Improvement of Power Quality of Distribution System using D-STATCOM

Shivani Shivhare[1] Dr. Yogesh Pahariya[2]
[1]M.Tech Student
[1,2]Department of Electrical Engineering
[1,2]RKDF, Institute of Technology, Bhopal, India

Abstract— In a Power System there is a main problem of power quality at the receiving side which is mainly related to the voltage fluctuation, current and frequency. The main purpose of this paper is to represents a role of D-STSTCOM in power system before fault, during fault and after fault condition and analysis power quality by using D-STATCOM. When fault occurs in power system at different cases the D-STATCOM will regulate supply voltage by absorbing and providing reactive power to mitigate voltage sag/swell .This model based on voltage source converter and also work on VSC principle. Voltage source converter consist of D.C. link capacitor .The various technique are used for carrying out the work with use of D STATCOM to minimize the problem which occurs in distribution system such as voltage sag, voltage instability in power system with different fault conditions for LG, LL, LLG fault. for supply the reactive power D - STATCOM is used and retain good power quality. The purpose of D-STATCOM is model and simulate using MATLAB/ Simulink version R-2010a.

Key words: Distribution STATCOM (D-STATCOM) Voltage Sags, Voltage Source Converter (VSC)

I. INTRODUCTION

To improve the problem of power quality, custom power device is used for a number of power quality solution. Currently various range of flexible alternating current controller which is newly available power electronics components are combine for custom power application .Among these the distribution static compensator is currently is used for present work .IN distribution system the fast response of D-STATCOM makes it good solution for improving power quality. D-STATCOM is used various controllers such as PI CONTROLLER to improve the quality of power under different fault conditions in distribution system. D–STATCOM is basically a voltage source converter based facts controller which sharing many similar concept with that of STATCOM used in a transmission system. A D – STATCOM at transmission level controls only reactive power and supply voltage. In distribution level D-STATCOM is also used at load side and also behaves as shunt active filter it works as the iEEE-519 standard limit since the electrical power distribution system very impotent to balance the power supply and requirement of active and reactive power in electrical power system. If there is any fault occurs than frequency and voltage excursion may occurs results in power system. So we can say that voltage and reactive power control key of stable power system. The distribution power losses and power quality problem increasing because of reactive power. The STATECOM is mainly used for the D -STATECOM exhibits high speed control of reactive power to provide better voltage stabilization in power system. The D STATCOM protect the distribution system from voltage sag/swell Flicker caused by reactive currant

II. VSC (VOLTAGE SOURCE CONVERTER)

A Voltage Source Converter (VSC) is called as power electronic device, this device can generate a sinusoidal voltage with any desired frequency, phase angle and also for magnitude. In variable-speed drives, Voltage source converters are mostly used and also be used to decrease the voltage drops. The VSC is used to inject the 'missing voltage' for completely replace the voltage. The 'missing voltage' is the difference between the transient wave and the actual sinusoidal wave. The converter is a solid state electronics device that supplies DC to the converter. The VSC is such an energy storage device. The VSC is used with D-STATCOM for power quality problems.

III. D-STATCOM

A D-STATCOM (Distribution Static Compensator), which is schematically depicted in Fig.1, consists of a two-level Voltage Source Converter (VSC), a dc power storage device, a coupling transformer connected in shunt to the distribution network with a coupling transformer. The VSC converts the dc voltage across the storage device into a set of three-phase ac output voltages. These voltages are in phase and coupled with the ac system through the reactance of the coupling transformer. Suitable adjustment of the phase and magnitude of the D-STATCOM output voltages allows effective control of active and reactive power exchanges between the DSTATCOM and the ac system. This configuration allows the device to absorb or generate controllable active and reactive power. The VSC connected in shunt with the ac system provides a multifunctional topology which can be used for up to three quite distinct purposes:

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

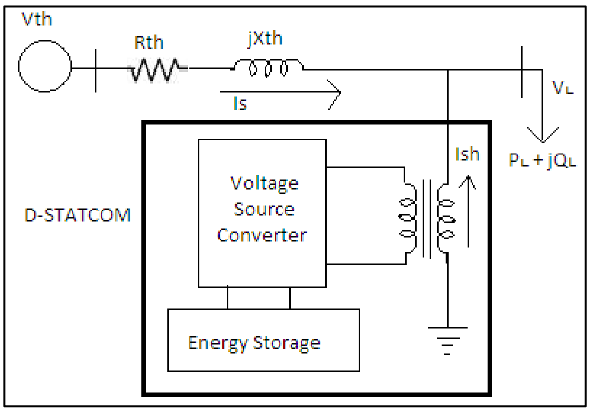

Fig. 3.1: Schematic Diagram of D-STATCOM

The shunt injected current Ish corrects the voltage sag by varying the voltage drop across the system impedance Zth. The value of Ish can be controlled by adjusting the output voltage of the converter. The shunt injected current Ish could be written as,

Ish IL – IS =IL – ((Vth - VL)/Zth……………(1)

Ish < γ = IL < (-θ) – (Vth/Zth) < (δ-β) + VL/Zth < (-β)….(2)

The complex power injection of the DSTATCOM can be written as,

$$Ssh = VL\ I{*}sh$$

It may be cleared that the effectiveness of the D-STATCOM in correcting voltage sag depends on the value of Zth or fault level of the load bus. When the shunt injected current Ish is kept in quadrature with VL, the desired voltage correction can be achieved without injecting any active power into the system. On the other hand, when the value of Ish is minimized, the same voltage correction may be achieved with minimum apparent power injection into the system.

IV. PI CONTROLLER

The purpose of the control scheme is to maintain constant voltage magnitude at the point where a sensitive load is connected, under system disturbances. The control system measures the r.m.s voltage at the load point, i.e., no reactive power measurements are required. The VSC switching strategy is based on a sinusoidal PWM technique which offers reliable and good response. Since custom power is a relatively low-power application, PWM methods offer a more flexible option than the Fundamental Frequency Switching (FFS) methods favored in FACTS applications. Besides, high switching frequencies can be used to improve on the efficiency of the converter, without incurring significant

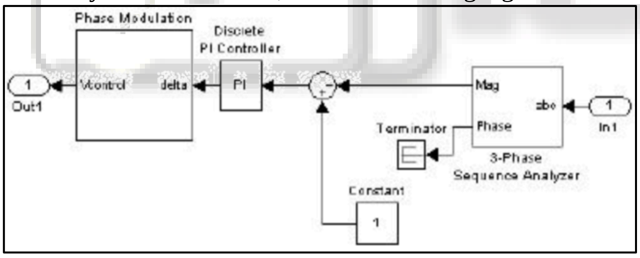

Fig. 4.1: Simulink Model of D-STATCOM Controller

V. SIMULATION MODEL OF TEST SYSTEM WITH & WITHOUT D-STATCOM & ITS OPERATION

In this modal test system we have a generating unit of 25kv, 50Hz. The test system employed to carry out simulations consisting the D-STATCOM. The output from generating unit s fed to primary winding of the three winding transformer. Further there is two parallel feeder of 11kv each are drawn. In one of the feeder D-STATCOM is connected in shunt is followed by circuit breaker and other feeder is kept as it is. For this test system a non-linear load is connected at the end of the feeder consisting of D-STATCOM. PI controller is used for the control section.

The simulation is carried out between times 0.4 to 0.9 sec. During which circuit breaker is not connected to

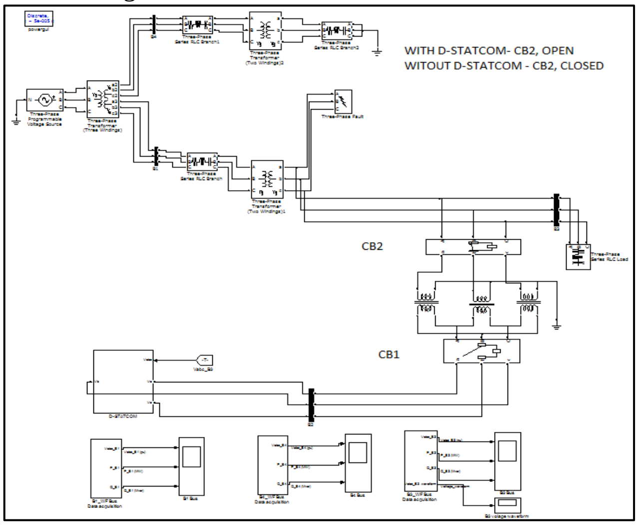

Fig. 5.1: Simulation Diagram for Test System

A. *Parameter of the Test System*

This model system has been tested on different fault conditions with non-linear load. This system employed with three phase programmable voltage source with configuration of 25kv, 50 Hz. The source is feeding two transmission line through a three phase winding transformer with power rating 250MVA.

