International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.11 No.04, pp 107-115, 2018

Ann Controller Based Photovoltaic Source Injected DVR

C.Vimalarani[1]*, M. Muthuramalingam[2], A. Revathy Jemimah[3]

[1]Department of Electrical and Electronics Engineering K.L.N. College of Engineering Sivagangai, Tamil Nadu, India
[2]Department of Electrical and Electronics Engineering Suguna College of Engineering Coimbatore, Tamil Nadu, India
[3]Department of Electrical and Electronics Engineering Latha Mathavan Engineering College Madurai, Tamil Nadu, India

Abstract : The power quality issues are the great extent due increasing usage of non-linear loads, unexpected switching of heavy loads. One of the effective modern custom power devices to mitigate such voltage disturbance problems of sensitive loads in the area of distribution system is the Dynamic Voltage Restorer (DVR). The primary advantage of the DVR is keeping the users always on-line with high quality constant voltage maintaining the continuity of production. In this paper analyze with Photovoltaic based DVR which inject voltage with Artificial Neural Network (ANN) that protects a sensitive load from the power quality issues as voltage sag under unbalanced loading conditions such as linear and non-linear. DVR consists of Voltage Source Converter (VSC), injecting transformer and the DC link capacitor or external energy source along with other parts of the distribution system are simulated using MATLAB/ SIMULINK.

Introduction

Recently, power quality problems become a major concern due to rapid growth of industrial energy need, utilization of sensitive and non linear loads in the house holds demands installation of number of generating stations makes complex transmission system and distribution systems [1]. The power quality problems like voltage sag, swell, harmonic, unbalance and flicker can be reduced by good power quality equipments there always a demand. In order to maintain best electrical supply should have constant magnitude in voltage and frequency waveform.By injecting voltage at thecommon coupling point gives voltage support to the load. To achieve this voltage support at the load, install mechanically switched shunt capacitors in the primary terminal of the distribution transformers. In this common method, data acquisition (SCADA) system and supervisory controlsignals will schedule the mechanical switching with some timing schedule or with no switching at all.The main drawback of this system is to cannot be compensated high speed transients. Time frame of the mechanical switching is limited. Within this limit some power quality problems are not corrected. Due to cost effect tap changing transformers may not be used.

C.Vimalarani *et al* /International Journal of ChemTech Research, 2018,11(04): 107-115.

DOI : http://dx.doi.org/10.20902/IJCTR.2018.110412

DVR is powerful custom device based on power electronic components connected in series with sensitive load to inject the appropriate/desired voltage to load bus. The main parts of DVR is consists of three single-phase Voltage Source Inverters (VSI), an energy storing unit, passive harmonic filters, and injection transformers. The system can be controlled by control strategy which has three sections: an estimation unit, a compensation strategy and a switching pattern, permit the DVR to inject three-phase controllable voltages of essential amplitudes and phase angles to maintain the load bus voltage in appropriate waveform during power quality problems [2, 3]. When frequency changes occurs in the feeders DVR combined with ac/ac converter mitigate the power quality problems [4, 5]. Based on the load characteristics only the DVR mitigate the voltage sags. In the literature there are three conventional sag mitigation techniques are available. These arein-phase, pre-sag and optimized energy. Each has distinct quality to mitigate sag [6]. Unlike UPS, the DVR is specifically designed for large loads ranging from a few MVA up to 50MVA or higher [7]. Phase-Locked Loop (PLL) [8-10] is used to track the frozen angle and amplitude of the positive sequence component can be compared with its reference value to inject the voltage in the pre-sag compensating strategy. By reducing injecting voltage is observed in the optimized control strategy and transient distortions can also be reduced in the load side [11]. Battery can be eliminated by using multi-line DVR to control multiple feeders [12-14]. DVR combined with PI controller is used to mitigate power quality problems. The improper tuning of gain values leads increase in settling time of the system stability and the continuous usage of controller with fixed PI parameters leads to reduce the life time of DVR [15].

