MAGNIFICATION OF POWER QUALITY IN DISTRIBUTION SYSTEM USING D-STATCOM IN TRANSMISSION LINE

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Abstract : power quality problem is observed as a non standard voltage, current and frequency with results in failure or disturbance in operation of receiving end user machines. Disturbance in utility of networks, sensitive industrial loads and critical commercial operations faces different types of outage and service interruption which effects financial losses. After restructuring of power system and shifting trend towards distributed and dispersed generation, the problem of power quality is going to take newer structure. In developing countries like India, where the variations and fluctuation of power and frequency and many such others determinants of power system which affects power quality of distribution line are themselves a serious problem, It is very indispensable to take positive steps in this direction. The present work is to identify the notable concerns in this area and hence the measures that can improve the power quality of power are recommended.

This paper propose the improvement of voltage sags, harmonics distortion and low power factor using Distribution Static Compensator (D-STATCOM). The model build on the principle of voltage source converter (VSC).The D-STATCOM injects a current into the system to appease the voltage sags,to improve harmonics disturbances and low power factor. The simulations were performed using MATLAB SIMULINK .

***Index Terms* – D-STATCOM, Total Harmonics Distortion (THD), Voltage Sags, Voltage Source Converter (VSC)**

I. INTRODUCTION

An electric distribution power system is part of an electric system of the sources and the consumer's service connections. The power sources are installed in or near the load area to be served by the distribution system and may be either generating stations or power substations supplied over transmission lines. Distribution system can be divided into six part sub transmission circuits, distribution substations, distribution or primary feeders, distribution transformers, secondary circuits or secondary's, and consumer's service connections and meters or consumer's services. There is a serious problem of power quality just like voltage sag and swells. It is decided two parameters, depth/magnitude and duration The voltage sag/swell magnitude is ranged from 10% to 90% of nominal voltage and with duration with ranged from half a cycle to 1 min. . In a three- phase system voltage sag is of nature a three-phase phenomenon, which results both the phase-to-ground and phase-to-phase voltages. Voltage sag is due to a fault in the utility system, a fault within the customer's serviceability or a large increase of the load current, like starting a motor or transformer energizing. Generally faults are single-phase or multiple-phase short circuits, which leads to high current. The high current results in a voltage drop over the network impedance. At the fault point the voltage in the faulted phases drops close to zero, whereas in the non-faulted phases it remains more or less unchanged voltage.

Voltage sags are one of the most common problems. In industry voltage sags occurs more often and cause seriously problems and economical losses. Utilities often focus on disturbances from end-user equipment as the main power quality problems

Harmonic currents in distribution system can cause due to harmonic distortion, low power factor and additional power losses as well as heating issue in the electrical equipment. It also can cause vibration and noise in machines and function of the sensitive equipment. There are different ways to improve power quality problems in transmission and distribution systems. the D-STATCOM is mostly effective device which is use here. To control electronics value of D-STATCOM a PWM technique is used.

The D-STATCOM has extra capability to sustain reactive current at low voltage, and can be developed as a voltage and frequency support by replacing capacitors with batteries as energy storage. To improve the power quality such as voltage sags/swell, harmonic distortion and low power factor in power distribution system.

2. VOLTAGE SOURCE CONVERTER (VSC)

A voltage source converter is a power electronics device, which can initiate a sinusoidal voltage of required magnitude ,frequency and phase angle. Voltage source converters are widely used in adjustable variable speed drives, but can also be used to mitigate variable voltage dips. The VSC is used for fully replaced the voltage and missing voltage. The missing voltage expressed in the difference between the nominal voltage and actual voltage. The converter is basically a type of energy storage, which will supply the converter with a DC supply voltage.The solid state electronics in the converter is then switched to find the required voltage . Generally the voltage source converter is used for voltage sag mitigation as well as other power quality issues just like flicker and harmonics.

3. ENERGY STORAGE CIRCUIT

Energy storage circuit is shown below in the fig. 3.1 DC source is to be connected in parallel with the DC capacitor .It takes the supply ripple current of the converter and it is the main reactive power storage element. This DC capacitor could be recharged by converter itself.

