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Mitigation of Voltage Fluctuation in Power Distribution System Using D-STATCOM

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ABSTRACT

Electrical Power Quality is becoming intensity concerned from both electric utilities and customers. Voltage Fluctuations is a major power quality problem as it has a significant impact on both the equipment and production environment. This work describes the voltage control technique of mitigation of voltage fluctuations and clearing fault using Distribution Static Synchronous Compensator (DSTATCOM). The test system used is IEEE 9-bus distribution system clarified optimal location of DSTATCOM by using Artificial Neural Network (ANN). A simulation was done using MATLAB/Simulink software to obtain the results.

Keywords: Power Quality, Voltage Fluctuation, DSTATCOM, Power distribution system, ANN

1. Introduction

The power quality has become one of the most focus of attention in the power industry since the late 1980s [1]. Voltage fluctuation is the main power quality regard for both power utility and customers. Voltage Fluctuations are defined as a series of random voltage changes, the magnitude of which does not normally exceed the voltage ranges specified by ANSI C84.1 of [0.9 to 1.1] per unit with frequencies less than 25 Hz and its typical duration is intermittent [2]. In this paper D-STATCOM to mitigate voltage fluctuation and clear fault in IEEE-9 bus power distribution system. The DSTATCOM is a fast response power quality device, which installed in distribution system for reactive power compensation and mitigation of voltage fluctuation and many of other power quality troubles [3]. D-STATCOM is connected in shunt with the main distribution line for compensation of voltage fluctuations [4]. The operation of the D-STATCOM is as follows. The Voltage Source Converter (VSC) voltage is compared with the AC bus voltage system, When the AC bus voltage magnitude is above that of the VSC magnitude voltage; the AC system sees the D-STATCOM as inductance connected to its terminals and it absorbs the increasing of nominal voltage. Also, if the VSC voltage magnitude is above that of the AC bus voltage magnitude, the AC system sees the D-STATCOM as capacitance to its terminals and injecting require voltage. If the voltage magnitudes are equal, the reactive power exchange is zero [5]. In this paper the test and simulation of DSTATCOM are using MATLAB/SIMULINK software in order to regulate and mitigate voltage fluctuations on IEEE 9-bus certified system. Feed forward Artificial Neural Network (ANN) based approach has been used to find optimal location of DSTATCOM [6]. Then we test the system with and without DSTATCOM at many cases such as fluctuated source, fluctuated load, fault occurrence and all of this case together in order to mitigate voltage and display a high response of DSTATCOM for mitigation voltage fluctuations and clearing faults.

2. Methodology and Model Description

DSTATCOM is used to regulate voltage on a 22-KV IEEE 9-bus distribution network. The structure of DSTATCOM and its equivalent circuit shown in figure1. The D-STATCOM regulates voltage by absorbing or injecting reactive power. This reactive power transfer through the leakage reactance of the coupling transformer. The D-STATCOM consists of the following components as shown in figure 1:

- A 22 kV/1.25kV coupling transformer which ensures coupling between the PWM inverter and the network.
- A voltage-sourced PWM converter consisting of two IGBT bridges. This twin inverter configuration produces fewer harmonic than a single bridge.
- LC damped filters connected at the inverter output. Resistances connected in series with capacitors.
- A 10000-microfarad capacitor represents a DC voltage source for the converter.
- A PWM pulse generator.
- Anti-aliasing filters used for voltage and current acquisition.
- DSTATCOM control system.

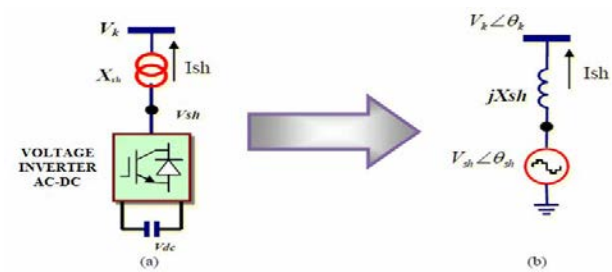


Figure 1: Structure of DSTATCOM, (b) Equivalent circuit

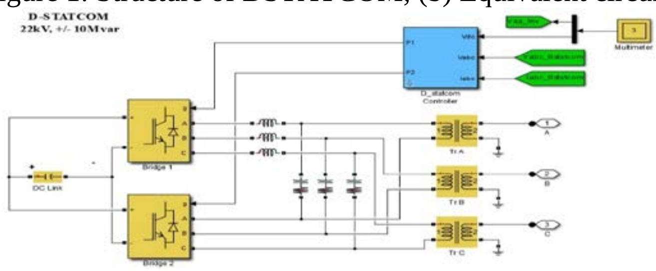


Figure 2: Simulink model of DSTATCOM components.

