International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 06, June-2015

Power Quality Improvement of Inductive Load using Distributed Static Synchronous Compensator (D-Statcom)

Er. Parul (EE)
SSIET,Derabassi
Punjab Technical University, Jalandhar

Er Davesh Bindal (HOD,EE)
SSIET,Derabassi
Punjab Technical University, Jalandhar

Abstract- **The Power quality is the important and its parameter Voltage, current and frequency are the three physical characteristics that mostly define the power quality and a power quality issue is defined as "any occurrence manifested in current, voltage, or frequency deviations that results in damage, upset or failure of end-use equipment's". So importance is being given to the development of D-Statcom to solve these problems to improve power. D-Statcom has been developed based on control strategies like instantaneous active and reactive power compensation scheme (p-q control) and instantaneous active and reactive current scheme. The compensation is carried out by the use of PI based regulator. The working of model has been explained by using the Matlab Simulink R2012b with the help of graphs**

Keywords - Voltage sag, Swell, harmonics, DSTATCOM, PI.

I. INTRODUCTION

Power quality in an electric system is one of the most important concerned areas of electric power system. The latest innovative idea to make the life simple is to use the technology based upon the application of power electronics on power quality. With increasing quantities of non-linear loads being added to electrical systems, it has become necessary to establish criteria for limiting problems from system voltage degradation [1]. The main power quality problems are voltage sag, swell, harmonics, transients and voltage flickers [2]

Inductive load is the one of the most important load that can be used in my industries like steel industries.Load current imbalance with large reactive components results in voltage fluctuations and imbalance due to the impedance of the system. Their presence also affects the performance of other electrical equipment connected to the power system network is due to the fact that it produces high levels of harmonic distortion in the electricity grid. Therefore, it is of utmost necessity to take appropriate measures to reduce the problem of power quality measures.

The possible solution for the above problem is the application of DSTATCOM with PI controller.Different fault conditions are considered with inductive load to analyse the performance of DSTATCOM for improvement of power quality in the distribution system.

II.CONFIGURATION AND OPERATION OF DSTATCOM

The basic model of a D-STATCOM which is connected to the ac system bus through a coupling transformer. In a D-STATCOM, the maximum compensating current is independent of system voltage, so it operates at full capacity even at low voltages. A D-STATCOM's advantages include flexible voltage control for power quality improvement, fast response, and applicability for use with high fluctuating loads.

The shunt inverter, transformer and connection filter are the major components of a D- STATCOM. The control system employed in this system maintains the magnitude of the bus voltage constant by controlling the magnitude and/or phase shift of the voltage source converter's output voltage. By properly controlling iq, reactive power exchange is achieved. The DC capacitor voltage is maintained at a constant value and this voltage error is used to determine the reference for the active power to be exchanged by the inverter.

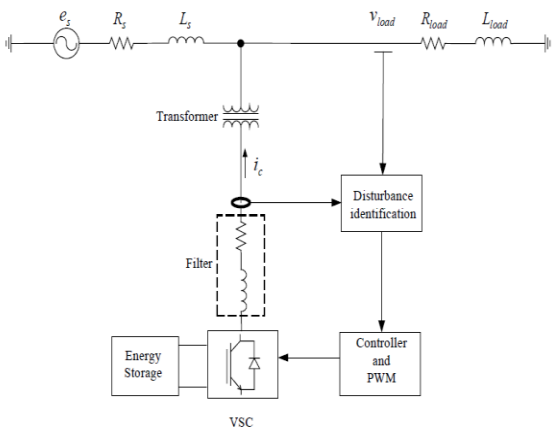

Figure-1 Basic Building Blocks of the D- STATCOM

The D- STATCOM is a static var generator whose output can be varied so as to maintain or control certain specific parameters of the electric power system. The D-STATCOM is a power electronic component that can be applied to the dynamic controlof the reactive power and the grid voltage. The reactive output power of the compensator

is varied to control the voltage at given transmission network terminals, thus maintainingthe desired power flows during possible system disturbances and contingencies. D-STATCOMs have the ability to address transient events at a faster rate and with better performance at lower voltages than a Static Voltage Compensator (SVC). The maximum compensation current in a D-STATCOM is independent of the system voltage. Overall, a D-STATCOM provides dynamic voltage control and power oscillation damping, and improves the system's transient stability. By controlling the phase angle, the flow of current between the converter and the ac system are controlled A D-STATCOM was chosen as a source for reactive power support because it has the ability to continuously vary its susceptance while reacting fast and providing voltage support at a local node.