In this paper explains the DVR coupled with PV system to mitigate the sag and 3rd harmonics occurred in the distribution system. The MATLAB/SIMULINK based simulated results were presented to validate the effectiveness of the proposed real power injected along with PV for DVR.

Dynamic Voltage Restorer

The basic block diagram of DVR along with PV system is shown in Fig. 1. It consists of PV system supply DC voltage which is maintained in the DC link capacitor. The DC voltage is converted in AC by using Voltage Source Inverter (VSI). The inverter switches are basically fired by a sinusoidal Pulse Width Modulation (PWM) technique.

A specially designed injection transformer is used to feed voltage in to common coupling point of the feeders and also limits transient energy from primary side. Filter circuits are performed to get quality voltage to feed into injection transformer.

Control scheme

The controller output when compared at PWM signal generator results in the desired firing sequence. The sinusoidal voltage $V_{control}$ is phase-modulated by means of the angle δ or delta as the modulated three-phase voltages are given by

$$V_A = \sin\left(\omega t + \delta\right) \quad (1)$$

$$V_B = \sin\left(\omega t + \delta - \frac{2\pi}{3}\right) \quad (2)$$

$$V_C = \sin\left(\omega t + \delta + \frac{2\pi}{3}\right) \quad (3)$$

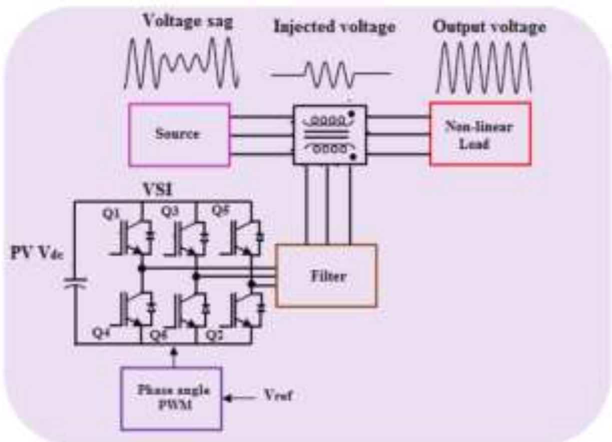

Fig. 1. Block diagram of proposed DVR system

The modulated angle is applied to the PWM generators in phase A. The angles for phases B and C are shifted by 120^o and 240^o. In this work ANN controller is taken as control technique and only voltage magnitude is taken as a feedback parameter in the control technique.

Artificial Neural Network (ANN) Controller

In this work, a trained ANN is used to find the output injected voltage for the nonlinear system. The ANN is used to estimate the optimal injected voltage in real time, which corresponds to maximum powerat any given input distortion voltage. The data set used to train the ANN is obtained from conventional control results. Fig. 2 ANN based DVR system of inverter control system. In this work, data set consists of 1250 patterns of system input and out voltage, which has divided into two sub-databases, 70%, of the samples are used to train the ANN, and the rest 30% are second-hand to test and validate the network. The performance is measured by calculating the mean- square error in Eq. (4).

$$e = \frac{1}{p}\sum_{i=1}^{p}\left\| y^{(i)} - v^{(i)} \right\|^2 \qquad (4)$$

Where, p= number of training data entries; y = ANN output vector; v = desired output. For a set of input parameters, a well-trained ANN would give as an output, the reference voltage that is very close to the desired value, giving an error almost zero.