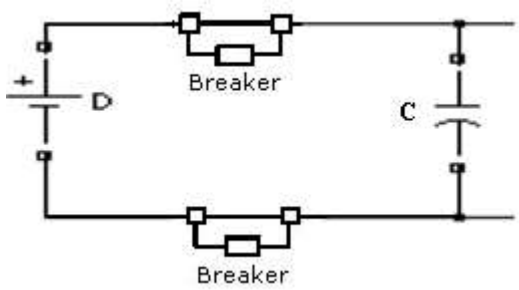


Fig.3.1.Circuit Diagram of DC Storage

4. CONTROLLER

The purpose of the control scheme is to maintain a constant voltage magnitude at the point where a sensitive load is connected, The control system measures only the r.m.s. voltage at the load side and there is no requirement of reactive power measurement. The VSC switching technique is based on sinusoidal PWM technique which offers good and reliable response. Since custom power is a low power applications, PWM methods offer a more frequent option than the Fundamental Frequency Switching (FFS) methods favored in FACTS application. It is also offers high switching frequencies can be used to improve the efficiency of converter , without incurring switching losses.

The controller input is an error signal received from the reference voltage and the r m s value of the terminal voltage and the value of r m s in the terminal voltage measured. Such type of error is processed by a PI controller the output is the angle δ ,which is transferred into the PWM signal generator. It is necessary to note that in this case, indirectly controlled converter, there is active and reactive power exchange by the network simultaneously . an error signal is produced by comparing the reference voltage with the rms value of voltage measured at the load side. The PI controller is process the error signal produced the required angle to drive the error signal to zero .

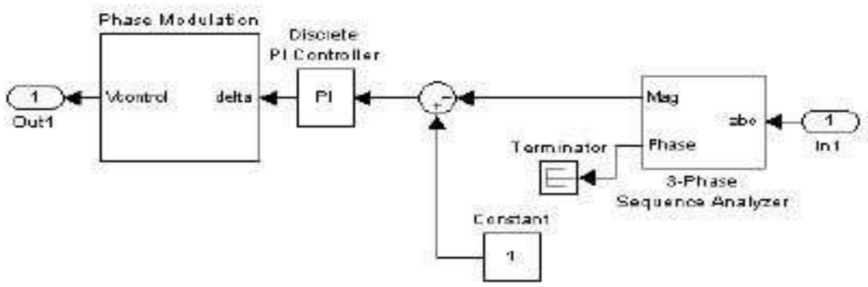


Fig.4.1. Simulink Model of D-STATCOM Controller

5. DISTRIBUTION STATIC COMPENSATOR (DSTATCOM)

A D-STATCOM (Distribution Static Compensator), which is schematically depicted in Figure-5.1, consists of a two-level of Voltage Source Converter (VSC), a DC storage device, and a coupling transformer connected in shunt of the distribution network with a coupling transformer. The VSC converts the dc voltage of the storage device into a three-phase ac output voltages. These voltages are in phase and coupled with the ac system voltage through the reactance of the coupling transformer. Perfect adjustment of the phase and magnitude of the D-STATCOM output voltages allows effective control of active and reactive power exchanges between the D-STATCOM and the ac system voltage. Such configuration allows the device to absorb or generate controllable active and reactive power.

The VSC which is connected in shunt with the ac system provides a multifunctional topology which can be used for up to three quite distinct purpose.

1. Voltage regulation and compensation of reactive power.
2. Correction of power factor
3. Elimination of current harmonics

