TECH-CHRONICLE
AN INTERNATIONAL E-JOURNAL ON
EMERGING TRENDS IN SCIENCE, TECHNOLOGY AND MANAGEMENT

Mitigation of Harmonics using STATCOM

Gaurav Karlekar
Dept. Of Electrical Power System
BIT,Bamni,India
karlekar.gaurav@gmail.com
97066561591

Sunil R. Waghale
Dept. Of Electrical Power System
BIT,Bamni,India
Sunil.waghale@gmail.com
9421783161

Bapina D. Shanti
Dept. of Electrical Power System
BIT, Bamni,India
bapina18@gmail.com
9021194817

Abstract:- **This paper discusses about reactive power compensation and harmonic mitigation in a grid connected system with a non-linear load by using STATCOM (Static synchronous compensator). The main objective of this paper is to show that there the harmonic distortion and the unbalance caused due to non-linear load is not affected at the grid side. Also it provides a control to maintain the dc link voltage as constant. The unbalance of dc capacitor voltage is caused due to switching loss. The control strategy used is using PI (Proportional Integral) controller and hysteresis control. This control scheme has the advantage of good stability and strong regulation capacity. The simulations are done in the MATLAB/SIMULINK. The graph shows that voltage is stabilized to a constant value also reactive power is compensated and THD (Total Harmonic Distortion analysis) is done both in the grid side and load side.**

Keywords— STATCOM(Static synchronous compensator), THD (Total Harmonic Distortion), PI controller, Hysteresis Controller

1. INTRODUCTION

The FACTS technology is essential to alleviate some but not all of these difficulties by enabling utilities to get the most service from their transmission facilities and enhance grid reliability. Power Generation and Transmission is a complex process, requiring the working of many components of the power system in tandem to maximize the output. One of the main components to form a major part is the reactive power in the system. It is required to maintain the voltage to deliver the active power through the lines. To improve the performance of ac power systems, we need to manage this reactive power in an efficient way and this is known as reactive power compensation. Load compensation consists of improvement in power factor, balancing of real power drawn from the supply, better voltage regulation, etc. of large fluctuating loads. Two types of compensation can be used: series and shunt compensation. These modify the parameters of the system to give enhanced VAR compensation. In recent years, static VAR compensators like the STATCOM have been developed. These quite satisfactorily do the job of absorbing or generating reactive power with a faster time response and come under Flexible AC Transmission Systems (FACTS). The FACTS based controller's gives instantaneous control of transmission voltage and increase capacity providing larger flexibility in bulk power transmission. It is also in damping out major grid oscillations. Static VAR controllers (SVC) control only one of the three parameters (voltage, impedance, phase angle) determining the power flow in

the AC power system viz the amplitude of voltage at selected terminals of transmission line. It has long been realized that an all solid state or advanced, static VAR compensator, which is true equivalent of ideal synchronous condenser, is technically feasible with the use of Gate Turn-off (GTO) thyristor. One of the many devices under the FACTS family, a STATCOM is a regulating device which can be used to regulate the flow of reactive power in the system independent of other system parameters. STATCOM has no long term energy support on the dc side and it cannot exchange real power with the ac system

2. LITERATURE SURVEY

A power system is a complex interconnected structure with generation, transmission and distribution sectors as its components. The power from generation system is connected to the distribution system through long transmitting lines. The quality of power has a direct economic and financial impact on both utilities and industrial customers. Various power quality problems occur when a nonstandard voltage, current or frequency results in failure or mal-operation of end user equipment's. One of the major problem is voltage sag. To solve this problem, capacitors, reactive power compensators and voltage regulators were conventionally used. These techniques involve inherent drawbacks. With the advancement of power electronic devices these drawbacks can be overcome easily. To reduce a severity of power quality problems, mitigation devices can be placed in the transmission and distribution systems.

The concept of Flexible AC Transmission Systems (FACTS) was introduced by N.G. Hingorani to combat with the power quality issues that originates from transmission systems. The invention of various custom power devices such as Distribution Static Compensator (D-STATCOM), Dynamic Voltage Restorer (DVR), and Unified Power Quality Conditioner (UPQC) can be used to solve the power quality problem in economical way than by using FACTS devices. The custom power devices are broadly classified into two categories namely series and shunt devices. DVR is connected in series with the system which is operates in

voltage control mode and it is used to protect sensitive loads from sag/swell or disturbances in the supply voltage. D-SATCOM is connected in shunt and operated in current control mode that eliminated harmonics and/or unbalance. A better solution can be obtained by using both series and shunt devices together in the system. This thought results in the usage of multi-type custom power devices in the system for the improvement of power quality.

