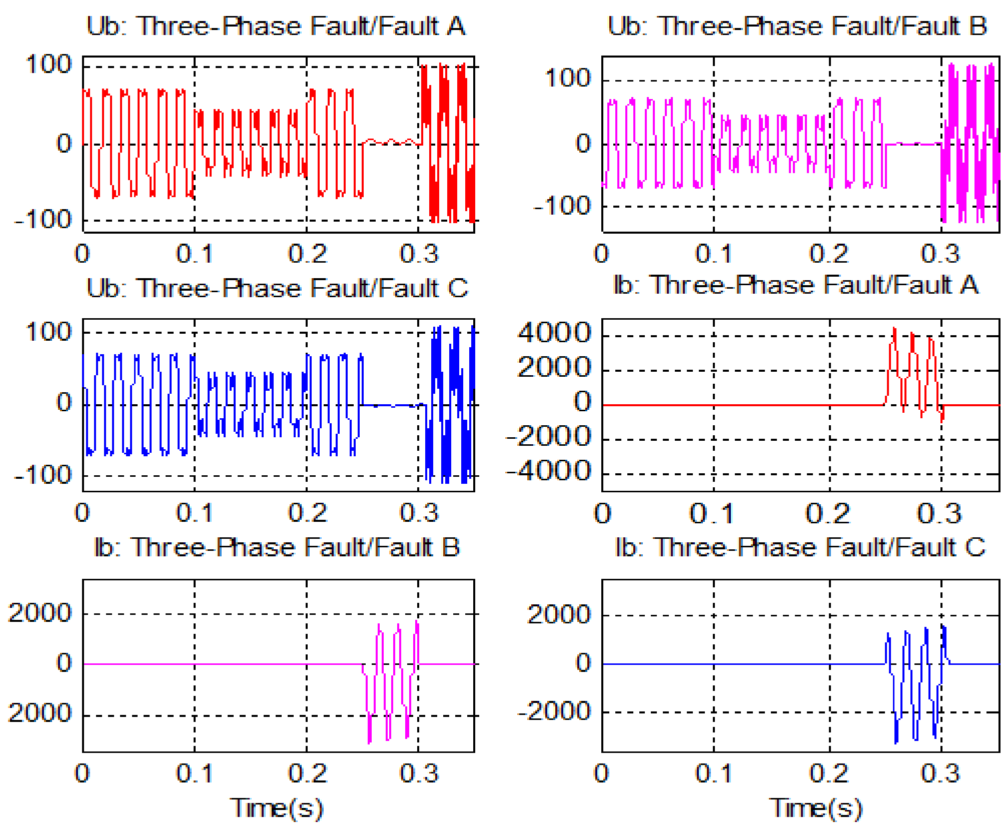


Figure 12. (a): single phase source voltage, fault current(ABC phases)

