Mitigation of Voltage Sag

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Abstract- *Power quality is major concern in the Electrical field. It has become important with the introduction of sophisticated devices, whose performance is very sensitive to the quality of power supply. It is an occurrence manifested as a nonstandard voltage, current or frequency that results in a failure of equipment. Major problems deal is the voltage sag. Custom power devices are used for solving the problem. Dynamic Voltage Restorer (DVR) which is the most efficient and effective power device used in power system. Research paper presents modelling, analysis and simulation of a DVR using MATLAB software. In this model a PI controller and Discrete PWM pulse generator are used.*

Keywords- voltage sag, dynamic voltage restorer, PWM technique

I. INTRODUCTION

The electronic devices are very sensitive to disturbances and become less tolerant towards short duration variation and waveform distortion. Voltage sag is considered most severe disturbances to the equipment [1, 6].

Voltage support at a load can be achieved by reactive power injection at the load PCC [3]. Method for this is to install mechanically switched shunt capacitors in the primary terminal of the distribution transformer. To presents benefit of DVR, DVRs are power devices for providing reliable distribution power quality problem. They employ a series of voltage boost technology using solid state switches for compensating voltage sags. The DVR applications are mainly for sensitive loads that may be drastically affected by fluctuations in system voltage [8, 9].

II.VOLTAGE SOURCE CONVERTERS (VSC)

VSC is a powerful electronic device, which can generate a sinusoidal voltage with any required magnitude, frequency and phase angle. VSC are used in adjustable speed drives. Also it can be used to mitigate voltage dips. The VSC is used to either completely replace the voltage.

III. SERIES VOLTAGE CONTROLLER (SVC)

SVC is connected in series with the protected load. Usually the connection is made via a transformer, but configurations with direct connection via power electronics also exist. The resulting voltage at the load bus bar equals the sum of the grid voltage and the injected voltage. It generates the required reactive power & the active power is taken from the energy storage. DVR has limitations on the depth and duration of the voltage sag that it can compensate.

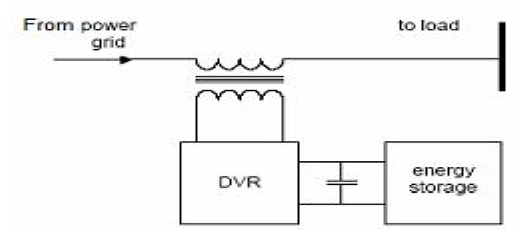

Fig.1. Dynamic Voltage Restorer

The system impedance depends on fault level of the load bus. When the system voltage drops, the DVR injects a series voltage V_{DVR} through the injection transformer so that the desired load voltage magnitude VL can be maintained. The series injected voltage of the DVR can be written as,

$$V_{DVR} = V_L + Z_{TH}. I_L - V_{TH}$$

Where

VL is the desired load voltage magnitude

Z_{Th} is the load impedance

IL is the load current

Vth is the system voltage during fault conditions

It may be mentioned here that when the injected voltage V_{DVR} is kept in quadrature with IL, no active power injection by the DVR is required to correct the voltage. It requires the injection of only reactive power and the DVR itself is capable of generating the reactive power. Note that DVR can be kept in quadrature with IL only up to a certain value of voltage sag and beyond which the quadrature relationship cannot be maintained to correct the voltage sag. For such a case, injection of active power into the system is essential. The injected active power must be provided by the energy storage system of the DVR.

A. Controller

There is active and reactive power exchange with the network simultaneously. Error signal is obtained by comparing the reference voltage with the rms voltage measured at the load point. The PI controller process the error signal generates the required angle to drive the error to zero, i.e., the load rms voltage is brought back to the reference voltage.

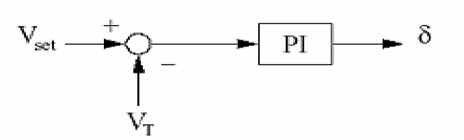

Fig. 2. PI controller

The sinusoidal signal Control is phase-modulated by means of the angle δ.

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

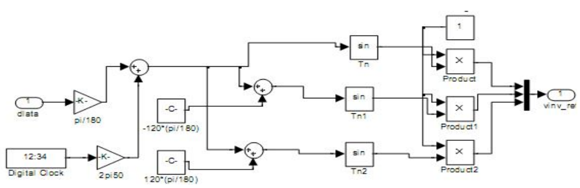

Fig.3. Phase modulation of angle δ

The modulated signal $V_{control}$ is compared against a triangular signal in order to generate the switching signals for the VSC valves. The main parameters of the sinusoidal PWM scheme are the amplitude modulation index of signal, and the frequency modulation index of the triangular signal.

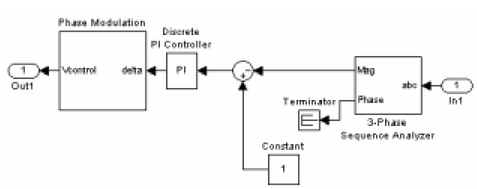

Fig. 4. Model of controller

It can be seen in that the control implementation is kept very simple by using only voltage measurements as the feedback variable in the control scheme. The speed of response and robustness of the control scheme is indicated in the results.