3. METHADOLOGY

The literature survey of STATCOMs can be grouped as follows:

1. Analysis and design of STATCOM
2. Modeling and control of STATCOM
3. Harmonic analysis of STATCOM
4. STATCOM operation with unbalanced voltages and currents
5. Diff. types of fault mitigation by STATCOM

4. STATCOM THEORY

STATCOM consists of a three phase inverter (generally a PWM inverter) using SCRs, MOSFETs or IGBTs, a D.C capacitor which provides the d.c. voltage for the inverter, a link reactor which links the inverter output to the a.c. supply side, filter components to filter out the high frequency components due to the PWM inverter. From the d.c. side capacitor, a three phase voltage is generated by the inverter. This is synchronized with the a.c supply. The link inductor links this voltage to the a.c supply side. This is the basic principle of operation of STATCOM. Such configuration allows the device to absorb or generate controllable active and reactive power.

The DSTATCOM (distribution static compensator) is a shunt connected FACTS controller best and economical for compensation of power quality problems in the current and voltage. Some of the topologies for DSTATCOM three-phase four-wire system for the mitigation of power quality problems are three phase three-leg VSC (voltage source converter), three single phase VSC, three –leg VSC with split capacitors, three-leg VSC with neutral terminal at the positive or negative of dc bus. A three- leg VSC is advantageous because an easily available 3-leg VSC is used, which reduces the complexity and cost of the system.

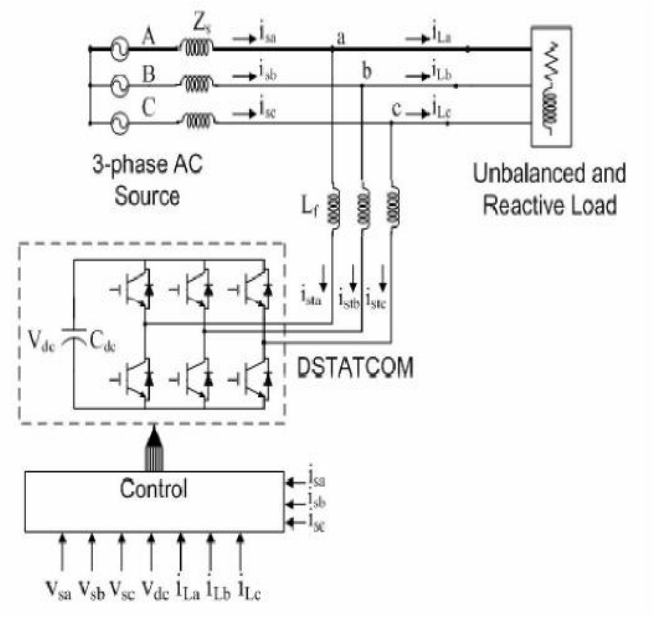

Fig. 1 Block Diagram of STATCOM

5. SIMULATION MODEL

a) Simulink model of DSTATCOM by using SRF method:

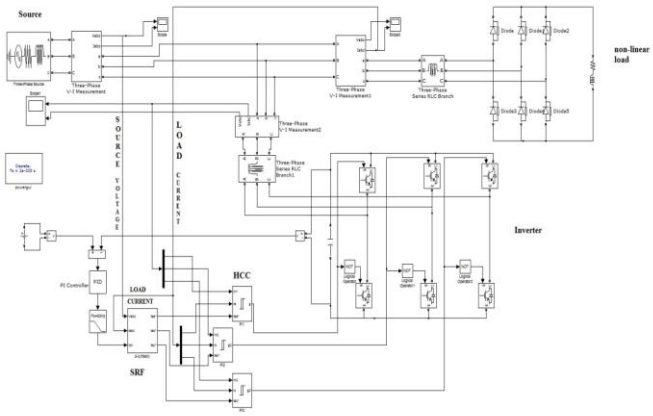

Fig. 2 Simulation model of DSTATCOM by using SRF theory

In this simulation model nonlinear load i.e. diode bridge rectifier is feeding from 400V source. And because of this nonlinear load harmonic gets generated at load side as well as at source side, and by using DSTATCOM these harmonics get mitigated. And now the source is harmonic free and provides sinusoidal power to load at distribution side.

b) Simulink model of d-q Theory:

The control scheme of DSTATCOM, which uses PLL for eneration of voltage templates. By using transformations load current is transformed from stationary frame to rotating frame at initial and it needs voltage templates during its transformation. After that a low pass filter is used to extract the DC component and

this again reverse transformed to stationary frame to get the signal in standard form.