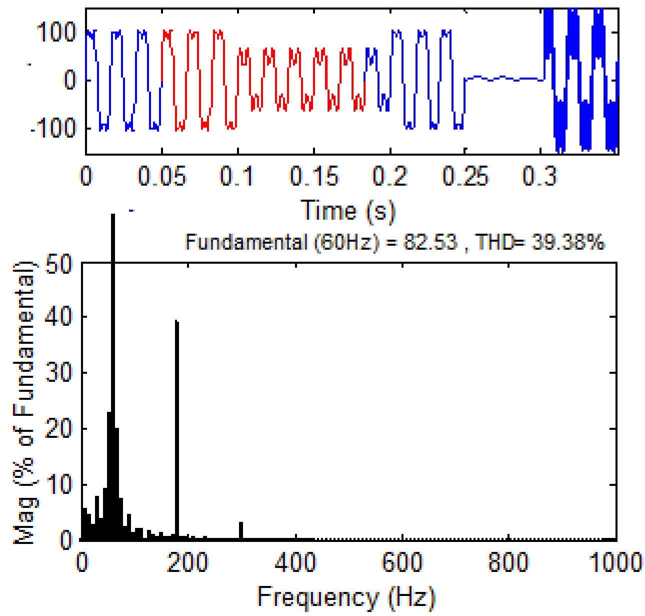


Figure 13 Frequency Spectrum source voltage

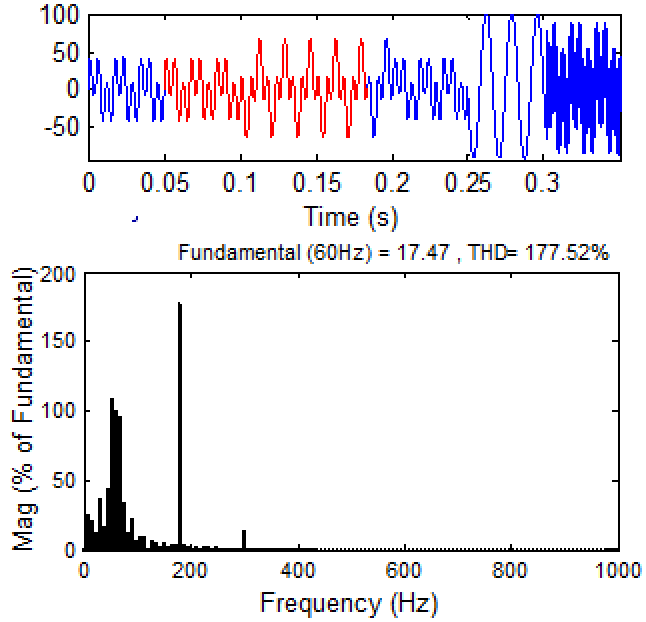


Figure 14: Frequency Spectrum injected voltage

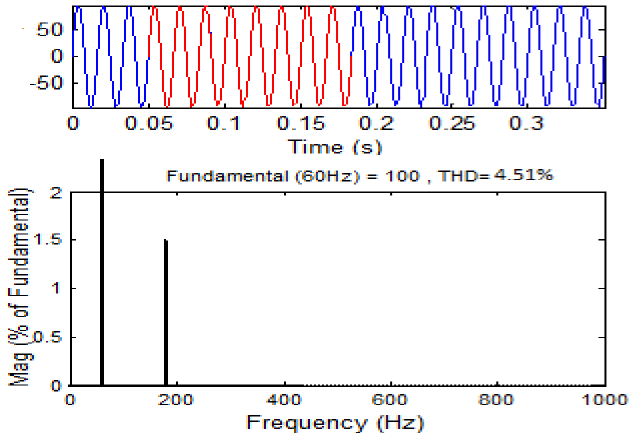


Figure 15 Frequency Spectrum load voltage

Case II:

For a test device that offers non-linear load, SLG fault is considered. The resistance to defect is here 0.001 ohm and the resistance of the field is 0.001 ohm. Duration of 0.25s to 0.3s is the product of the fault. Figure. 15(a)-(c) With the ANN controller display the output waves for the load voltage, the injected voltage and the offset voltage. The performance view of harmonics, sag and fault configuration of Figure.16. Frequency continuum Figure. (17)-(19) with and without source voltage compensation, injected voltage and load voltageThe output wave shapes here indicate that the voltage during the fault generation process in the uncompensated feeder rises.[12-14] The unbalance is minimized when DVR is attached to the device.