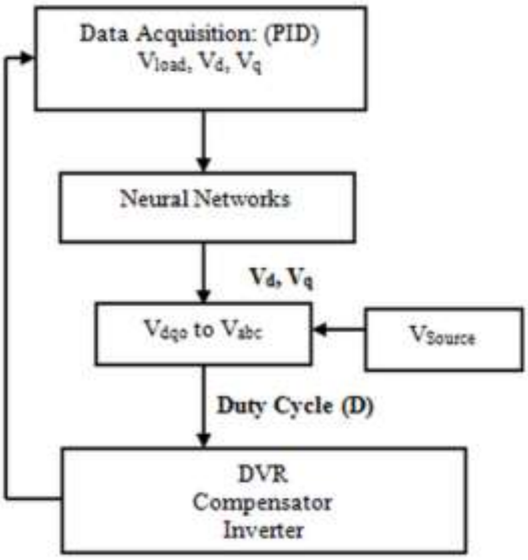

Fig. 2. ANN based DVR system

The control system of the general configuration typically consists of a voltage correction method which determines the reference voltage that should be injected by DVR and the VSI control which is in this work consists of PWM with ANN controller.

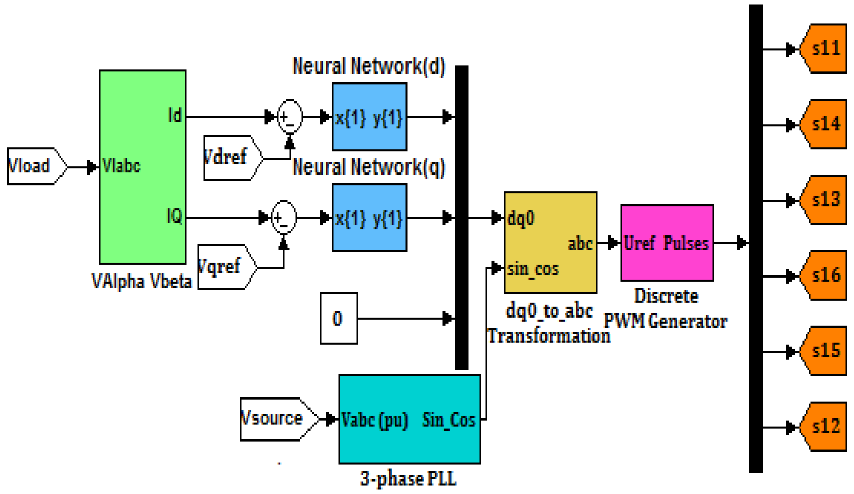

Fig.3. ANN controller

The controller input is an error signal obtained from the reference voltage and the value of the injected voltage. DVR Control strategies fall mainly in one of the two categories namely linear control methods and Non-linear control methods. The control of the proposed DVR is based on ANN controller shown in Fig. 3. The PWM signal generator controls the DVR inverter to generate the required injected voltage.

C. Parameters of DVR test system

System parameters are listed in Table 1. Load voltage is sensed and passes through a sequence analyzer. The magnitude is compared with V_{ref}. System comprises of 11 kV, 50 Hz generator, feeding transmission lines through a three-phase, three-winding transformer connected in Δ/Y/Y, 11000/400/400V. In this test system, two similar loads with different feeders are considered. One of the feeders is connected to DVR and the other is kept as it is.

This test system is analyzed under SLG fault condition. The proposed system configuration of DVR is composed by a 100V, 60 Hz generation system, feeding two transmission lines through a 3- winding inductive filer connected.

The MTG system output is the three phase voltage further rectified and it is given to the DC link of DVR. To verify the working of DVR for voltage compensation, both linear & nonlinear loads are connected at the distribution end.

The DVR is simulated to be in operation only for the heavy load condition. Thus, DVR will be inserted in series with the load to help improving the supply voltage before to be fed by load.

Table I. Parameters of DVR

S.No	Parameters	Values
1	Source Voltage	100V
2	No. of bridge arms	3
3	Transition time	0.25 to 0.3 sec
4	Snubber resistance	0.1 mΩ
5	Breaker resistance	0.0001Ω
6	Line frequency	60Hz

Simulation Models and Results

In this SIMULINK model, systems with two parallel feeders are considered. In both the feeders further similar loads are connected. ANN controller simulation detailed control system shown in Fig. 4. In one feeder DVR is connected in series with line and the other feeders is kept as it is. The simulations are performed on the

DVR test system using MATLAB/SIMULINK. The system performance is analyzed to compensate the load voltage in distribution networks under SLG fault condition. Third order harmonic load conditions are considered to study the impact of DVR in distribution system.