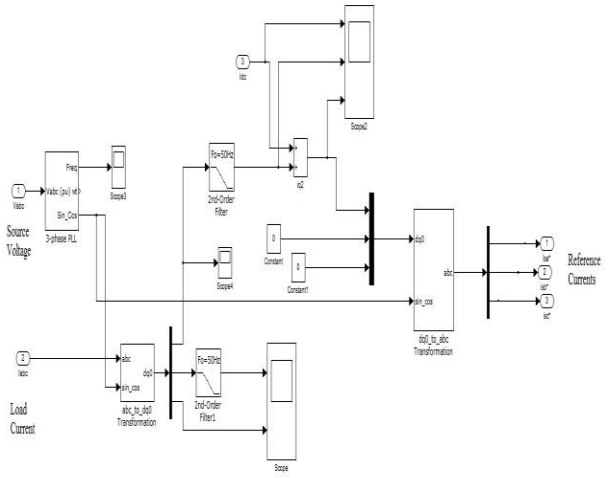

Fig. 3 Simulation model for SRF theory

6. SIMULATION RESULT

This first result in the following fig. Shows that the source current before compensation and second result shows that current after compensation.

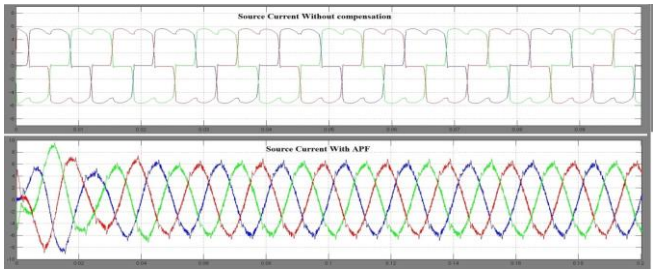

Fig. 4 Source current before compensation & After compensation

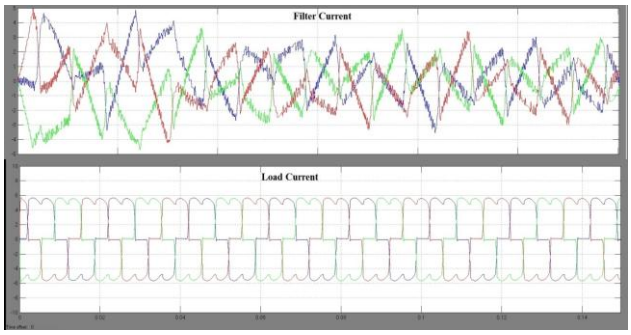

Fig. 5 Filter current and load current.

a) THD CALCULATIONS

Fig. shows the harmonic calculation before and after connecting the DSTATCOM as it decreased from 28.11% to 2.20%.

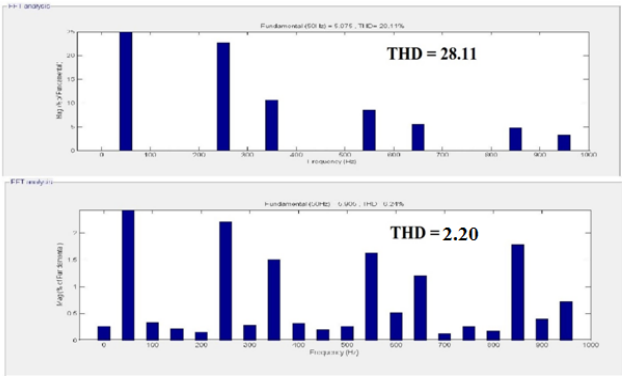

Fig. 6 THD before compensation 28.11 & THD after compensation 2.20

b) ACTIVE AND REACTIVE POWER CALCULATION

So by using below Simulink model in fig 7 we can calculate Active and Reactive Power by connecting a block and results in fig 8 shows calculated Active and Reactive Power are as follows. As it shows source is harmonic free and it will provide pure sinusoidal power.