III. CONTROL PHILOSOPHY

The SIMULINK model representing the compensation using DSTATCOM of a distribution network with inductive load is investigated in this work.The magnitude of the load current is compared to reference current. Pulse width modulated (PWM) control technology is applied to the inverter switching to produce a 50 Hz three-phase sinusoidal current through the load terminals. Switching frequency is maintained in the range of a few KHz. PI controller is used with IGBT inverter to reduce harmonic distortion due to inductive load. The block output controller is in the form of an δ angle used to introduce additional phase delay /lead in the three phase voltages.

Proportional- integral controller (PI Controller) is a feedback controller, which drives the system to be controlled with a weighted sum of the error signal (difference between the output and desired set point) and the integral of that value. In this case, PI controller will process the error signal to zero. The load r.m.s voltage is brought back to the reference voltage by comparing the reference voltage with the r.m.s voltages that had been measured at the load point. It also is used to control the flow of reactive power from the DC capacitor storage circuit. PWM generator is the device that generates the Sinusoidal PWM waveform or signal. To operate PWM generator, the angle is summed with the phase angle of the balance supply voltages equally at 120 degrees. Therefore, it can produce the desired synchronizing signal that required. PWM generator also received the error signal angle from PI controller. The modulated signal is compared against a triangle signal in order to generate the switching signals for VSC valve.

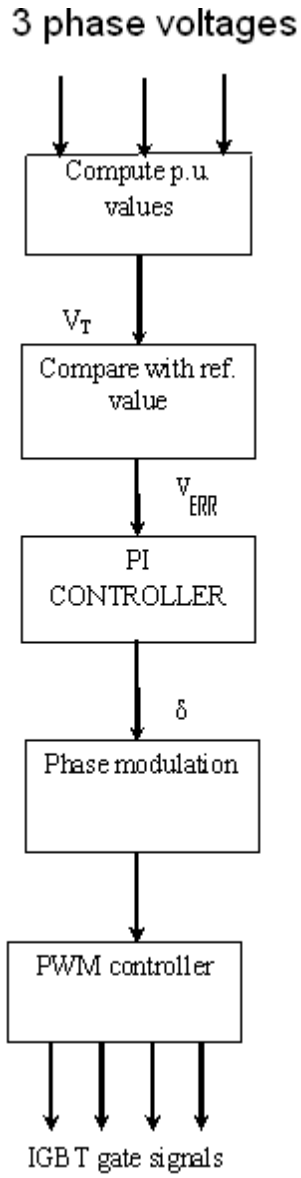

Figure2Control algorithm of DSTATCOM with PI controller

IV SIMULINK MODEL OF TEST SYSTEM

In this simulation model we have one transmission line feed from the generating station of 33KV , 50KW, 50Hz.then it is connected to industrial load of 100 KW , three phase 380 volt inductive load as data is taken from EMM Kay industry in Mohali . To enhance the performance of distribution system, D-STATCOM was connected to the distribution system. D-STATCOM was designed in MATLAB Simulink R2012b. In this model we study the effect of the inductive load as we know that whenever we switch on very heavy load it result in the Sag, Swell, and harmonics .which effect the power quality of the power supply to different load connected to same lines.So here we design two types of models

1. Simulink model without D-STATCOM Compensation

2. Simulink model with D-STATCOM compensation.

CASE I SIMULINK MODEL WITHOUT D-STATCOM COMPENSATION

This model consists of case study of Inductive load of 100 KW from EMM KAY industry. So in this load we got three type of different situation due to inductive load. The first is Sag due to heavy load as the inrush current is very heavy for any inductive load as there is no back emf in it. So there is no opposition to it. Unloading large inductive load and energizing large capacitor banks are the possible reasons of the voltage swell and harmonics