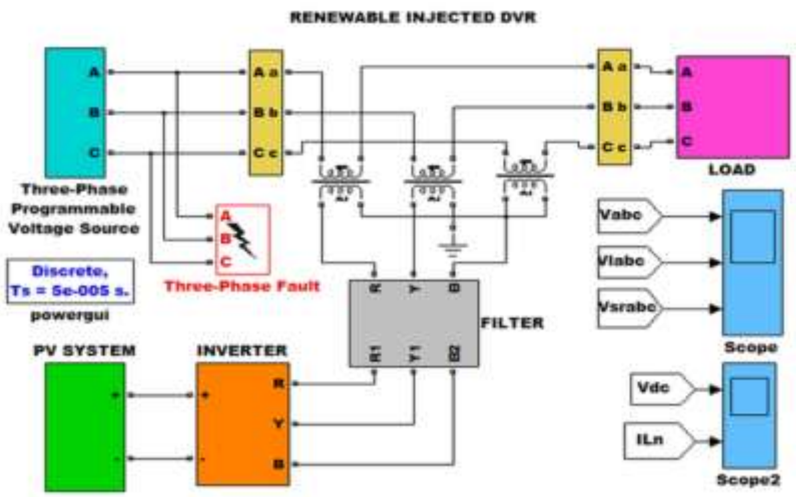

Fig. 4. Simulation Model of DVR Test System

Simulink model of the test system with Non-linear load

Third order harmonics, sag and 3ph fault with non-linear load

Here the fault resistance is 0.001 ohm and the ground resistance is 0.001 ohm. Voltage sag from 0.1s to 0.2s.The fault is created for the duration of 0.254s to 0.3s.

The PV out voltage and inverter load current shown in Fig. 5.The output waves for the load voltage without and with compensation are shown in Fig.6. (a)–(c), single phase voltage and current simulation output of harmonic ,sag and fault shown in Fig. 7. The ANN Controlled PV injected real power frequency spectrum of source voltage. Injected voltage and load voltage with compensation is shown in Fig. 8-10.

Here it is clear from the output wave shapes that the voltage in the phase where fault is created is increasing during the fault duration in the uncompensated feeder. When DVR is connected in the system the unbalancing is reduced.

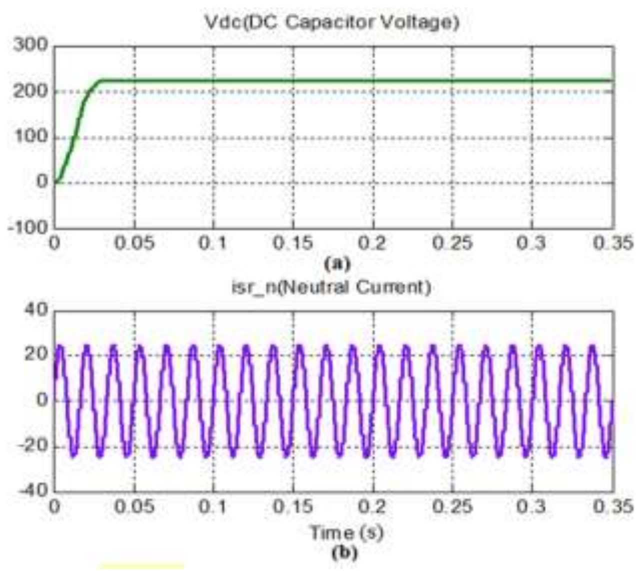

Fig. 5. (a) PV voltage (V), (b) load current (A)