1) *Winding 1*

V1rms (Ph-Ph) = 25kv, R1= 0.002(pu), L1 = 0.08002(pu) Winding 2: V2rms (Ph-Ph) = 11kv, R2= 0.002(pu), L2 = 0.08002(pu) Winding 3: V3rms (Ph-Ph) = 11kv, R3= 0.002(pu), L3 = 0.08002 (pu) Inverter Parameter : IGBT based , 3arm , 6 pulse , carrier frequency = 1080Hz., sample time = 5μ sec. the power system, such as CB2 is closed when D-STATCOM is not in operating mode.

B. *Simulation Results: Case 1. : Single Line to Ground Fault (LG) Condition*

In this case single line to ground fault is considered for both the feeders. Here the fault resistance is 0.98 ohm and the ground resistance is 0.001ohm. The fault is created for the duration of 0.4s to 0.9s. The output waveform for LG fault is

C. *Result without D-STATCOM (LG Fault)*

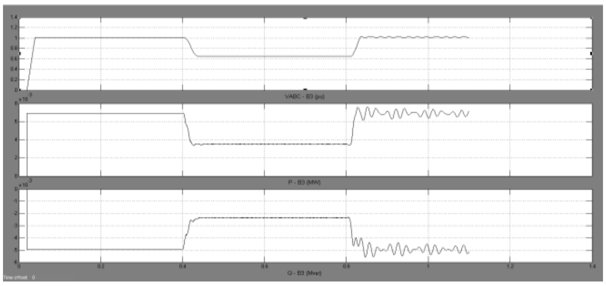

Fig. 5.3: Three Phase Voltage (pu), Active Power and Reactive Power at Bus 3 Without D-STATCOM (LG Fault)

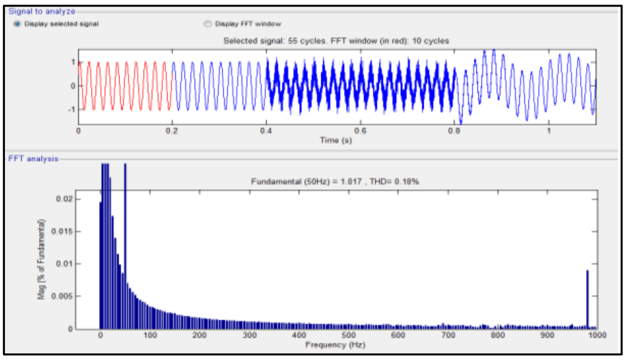

Fig. 5.4: FFT Analysis before Fault without D-STATCOM (LG Fault)

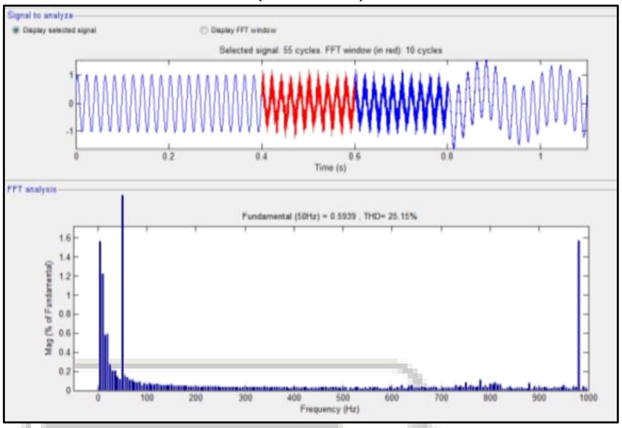

Fig. 5.5: FFT Analysis during Fault without D-STATCOM (LG Fault)