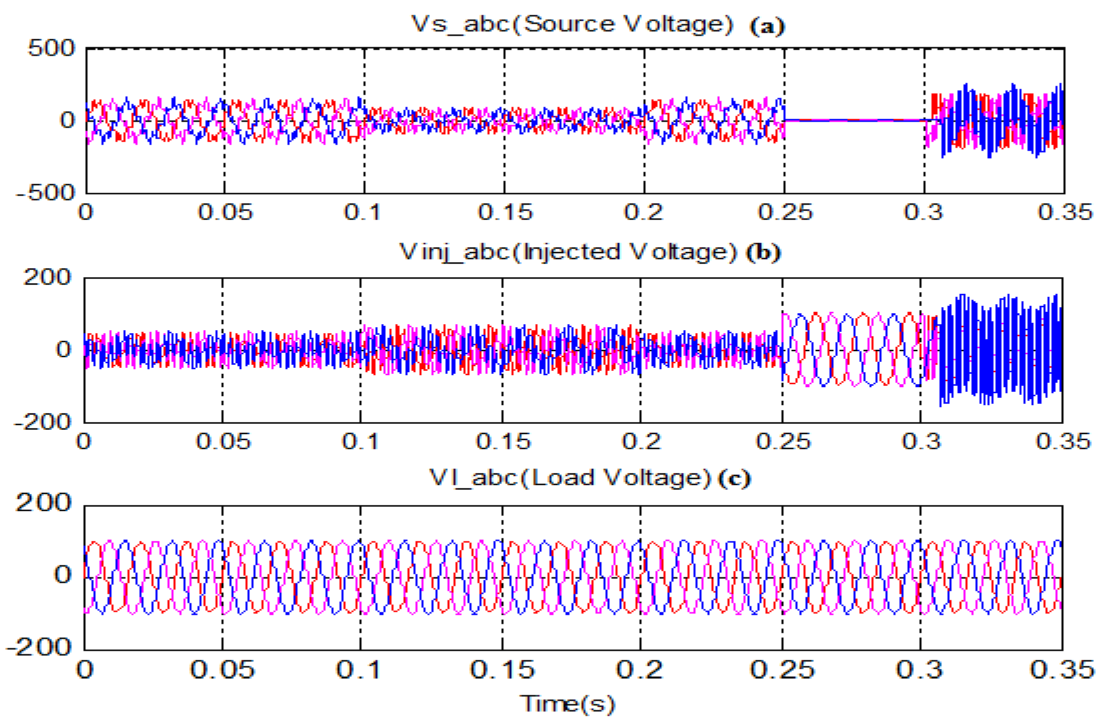


Figure 16 (a): source voltage,(b) injected voltage (c) load voltage

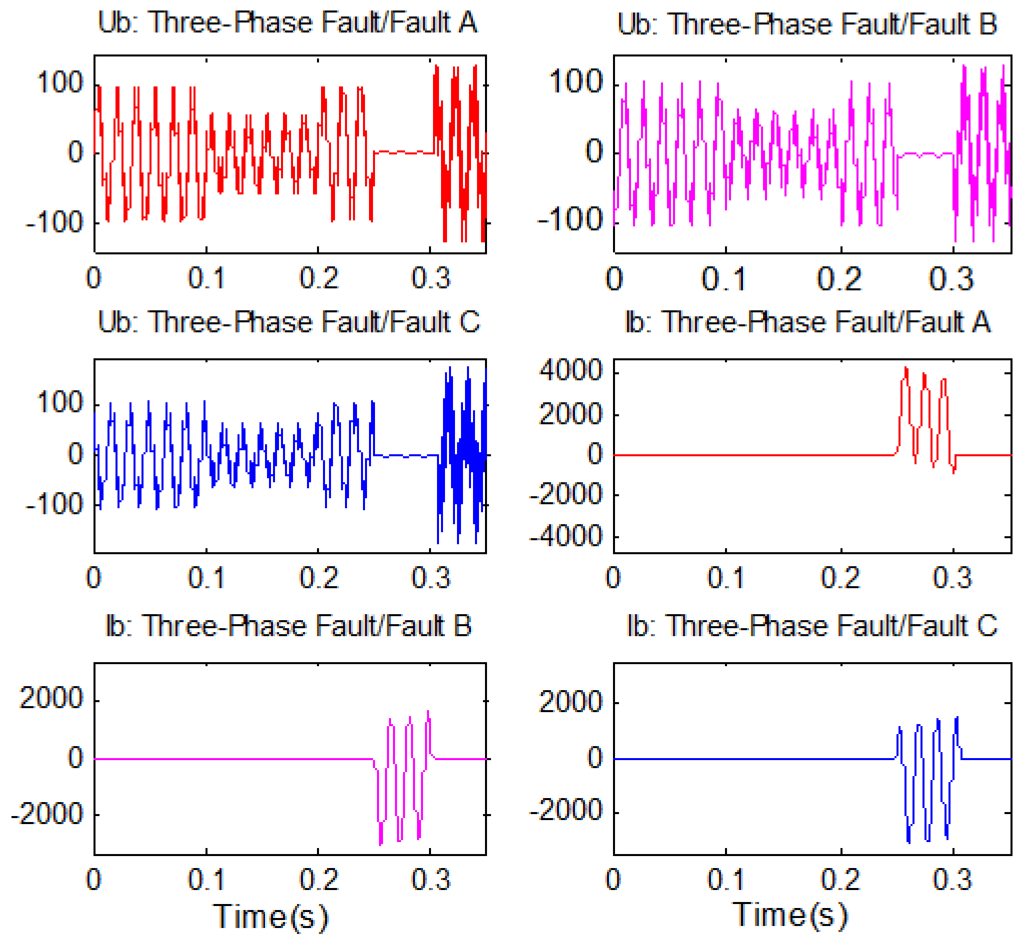


Figure 17 (a): single phase source voltage, fault current (ABC phases)