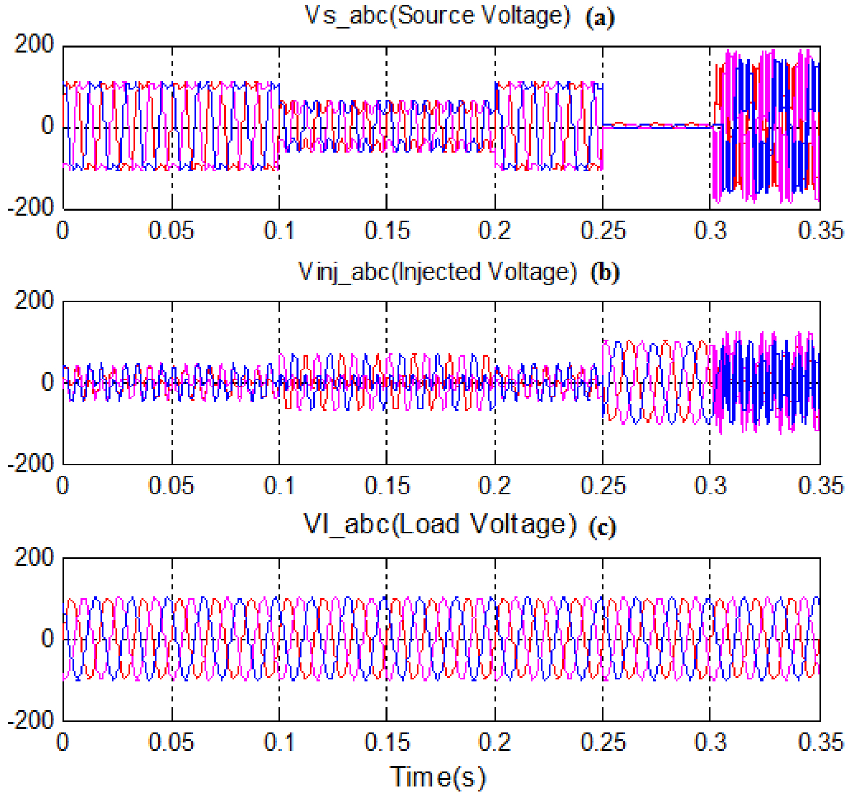

Fig. 6. (a): source voltage, (b) injected voltage (c) load voltage

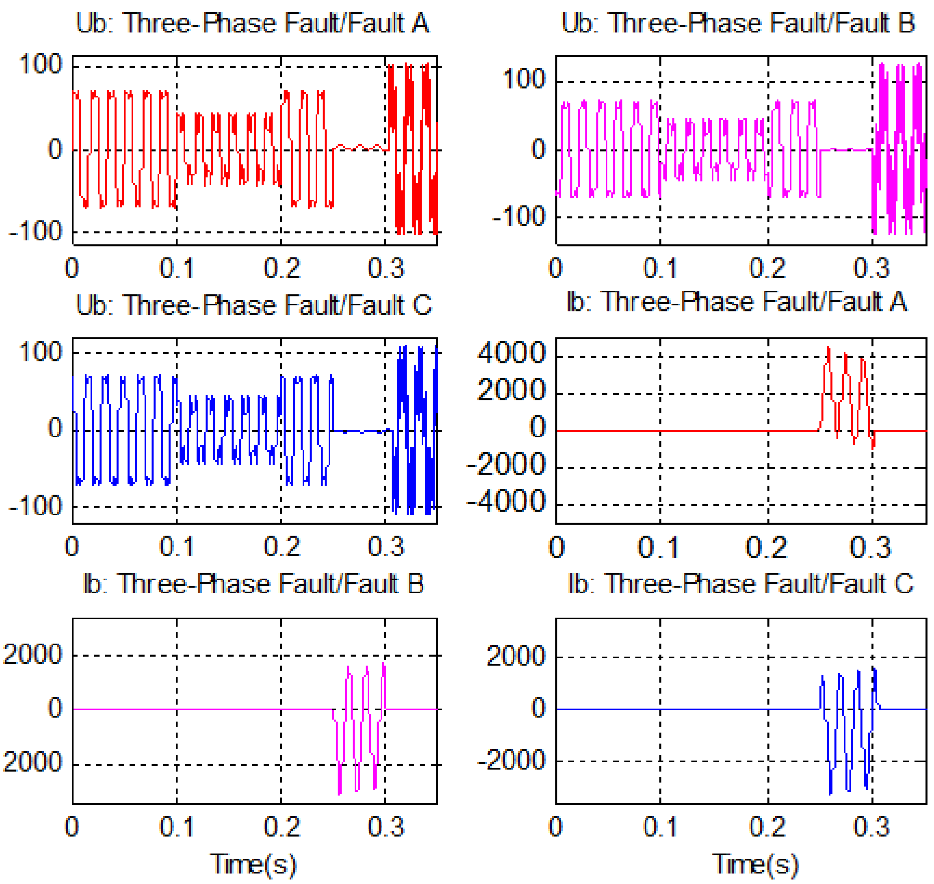

Fig. 7. Single phase source voltage, fault current (ABC phases)