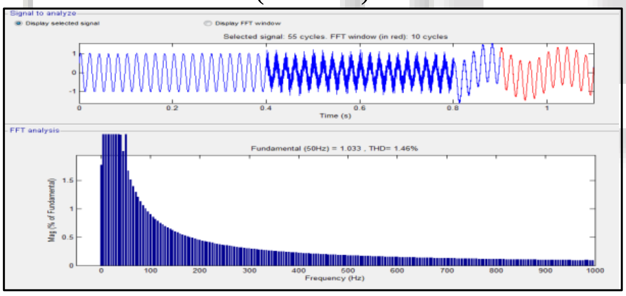

Fig. 5.6: FFT Analysis after Fault without D-STATCOM (LG Fault)

D. Result with D-STATCOM (LG Fault)

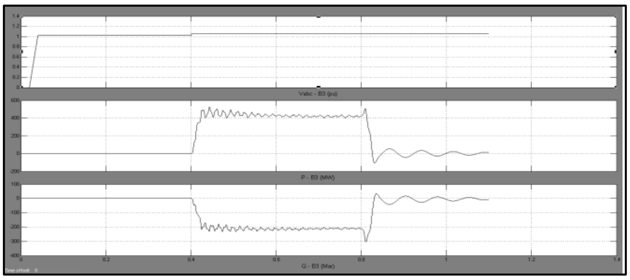

Fig.5.7Three Phase Voltage (pu), Active Power & Reactive Power at Bus 3 With D-STATCOM (LG Fault)

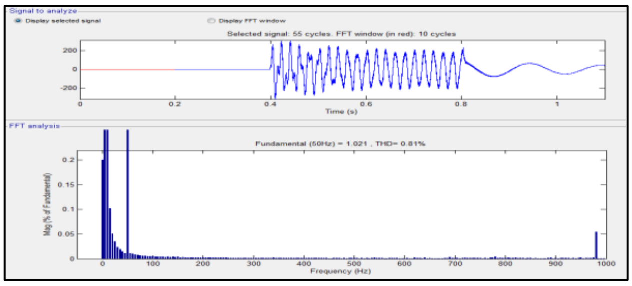

Fig. 5.8: FFT Analysis before Fault with D-STATCOM (LG Fault.

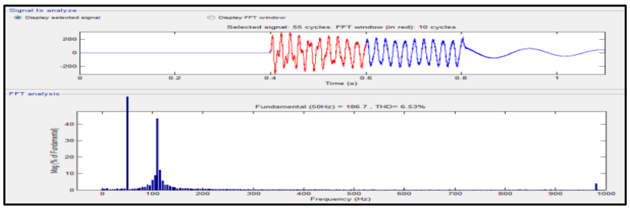

Fig. 5.9: FFT Analysis during Fault with D-STATCOM (LG Fault)

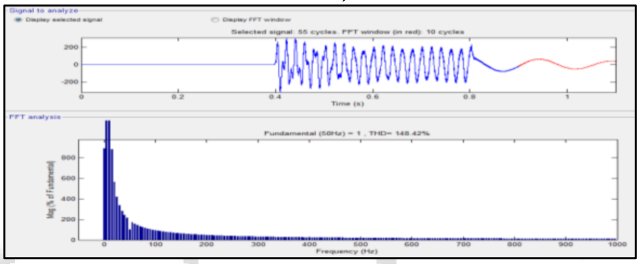

Fig. 5.10: FFT Analysis after Fault with D-STATCOM (LG Fault)

E. Result Without D-STATCOM (LLG Fault):

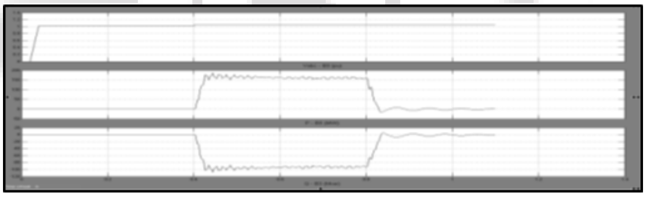

Fig. 5.11: Three Phase voltage (pu), Active Power & Reactive Power at Bus 3 With D-STATCOM (LLG Fault)