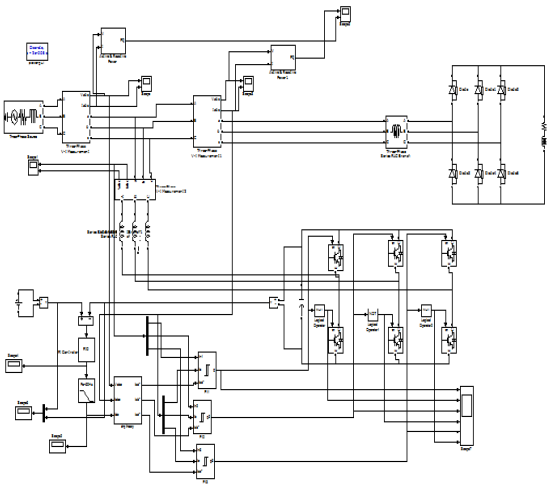

Fig. 7 Simulation model to calculate active and reactive power

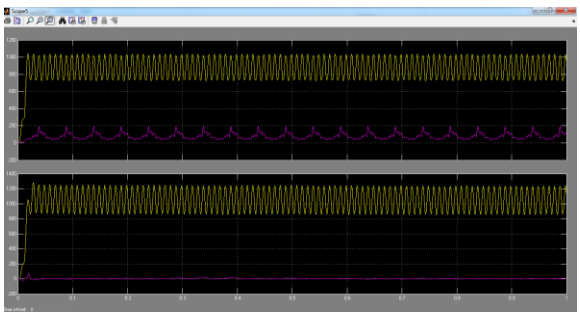

Fig. 8 results showing calculated Active and Reactive power at

i) source and ii) Load side

c) Simulation model for Voltage Sag mitigation by STATCOM

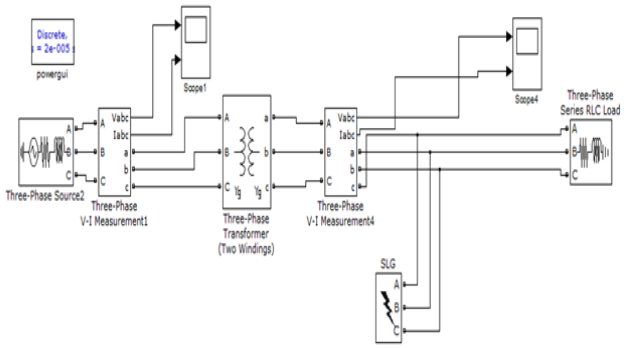

Fig. 9 Simulink model for voltage Sag

In this system 400KV source feeds the 11KV load and single phase fault occurs on system and source affected with voltage sag only in single phase and 2nd fig. shows that this single phase fault compensated by DSTATCOM.