In our work, we used modified IEEE 9-bus in order to agree with Native Power Distribution System. So, it comprises a 22 KV, 50 HZ and 6 lines with three loads at buses (8, 6, and 5) as shown in figure 2. The parameter values of IEEE 9-bus system as shown in Table 1. Then we test the system with and without DSTATCOM at many cases such as fluctuated source, fluctuated load, fault occurrence and all of this case together in order to mitigate voltage and display a high response of DSTATCOM for mitigation voltage fluctuations and clearing faults.

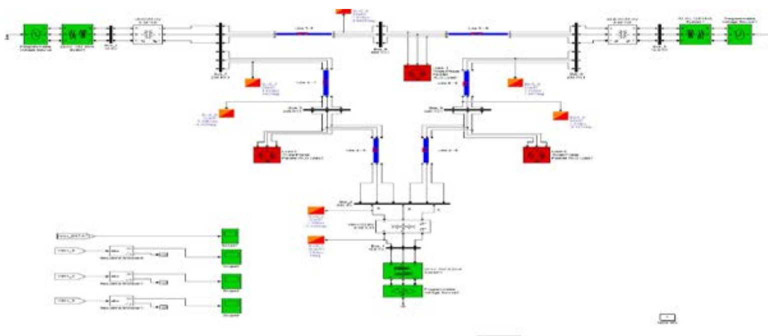


Figure 3: IEEE 9-bus Distribution System.

Table 1. The parameter values of IEEE 9-bus system.

Parameters	Values
Source voltage	22KV/ 50Hz
Source Values	Source (1):13.8KV, 128MVA with13.8/22 KV Trans. Source (2):18KV, 192MVA with18/22 KV Trans. Source (3):16.5KV,247MVA with 16.5/22 KV Trans.
Load Values	Load (1): 30MW, 3.5MVAR. Load (2): 32MW, 3MVAR. Load(3): 35MW, 5MVAR
Coupling Trans. of DSTATCOM	22 kV/1.25kV
DSTATCOM value	+/- 10MVAR
Reference Voltage of DSTATCOM	1Pu
Simulation time	One second

3. Optimal Placement of DSTATCOM in IEEE 9-bus

In this part, feed forward Artificial Neural Network (ANN) with back propagation algorithm has been used to find optimal location for DSTATCOM placement [7, 8]. The architecture of this network (Artificial Neural Network) has been shown in figure 4. The Mean Square Error (mean of squared deviation of post-fault bus voltages from target value) is calculated for different load buses by ANN. The bus having highest Mean Square Error (M.S.E.) is considered as the optimal placement of DSTATCOM. The aim is getting Mean Square error (deviation of post-fault bus voltages from pre-faults voltages) resulting from different type of short circuits (Faults) at all load buses (bus 8, 6, 5) in IEEE 9-bus. This model is used to find the three phase voltages in per unit (p.u). The voltage database in per unit was prepared by creating single line to ground (L-G), line to line (L-L) and three phase (L-L-L or L-L-L-G) faults at different load buses during the period 0.1 seconds to 0.2 seconds.

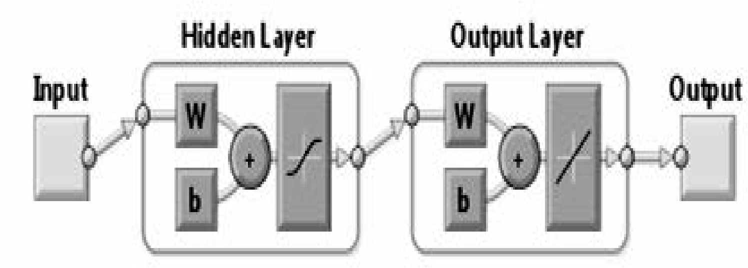


Figure 4: Artificial Neural Network architecture

Target bus voltages are pre-faults voltages before any faults. Input data is Post-fault voltages (before making any type of faults). Post-fault voltages have been used to train a feed forward Artificial Neural Network with back-propagation algorithm. The training process is done with large number of inputs and output target data Now, MSE (Mean Square Error) were calculated at each load buses using target data (pre-faults voltages) and input data (Post-fault voltages) by ANN as shown in table 2.