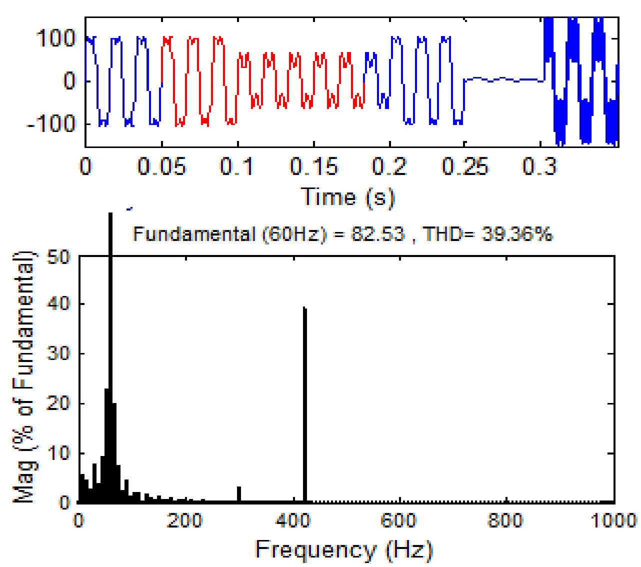


Figure 18 Frequency Spectrum source voltage

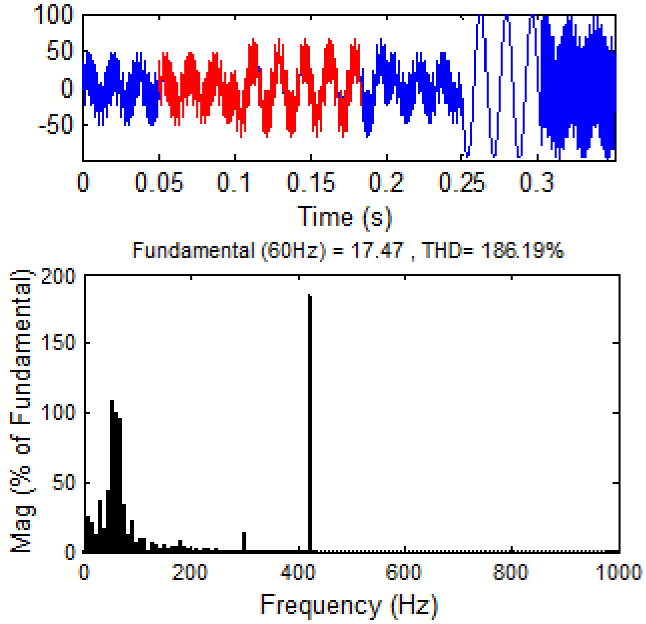


Figure 19 Frequency Spectrum injected voltage

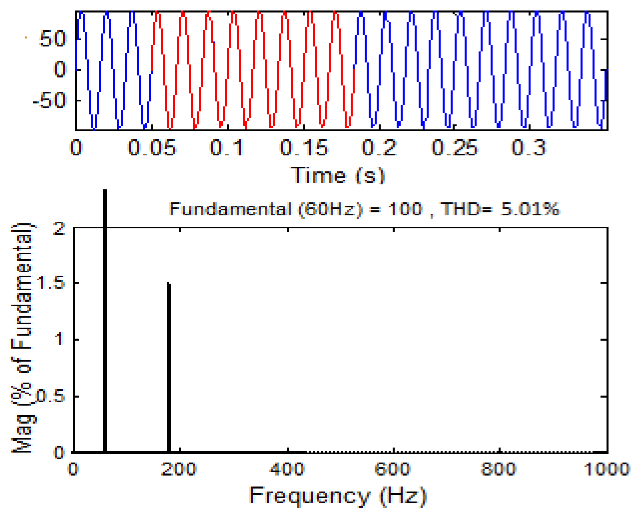


Figure 20 Frequency Spectrum load voltage

8.2 COMPARISON OF THD LEVELS FOR DIFFERENT TYPES OF LOADS

Table 2 demonstrates the contrast of THD ratios with or without SLG faults with various types of loads. The THD analysis reveals that DVR eliminates the harmonics from the load voltage successfully and makes them smooth. Table 2 THD levels