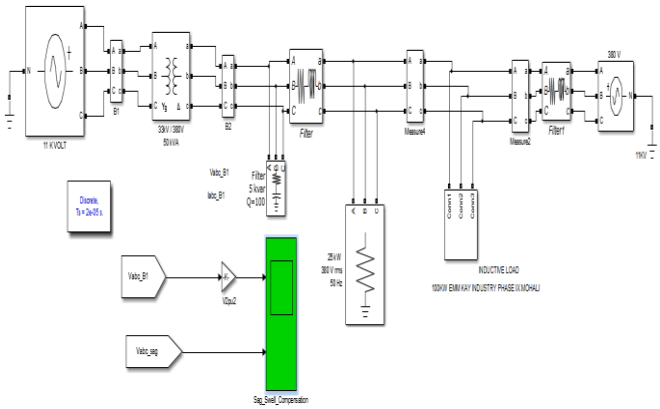

Figure 3 Simulink Model without Compensation

CASE II SIMULINK MODEL WITH D-STATCOM COMPENSATION

In the compensation we introduce the D-Statcom on industrial end which only got effective when there is any change in the load .They keeps on sensing the load parameter which is magnitude and current .Then these parameters are converted to d and q as we need only magnitude of both voltage and current. Then this voltage and current is compared with the reference voltage. Then the required firing pulse signal is generated to control the rectification which results in controlled Battery charging. On the other hand the load voltage is sense and then feed to the invertors IGBT firing control unit which result in maintaining the required voltage level.

In the above model first the AC is converted to DC. This DC is stored in batteries the battery controller is provide the required Pulse to make battery charge on required voltage and current level. As we know on over voltage charging result in damage of battery and with high current charging result in heating or battery and sometime burst.In this compensation model we have other controller caller inverter controller which control the Firing angle with PWM technique which generate Pulses of 2000Hz.Hz. It generates three phase PWM control pulses for IGBT Gates. These PWM wave is pass through the three phase LC filter which result in the smoothing of the wave square wave in to sine wave. This sine wave compensates the effect of sag and swell and harmonics. The coupling transformer is used to inject the voltage in the system to make it stable and smooth sine wave so that it not disturb the working of the other load connected parallel to the system.