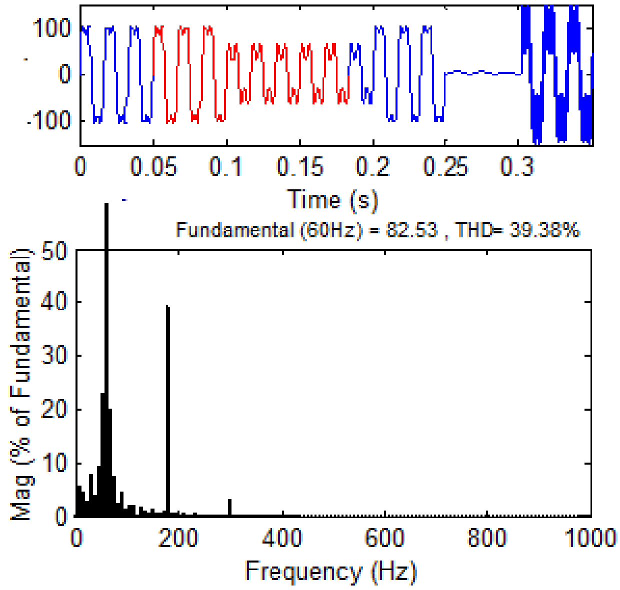

Fig. 8. Frequency Spectrum source voltage

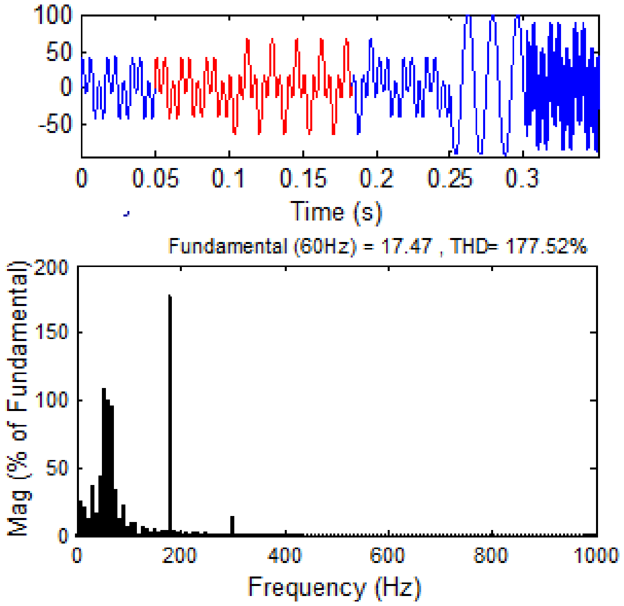

Fig. 9. Frequency Spectrum injected voltage

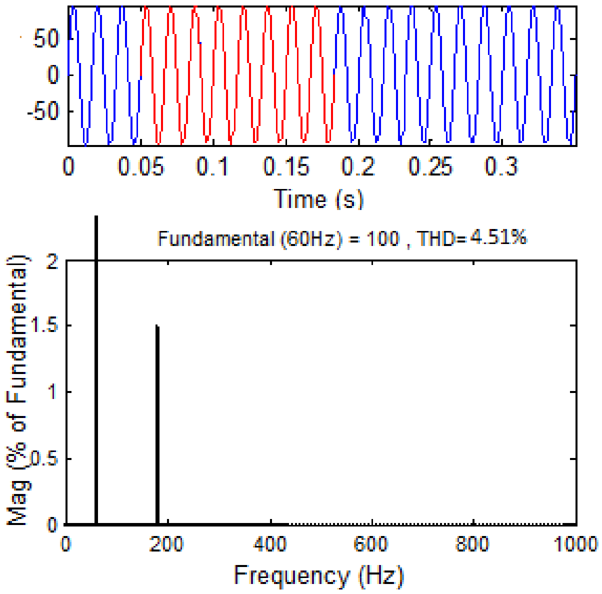

Fig. 10. Frequency Spectrum load voltage

Conclusion

In this paper, DVR has been modeled and simulated in MATLAB environment with ANN controller. The performance of DVR has been analyzed for varying linear loads, non-linear loads. DVR has been found to regulate voltage under varying load condition and load unbalancing. It is clear from comparison of THD analysis for different types of loads under SLG fault condition that DVR reduces harmonics from load voltage very effectively and makes it smooth. Hence, it is concluded that DVR has a huge scope in improving power quality in distribution systems.

References

1. Benachaiba .C and B. Ferdi, 2009. Power quality improvement using dynamic voltage restorer. J. Applied Sci., 6:396-400.
2. Chellali Benchaiba,Brahim Ferdi. Voltage Quality Improvement Using DVR. Electrical Power Quality and Utilization,Journal. 2008.XIV:1.
3. Boonchiam P. and Mithulananthan N. Understanding of Dynamic Voltage Restorers through MATLAB Simulation. Thammasat Int. J. Sc. Technology. July-Sept 2006.11: 3.
4. Pirjo Heine, Matti Lehtonen. Voltage Sag Distributions Caused by Power System Faults. IEEE Transactions on Power Systems.November 2003.18:4
5. Shairul Wizmar Wahab and Alia Mohd Yusof. Voltage Sag and mitigation Using Dynamic Voltage Restorer (DVR) System. Faculty of Electrical Engg. University Of Malaysia.