Table 2. Training performance of ANN at different buses

Bus No.	M.S.E.
Load bus (8)	0.048292
Load bus (6)	0.045625
Load bus (5)	0.042972

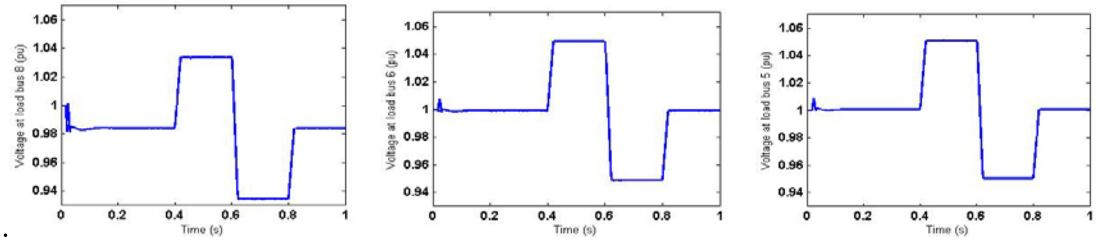
It is observed from table II that bus-8 has the highest value of Mean Square Error. Consequently, bus-8 was considered as the optimal location for the placement of DSTATCOM.

4. Result and Discussion

In this term we test and simulate DSTATCOM using MATLAB/SIMULINK software in order to mitigate voltage fluctuations on 22-kV IEEE 9-bus distribution system as shown in figure 3. The simulation time is one second. In this simulation we test the system with and without DSTATCOM at many cases such as fluctuated source, fluctuated load, fault occurrence and all of this case together in IEEE 9-bus system. DSTATCOM used in this simulation +/- 10 MVAR.

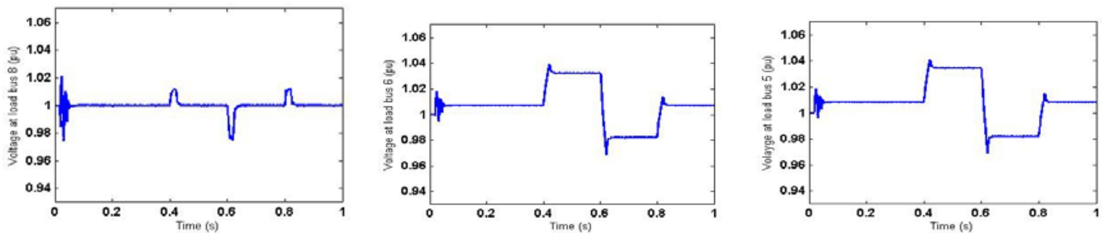
A. Test System at Fluctuated Source Only

In this case, the system without and with installing DSTATCOM is displayed when voltage fluctuation comes from all supply sources and display the effect of inserting DSTATCOM on voltage quality of the distribution system as shown in figure 6.