B. DVR TEST SYSTEM

SLD of the test system is shown in Fig.5 and the test system employed to carry out the simulations for DVR. Such system is composed by a 13 kV, & frequency 50 Hz generation system, feeding two transmission lines through a 3-winding transformer connected in Y/Δ/Δ, 13/115/115 kV. Such transmission lines feed two distribution networks through two transformers connected in Δ/Y, 115/11 kV.

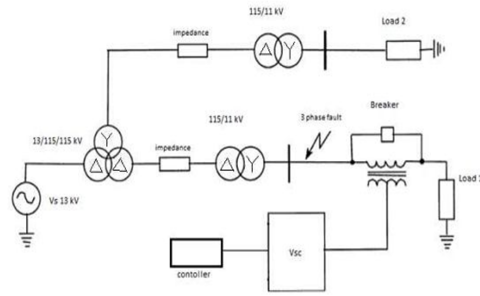

Fig.5.SLD of DVR test system

To verify the working of a DVR employed to avoid voltage sags during short circuit, a fault is applied at point X via a resistance of 0.66 Ω. Such fault is applied for 0.2sec. Using the facilities available in MATLAB, the DVR is simulated to be in operation only for the duration of the fault, as it is expected to be the case in a practical situation.

C. Result Of DVR

Case 1: Single line to ground fault

The first simulation contains no DVR and single line to ground fault is applied to a system with fault resistance of 0.66 Ω, during the period 0.4 to 0.6 s. The second simulation is carried out using the same scenario as above, but now with the DVR in operation.

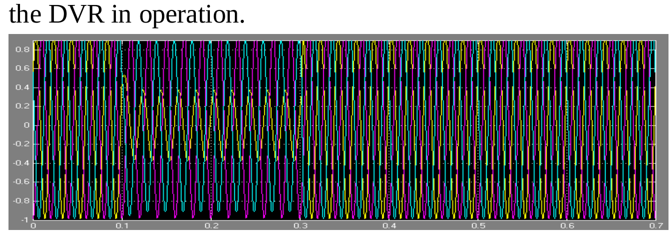

Fig.6. voltage at load point without DVR

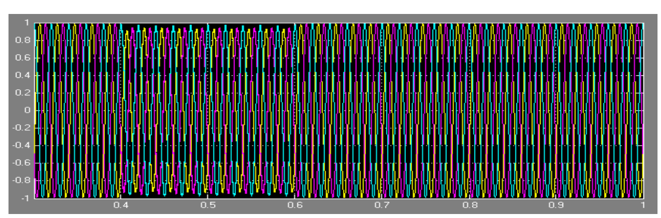

Fig.7. voltage at load point with DVR

Case 2: Double line to ground fault

The first simulation contains no DVR and double line to ground fault is applied to a system with fault resistance of 0.66 Ω, during the period 0.4 to 0.6 s. The second simulation is carried out using the same scenario as above but now with the DVR in operation.

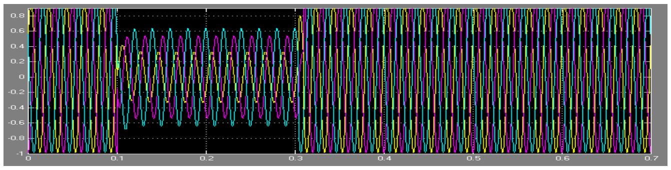

Fig.8. Voltage at load point without DVR

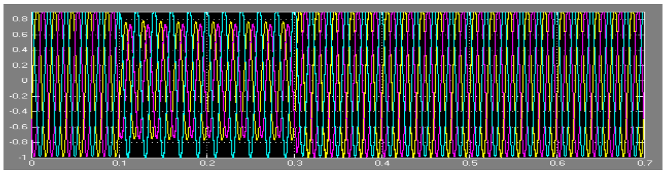

Fig.9. Voltage at load point with DVR

Case 3: Three phases to ground fault

The first simulation contains no DVR and three phases to ground fault is applied to a system with fault resistance of 0.66 Ω, during the period 0.4 to 0.6 s. The second simulation is carried out using the same scenario as above, but now with the DVR in operation.