6. Brice J Quirl,Brain K Johnsom,Senior member IEEE. Mitigation of voltage sags with phase jump using Dynamic Voltage Restorer. IEEE conference on Power Symposium. 2007.
7. Paosan Boonchaiam and Nadarajah Mothulananthan. Understanding Dynamic Voltage Restorers through MATLAB simulation. Electrical Power system Management,energy Field of Study, Asian Institute of Technology, Thailand.
8. 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.
9. 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.
10. Mahmoud A. El-Gammal, Amr Y. Abou-Ghazala & Tarek I. El- Shennawy. Dynamic Voltage Restorer (DVR) for Voltage Sag Mitigation. International Journal on Electrical Engineering and Informatics. 2011. 3 (1)

11. C S Chang, Y.S. Ho, P.C. Lo. Voltage Quality Enhancement with Power Electronics Based Devices, IEEEPower Engineering Society Winter Meeting. 2000.4:2937 – 2942.
12. Glanny M Ch Mangindaan, M Ashari Mauridhi HP. Control of Dynamic Voltage Restorer For Voltage Sag Mitigation ICTS 2008.
13. T.Devaraju & V.C.Veera Reddy. Performance of DVR under different voltage sag and swell condition. ARPN Journal of Engineering and Applied Sciences, 2010. 5:10.
14. Nita R. Patne, Krishna L. Thakre. Factor Affecting Characteristics Of Voltage Sag Due to Fault in the Power System. Serbian Journal Of Electrical engineering, Vol. 5, No.1, 2008, pp. 171-182,
15. Alexander Eigels Emanuel, John A. McNeill. Electric Power Quality. Annu. Rev. Energy Environ 1997.22:263-303.

*****