[1] Load bus 8 [2] Load bus 6 [3] Load bus 5

Figure 5. Terminal Voltage at load buses without DSTATCOM

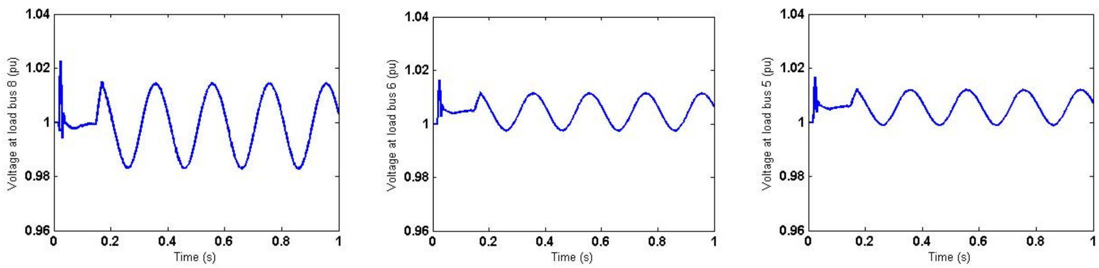


[1] Load bus 8 [2] Load bus 6 [3] Load bus 5

Figure 6: Terminal Voltage at load buses with DSTATCOM

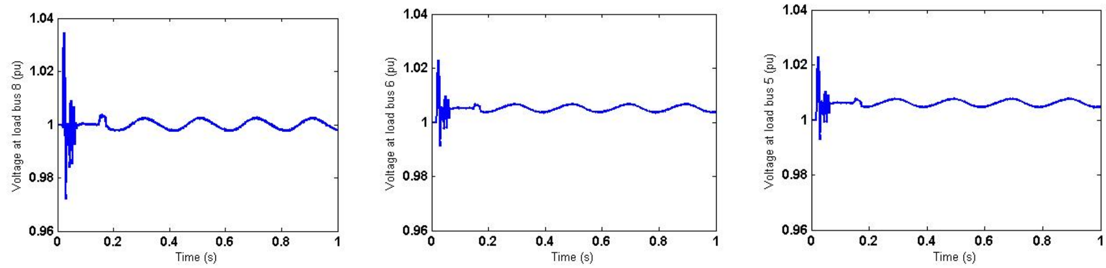
B. Test System at Fluctuated Load Only

In this case, the system without and with installing DSTATCOM is displayed when voltage fluctuation comes from customer load only. And show the effect of inserting DSTATCOM to mitigate voltage fluctuations resulting from fluctuated load bus (8) as shown in figure 8.



[1] Load bus 8 [2] Load bus 6 [3] Load bus 5

Figure 7: Terminal Voltage at load buses without DSTATCOM

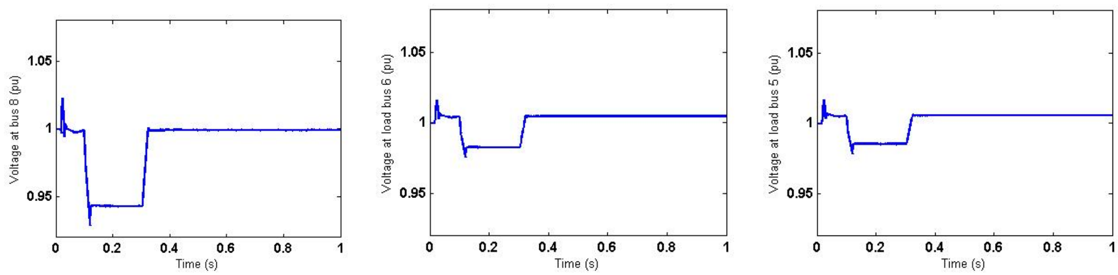


[1] Load bus [2] Load bus 6 [3] Load bus 5

Figure 8: Terminal Voltage at load buses with DSTATCOM

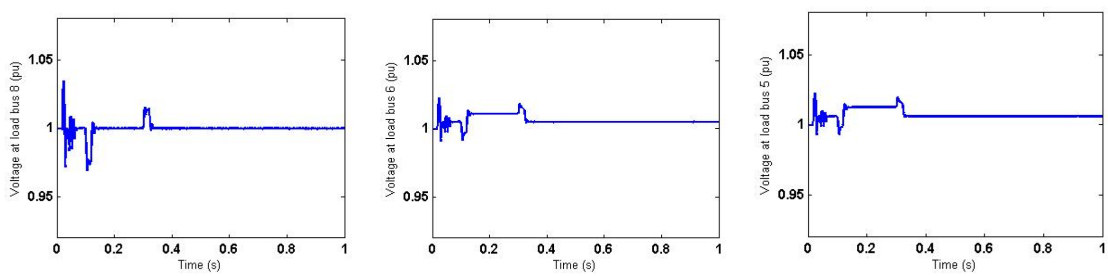
C. Clearing Three Phase Fault to Ground

In this case, the system without and with installing DSTATCOM is displayed where a three phase fault to ground applied at load bus (8). And display the effects of inserting DSTATCOM on a three phase fault mitigation of the IEEE 9-Bus distribution system as shown in figure 10.