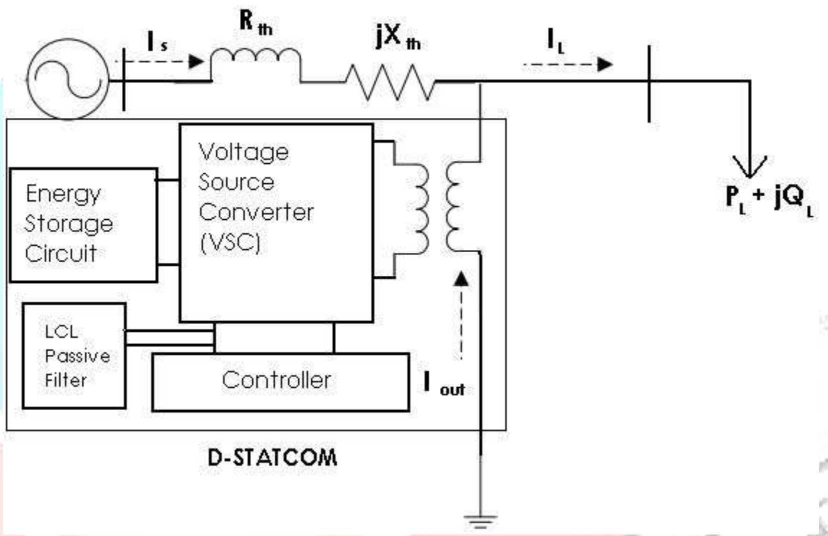


Fig.5.1. Schematic Diagram of D-STATCOM

6. METHODOLOGY

To improve the performance of distribution system, D-STATCOM was connected to the distribution system. D-STATCOM was designed using MATLAB simulink version R2009b.

The test system shown in figure 6.1 comprises a 230kV, 50Hz transmission system, represented by a Thevenin equivalent, feeding into the primary side of a 3-winding transformer connected in Y/Y/Y, 230/11/11 kV. A varying load is connected to the 11 kV, secondary side of the transformer. A two-level D-STATCOM is connected to the 11 kv tertiary winding to provide instantaneous voltage which support at load point . A 750 µF capacitor on the DC side provides the D-STATOM energy storage capacity. Circuit breaker is used to control the time of the operation of D-STATCOM.

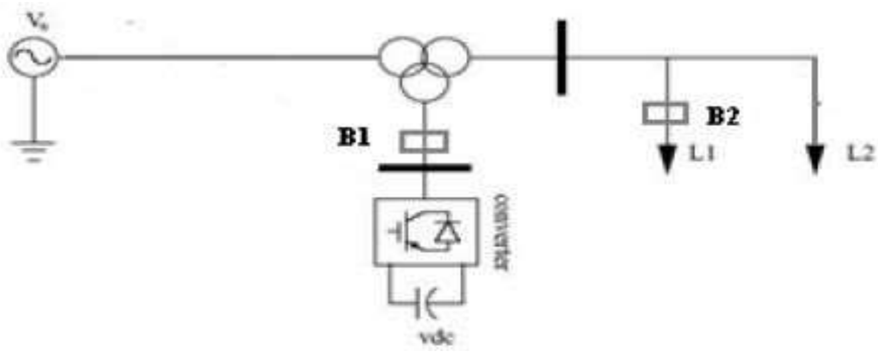
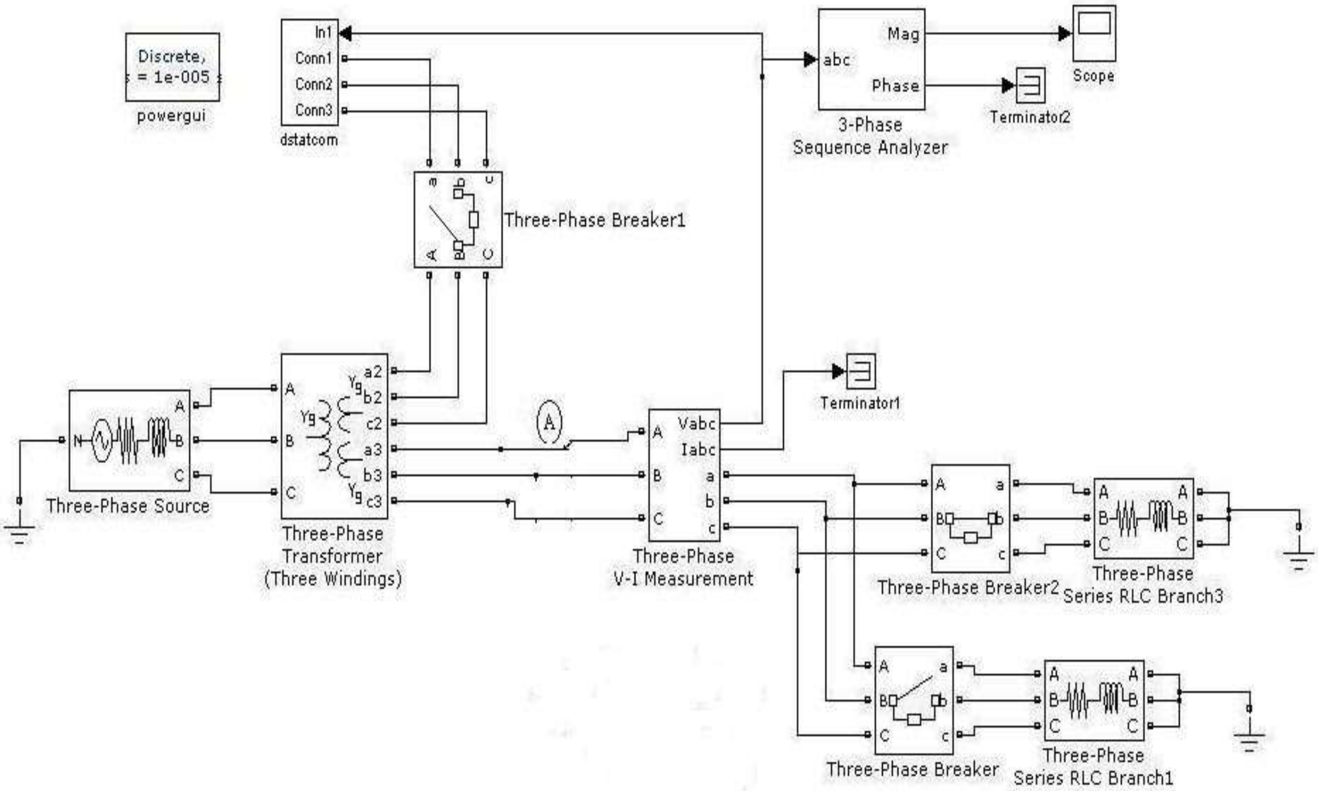