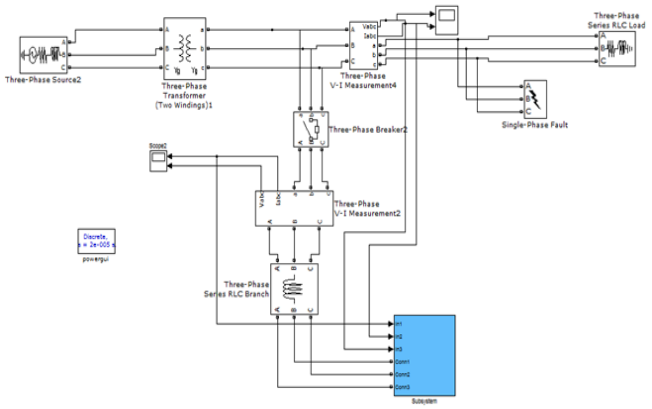

Fig.10 Simulation model of STATCOM for Voltage Sag

d) Results showing Voltage Sag and Compensation of Voltage Sag

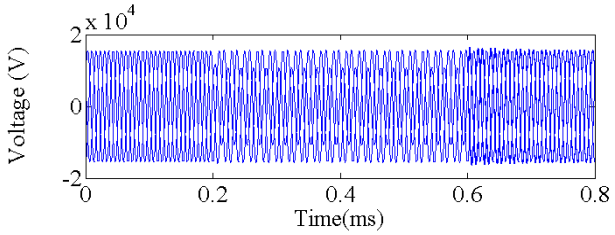

Fig. 11 Results Voltage Sag i) without STATCOM

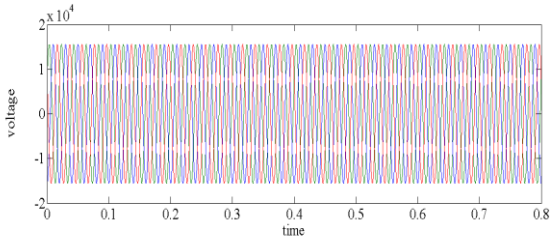

Fig. 12 Results Voltage Sag ii) with STATCOM

So above results shows the load side voltage affected with single phase fault in fig. 6.9(i) and fig. 6.9(ii) Shows this single phase voltage sag is mitigates after connecting the DSTATCOM.

7. CONCLUSION

This project report recommends STATCOM based control scheme using instantaneous SRF theory for improving the power quality of distribution system .The performance of DSTATCOM has been validated at the radial distribution system by examining the voltage waveform before and after the STATCOM operation .When there is voltage sag and swell on system, STATCOM injects current into the three phase system to compensate the sag and absorbs the current from the system when there is swell thus enhancing the quality of power at distribution level .The design and applications of D-STATCOM for voltage sags, swells are simulated in MATLAB/SIMULINK software and the comprehensive results are presented that shows DSTATCOM provides relatively better voltage regulation capabilities.

8. *FUTURE SCOPE*

The power demand is always increasing day by day. The power quality problems are also following the same trend and increasing day by day. So there is need to reduce such power quality problems like voltage sag and swell and make the supply system efficient. STATCOM is one of the promising technologies to enhance the power quality of system. The power quality can be still improved by using soft computing techniques like Unified power flow controller, Dynamic Voltage Restorer etc. FACT devices can be controlled through different control techniques to get better coordination between real and reactive power.

REFERENCES

[1] Ravilla Madhusudan, Student Member, IEEE, G. Ramamohan Rao, "Modeling and Simulation of a Distribution STATCOM (D-STATCOM) for Power Quality Problems-Voltage Sag and Swell Based on Sinusoidal Pulse Width Modulation (SPWM)", *IEEE- International Conference On Advances In Engineering, Science And Management (ICAESM -2012) March 30, 31,2012 436*

[2] P. Ramesh, C. Surya Chandra Reddy, D. Prasad, D. Prameela, A.Anusha,"Mitigation of faults In The Distribution System By Distributed Static Compensator (Dstatcom)",International Journal Of Modern Engineering Research (Ijmer), Vol.2, Issue.2, Mar-Apr 2012 Pp-506-511.

[3] Ashish Nigam and J.K. Dwivedi, "PERFORMANCE ANALYSIS OF D-STATCOM AND DVR FOR POWERQUALITY IMPROVEMENT IN DISTRIBUTION SYSTEM" *VSRD International Journal of Electrical, Electronics & Communication Engineering, Vol. 3 No. 5 May Journals.*

[4] Jyothilal Nayak Bharothu, K Lalitha , "Compensation of voltage flicker by using facts devices" *American Journal of Electrical Power and Energy Systems 2013; 2 (3) : 66-80Published online May 30,2013.*

[5] B.Singh, R.Saha, A.Chandra, K.Al Haddad "Static synchronous compensators (STATCOM)" *a review Department of Electrical Engineering, Indian Institute of Technology, New Delhi 110 016, India.*

[6] DaeWook Kang, Woo-Chol Lee, Dong-Seok Hyun "The Distribution STATCOM for Reducing the Effect of Voltage Sag and Swell", *Department of Electrical Engineering, Han Yang University, Haeng Dang Dong, Sung Dong GU ,SEOUL 133-791*

[7] Consalva J. Msigwa, Beda J. Kundy and Bakari M. M. Mwinyiwiwa, "Control algorithm for shunt active power filter using synchronous reference frame theory," *World Academy of Science, Engineering and Technology 34 2009.*

[8] María Isabel Milanés Montero, Enrique Romero Cadaval, and Fermín Barrero González, "Comparison of control strategies for shunt active power filters in three-phase four-wire systems," *IEEE Trans. on Power Electronics, vol. 22, no. 1, January 2007*