[1] Load bus 8 [2] Load bus 6 [3] Load bus 5

Figure 9: Terminal Voltage at load buses without DSTATCOM

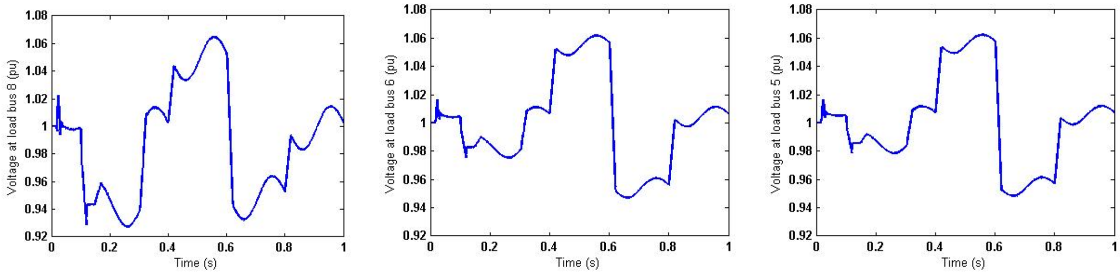


[1] Load bus 8 [2] Load bus 6 [3] Load bus 5

Figure 10. Terminal Voltage at load buses with DSTATCOM

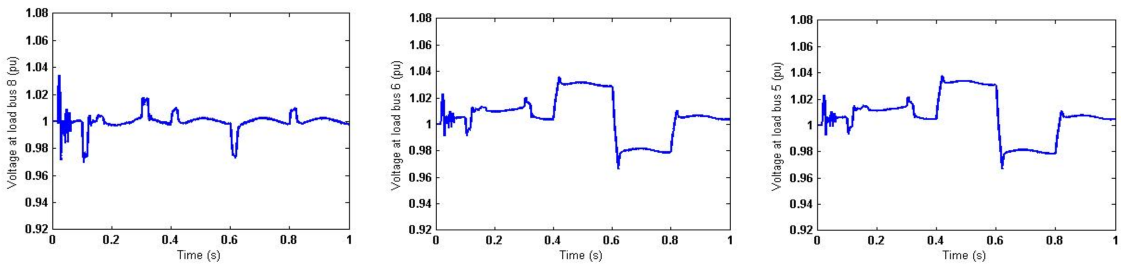
C. Test Simulation System at Fluctuated Source and Fluctuated Load applying Three Phase Fault to Ground Together

In this case, the system without and with installing DSTATCOM is displayed during the occurrence of all cases mentioned above together as. Displaying the effect of installing DSTATCOM on voltage fluctuation mitigation of the distribution system as shown in figure 12.



[1] Load bus 8 [2] Load bus 6 [3] Load bus 5

Figure 11. Terminal Voltage at load buses without DSTATCOM



[1] Load bus 8 [2] Load bus 6 [3] Load bus 5

Figure 12. Terminal Voltage at load buses with DSTATCOM

5. Conclusion

In this paper D-STATCOM is used to mitigate voltage fluctuation and flicker in IEEE 9-bus distribution system. Artificial Neural Network (ANN) based approach has been used in this paper to find optimal location of DSTATCOM. This paper presents a fast response reaction by using D-STATCOM to overcome voltage fluctuations and clear faults as shown in previous figures.

6. References

[1]. R. C. Dugan, M. F. McGranaghan, S. Santoso, and H. W. Beaty, Electrical Power Systems Quality. 2002.

[2]. K. C. Cornelius, J. H. Dulas, K. a Shaw, and S. M. Peeran, "Source : Standard Handbook For Electrical Engineers Section 20 Motors And Drives," Library (Lond)., pp. 1–88, 2006.

[3]. A. Sharma, "Power Quality Improvement for D-Statcom in Distribution System Abstract :," vol. 3, no. 9, pp. 264–268, 2011.

[4]. S. Dey, "Application of Distribution Static Synchronous Compensator in Electrical Distribution System," vol. 3, no. 5, pp. 144–149, 2015.

[5]. A. Mokhtari, F. Z. Gherbi, C. Mokhtar, and D. E. Kamel, "Study , analysis and simulation of a static compensator D-STATCOM for distribution systems of electric power," no. 25, pp. 117–130, 2014.

[6]. D. K. Tanti, M. K. Verma, B. Singh, and O. N. Mehrotra, "Optimal placement of custom power devices in power system network to mitigate voltage sag under faults," Int. J. Power Electron. Drive Syst., vol. 2, no. 3, pp. 267–276, 2012.

[7]. O. Placement, O. F. Custom, P. Devices, I. N. Power, and V. Balancing, "© I A E M E," vol. 3, no. 3, pp. 187–199, 2012.

[8]. B. Singh, "an Ann Based Approach for Optimal Placement of Dstatcom for Voltage Sag Mitigation," Int. J. Eng. Sci., vol. 3, no. 2, pp. 827–835, 2011.