Fig.6.1. Single line Diagram of Test System

7. SIMULINK MODEL FOR THE TEST SYSTEM

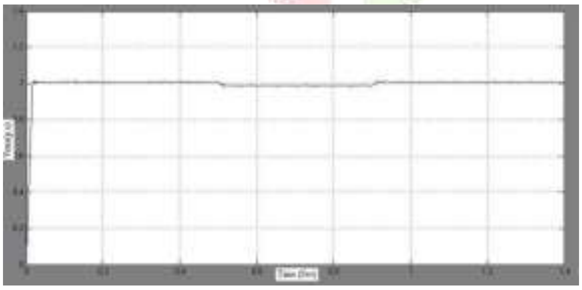


8. RESULT

8.1 Simulation results of voltage sag during single line to ground fault

In this case, D-STATCOM is not connected and a single line to ground fault is applied at a point 'A' having a fault resistance of 1.06 Ω. The voltage sag is shown in fig.8.1. with a time period of 500ms-900ms.

From the fig.8.2. the voltage sag is mitigated with an energy storage of 18.2 kv, when the D- STATCOM is connected to the system



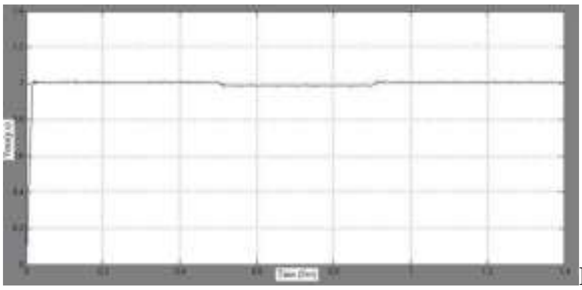


Fig.8.1.Voltage Vrms at the load point without DSTATCOM:

Fig.8.2.Voltage Vrms at the load point with DSTATCOM with energy storage of 18.2 kv

8.2 simulation results of voltage interruption during three phase fault

In this case, D-STATCOM is not connected and a three-phase fault is applied at a point 'A' with a fault resistance occurs 0.96 Ω. The voltage sag is shown in fig.8.3. with a time period of 500ms-900ms.