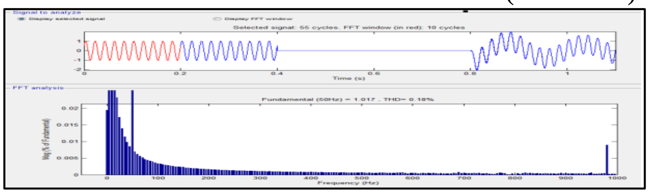

Fig. 5.12: FFT Analysis before Fault without D-STATCOM (LLG Fault)

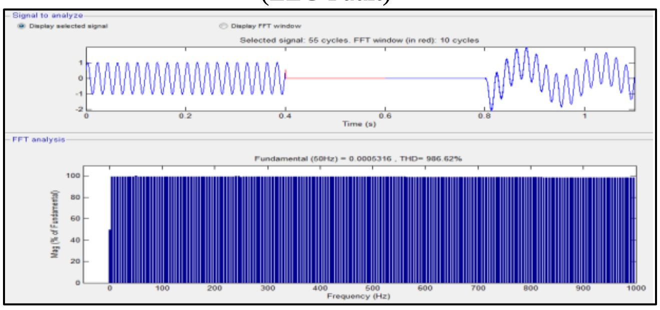

Fig. 5.13: FFT Analysis during Fault without D-STATCOM (LLG Fault.

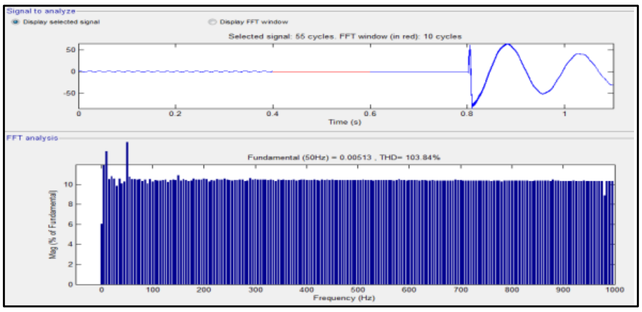

Fig. 5.14: FFT Analysis after Fault with D-STATCOM

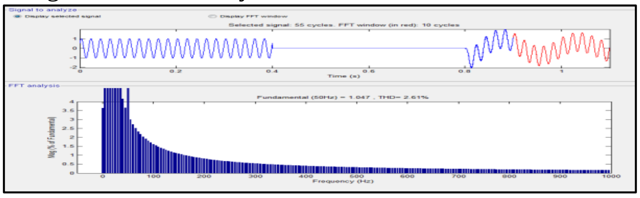

Fig. 5.15: FFT Analysis during Fault (LLG Fault)

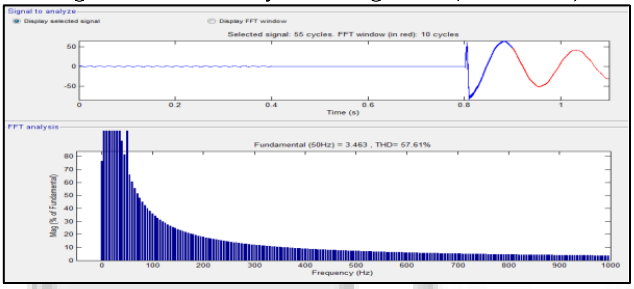

Fig. 5.16: FFT Analysis after Fault (LLG Fault)

VI. THD COMPARISON

S. No.	Type Of Fault	With D-STATCOM (CB_2 -Closed)			With D-STATCOM (CB_2 – Open)		
		Before Fault	During Fault	After Fault	Before Fault	During Fault	After Fault
1.	LG	0.20%	24.92%	1.44%	0.81%	5.02%	71.6%
2.	LLG	0.20%	12.35%	2.67%	0.81%	0.61%	53.32%

Table 1:

VII. CONCLUSIONS

This paper has presented the power quality problems such as voltage dips, interruptions. The objective of this work is to study the performance of D-STATCOM for mitigating voltage sag (dip) and to improve the power quality in distribution network with non-linear load. The investigation is made on different fault condition for non-linear load. In this work the investigation is composed of power system distribution network with and without D-STATCOM.THD comparison of different fault condition is also carried out during fault, before fault and after fault condition. So it can be concluded that D-STATCOM effectively improves the power quality in distribution network with non-linear load.

REFERENCES

[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