Description	THD %		
	Source voltage	Injected voltage	Load voltage
Case1	39.38	177.52	4.51
Case 2	39.36	186.19	5.01

Simulations of MATLAB/SIMULINK are done on the DVR test system. The machine output in delivery networks under SLG fault is evaluated to compensate for the load voltage.[15] The effect of DVR on the delivery system will be analyzed in three cases with separate load conditions. The following is a list of various cases :

9.CONCLUSION

DVR was modeled and simulated with an ANN controller in the MATLAB environment. DVR efficiency for varying linear charges and non-linear charges has been evaluated. DVR was observed for balance voltage during different load conditions and underbalanced system. Compared to the THD analyzes for various charging types in the SLG fault state, it is obvious that DVR very effectively decreases the harmonics of charging tension and makes it simple. It is also inferred that DVR has great space to boost delivery system power efficiency.

REFERENCES

[1] Tarek I El-Shennawy, Abdel-Mon'em Moussa, Mahmoud A El-Gammal and Amr Y Abou-Ghazala "A Dynamic Voltage Restorer for Voltage Sag Mitigation in a Refinery with Induction Motors Loads" 2010.

[2] Chellali Benchaiba,Brahim Ferdi "Voltage Quality Improvement Using DVR" Electrical Power Quality and Utilization,Journal Vol.XIV no.1,2008 available from

[3] Shairul Wizmar Wahab and Alia Mohd Yusof "Voltage Sag and mitigation Using Dynamic Voltage Restorer (DVR) System" Faculty of Electrical Engg,University Of Malaysia available from

[4] Brice J Quirl,Brain K Johnsom,Senior member IEEE " Mitigation of voltage sags with phase jump using Dynami Voltage Restorer"

[5] Paosan Boonchaiam and Nadarajah Mothulananthan "Understanding Dynamic Voltage Restorers through MATLAB simulation" Electrical Power system Management ,enerfy Field of Studey, Asian Institute of Technology, Thailand available from

[6] B H Lai,S S Choi D M Vilathgamuwa "A New Control Strategy for Energy-Saving Dynamic Voltage Restoration"School of Electrical and Electronic Engg. Nanyan Technological University Singapore 639798.

[7] Mehmet Tumay ,Ahmet Teke , K Cagatay Baymdr and M Ugras Cuma "Simuation and Modelling of a Dynamic Voltage Restorer" Departmetn of Electrical and Electronics Engg. Turkey.

[8] ELECTROTEK Concepts, Voltage Sag Studies Date : 10/03/2009

[9] C S Chang, Y.S. Ho, P.C. Lo "Voltage Quality Enhancement with Power Electronics Based Devices.

[10] Glanny M Ch Mangindaan, M Ashari Mauridhi HP "Control of Dynamic Voltage Restorer For Voltage Sag Mitigation" ICTS 2008 available from

[11] IEEE Standard 1159-1995 "IEEE Recommended Practice for Monitoring Electric Power Quality.Published 1995.

[12] Richard P. Bingham "Sags and Swells" available from

[13] Nita R. Patne, Krishna L. Thakre "Factor Affecting Characteristics Of Voltage Sag Due to Fault in the Power System" Vol. 5, No.1, May2008, 171-182, Serbian Journal Of Electrical engineering.

[14] Alexander Eigels Emanuel, John A. McNeill "Electric Power Quality". Annu. Rev. Energy Environ 1997.22:263-303.

[15] Mohd Izhwan Muhammad, Norman Mariun, Mohd Amran Mohd Radzi " Effects Of Power Quality to the Industries" 11-12 December 2007, Malaysia