As the simulation is carried out with a D- STATCOM connection as shown in the fig.8.4. The voltage sag is mitigated with energy storage of

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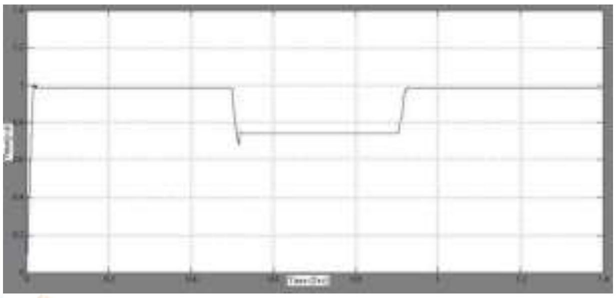

Fig.8.3.Voltage Vrms at the Load point without DSTATCOM.

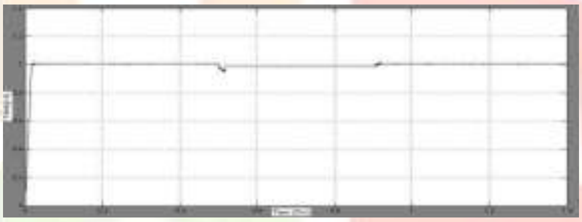

Fig.8.4.Voltage Vrms at the Load point with DSTATCOM with energy storage of 18.2 kv.

8.3 simulation results of voltage swell

In this case, D-STATCOM is not connected and a capacitive load is connects at a point 'A'. The voltage swell is shown in fig.8.5. with a time period of 500ms-900ms.

As the simulation is carried out with a D- STATCOM connection as shown in the fig.8.6. The voltage swell is mitigated with energy storage of 13.2 kv,

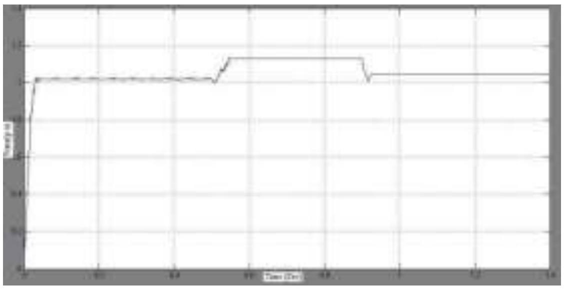

Fig. 8.5.Voltage V_{rms} at the load point without D- STATCOM with

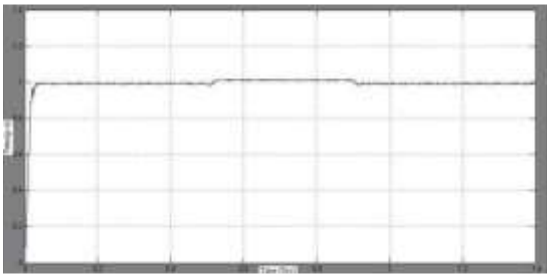

Fig.8.6. Voltage V_{rms} at the load point with D- STATCOM: Energy storage of 13.2 kv.

9 CONCLUSION

A single-phase to ground fault, three-phase fault and voltage sag and swell are occurred in a time period of 500ms-900ms at different inductive and capacitive loads. D-STATCOM is designed by the combination of two-level VSC and PWM-based control. Here the voltage measurement is controlled by PWM- controller. So by using D-STATCOM sag of 13%, interruption of 25% and swell of 11% conditions are mitigated

10. REFERENCCES

[1] G. Yaleinkaya, M.H.J. Bollen, P.A. Crossley, "Characterization of voltage sags in industrial distribution systems", IEEE transactions on industry applications, vol.34, no. 4, July/August, pp. 682-688,

1999.

[2] Haque, M.H., "Compensation of distribution system voltage sag by DVR and D-STATCOM", Power Tech Proceedings, 2001 IEEE Porto, vol.1, pp.10-13, Sept. 2001.

[3] Anaya-Lara O, Acha E., "Modeling and analysis of custom power systems by PSCAD/EMTDC", IEEE Transactions on Power Delivery, Vol.17, Issue:1, Jan. 2002, Pages:266 – 272.

[4] Bollen, M.H.J.," Voltage sags in three-phase systems" Power Engineering Review, IEEE, Vol. 21, Issue: 9, Sept. 2001, pp: 8 - 11, 15.

[5] R.Mienski,R.Pawelek and I.Wasiak., "Shunt Compensation for Power Quality Improvement Using a STATCOM controller: Modelling and Simulation", IEEE Proce., Vol.151, No.2, March 2004.