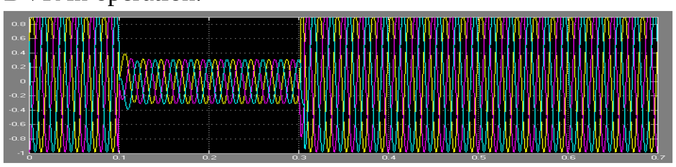

Fig.10. Voltage at load point without DVR

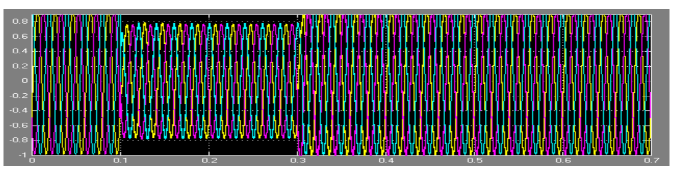

Fig.11. Voltage at load point with DVR

Case 4: Two phase's line to line fault

The first simulation contains no DVR and three phases line to line fault is applied to a system with fault resistance of 0.66 Ω, during the period 0.4 to 0.6 s. The second simulation is carried out using the same scenario as above but now with the DVR in operation

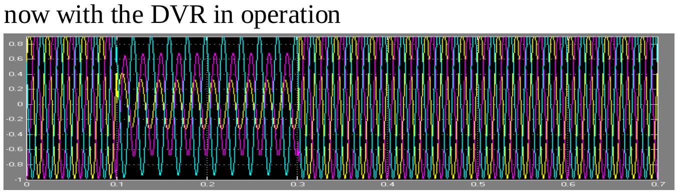

Fig.12. Voltage at load point without DVR

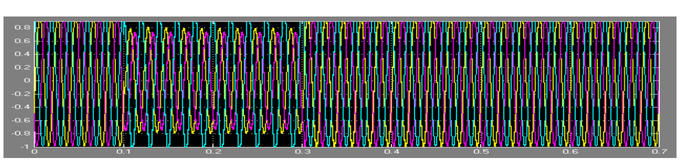

Fig.13. Voltage at load point with DVR

Case 5: Three phases line to line fault

The first simulation contains no DVR and three phases line to line fault is applied to a system with fault resistance of 0.66 Ω, during the period 0.4 to 0.6 s. The second simulation is carried out using the same scenario as above but now with the DVR in operation.

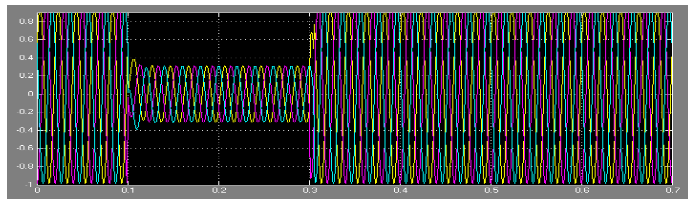

Fig.14. Voltage at load point without DVR

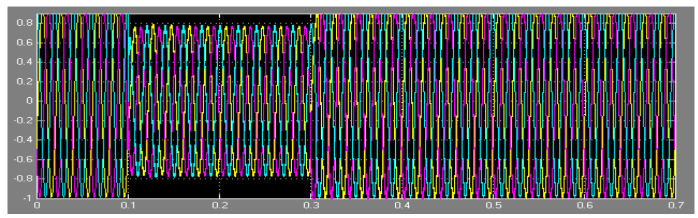

Fig.15. Voltage at load point without DVR

IV. CONCLUSION

This paper has presented the power quality problems such as voltage sag. Compensation techniques of DVR are presented. The design and applications of DVR for voltage sags with PWM based control scheme is presented, which opposed to fundamental frequency switching schemes. This characteristic makes it ideally suitable for low voltage custom power applications.

REFERENCES

[1] S. S. Choi, B. H. Li, and D. D.Vilathgamuwa, "Dynamic voltage restoration with minimum energy injection," IEEE Trans. Power Syst., vol. 15,pp. 51–57, Feb. 2000

[2] M.H.Haque,"Compensation of distribution system voltage sag by DVR And DSTATCOM" Power Tech Proceedings, 2001 IEEE Portro,Volume 1,10-13 sept.2001,Pages 5

[3] John G. Nielsen, Frede Blaabjerg, "comparision of system topologies for DVR, 0-7803-7114-3/01/$10.00 (C) 2001

[4] O. Viktorin 1, J.Driesen2, R.Belmans, "The Prototype of a Single-phase Dynamic Voltage Restorer' © Electrical Power and Energy Systems 25 (2003), pp.525–531.(4)

[5] O. Viktorin, J. Driesen, ,R. Belmans, "Comparison of dynamic restorer topologies'0-7803-7967-5/03/@2003 IEEE(5)

[6] S.V Ravi Kumar and S. Siva Nagaraju, "Simulation Of D-STATCOM And DVR In Power System' ARPN Journal of Engineering and Applied Sciences Vol. 2, No. 3, June 2007, (6)

[7] Mohamed fuad faisal, "Power Quality Guidebook, Tenaga National Berhad, 28 march, 2007.(7)

[8] Mahmoud A. El-Gammal, Amr Y. Abou-Ghazala, and Tarek I. El-Shennawy, "Dynamic Voltage Restorer (DVR)forVoltageSagMitigationInternational Journal on E lectrical Engineering and Informatics - Volume 3, Numbe r 1, 2011(8)

[9] D. Murali, Dr. M. Rajaram , "Simulation and Implementation of DVR for Voltage Sag Compensation , International Journal of Computer Applications (0975 – 8887), Volume 23– No.5, June 2011 (9)