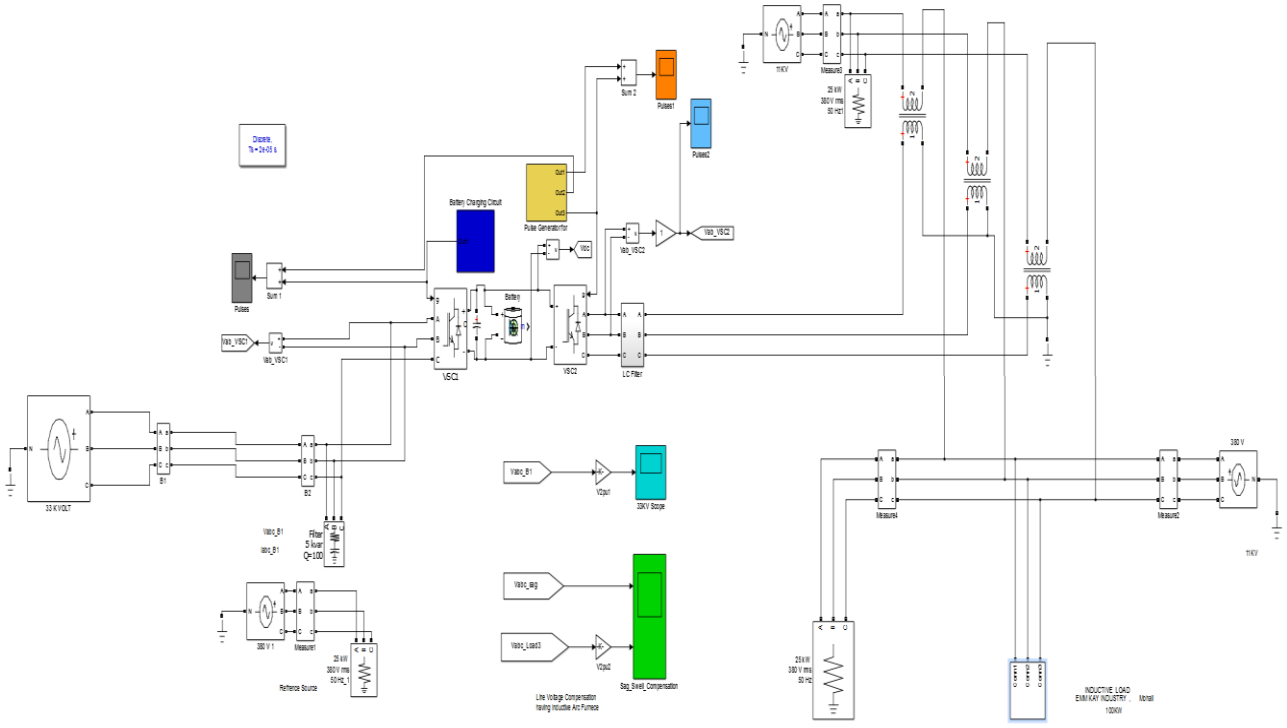

Figure 4 Simulink Model with Compensation

V SIMULATION RESULTS

The simulation is performed on the test system with Inductive load using MATLAB SIMULINK. The simulations are performed for the cases: (i) without DSTATCOM and (ii) with DSTATCOM - in the circuit. The system performance is analysed. These cases are summarized below:

Case I:WITHOUT DSTATCOM

The scope result is given below of uncompensated load when Sag, swell and harmonics travel on line.

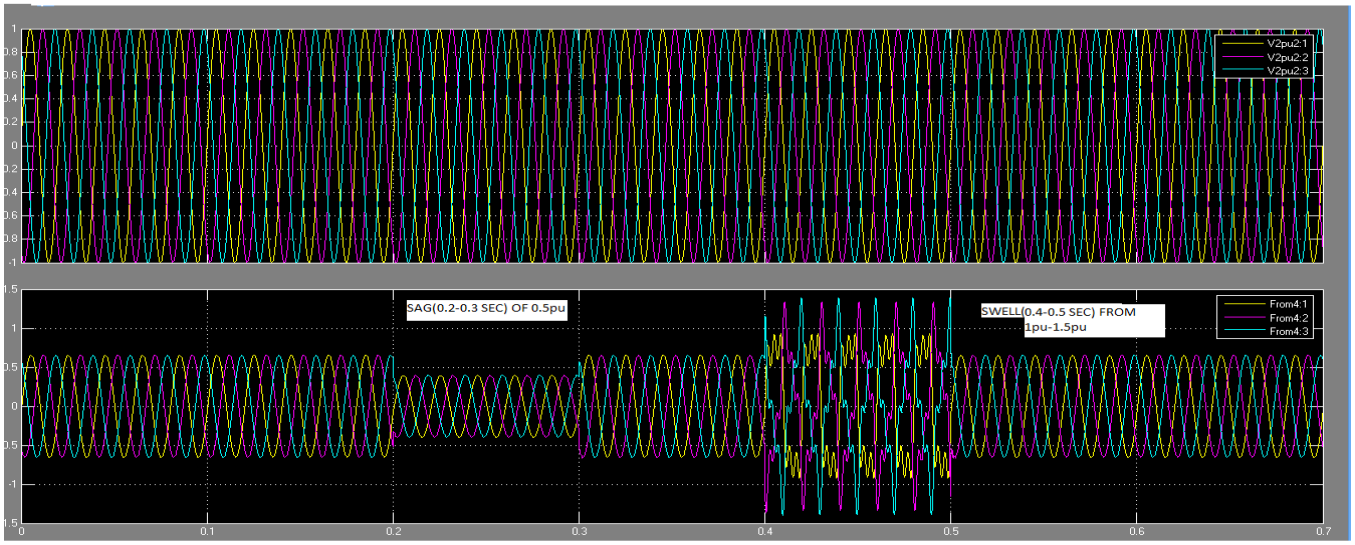

Figure 5 Load current without DSTATCOM

So in the above scope we can observe that there is SAG from 0.2 to 0.3 Sec. of 0.5 pu .Then from 0.5 to 0.6 sec we got swell which cause due to sudden open of heavy load.

But we find in swell due to harmonics the voltage rise from 1 p.u to 1.5 pu. As it consist of 3rd and 5th fundamental harmonics

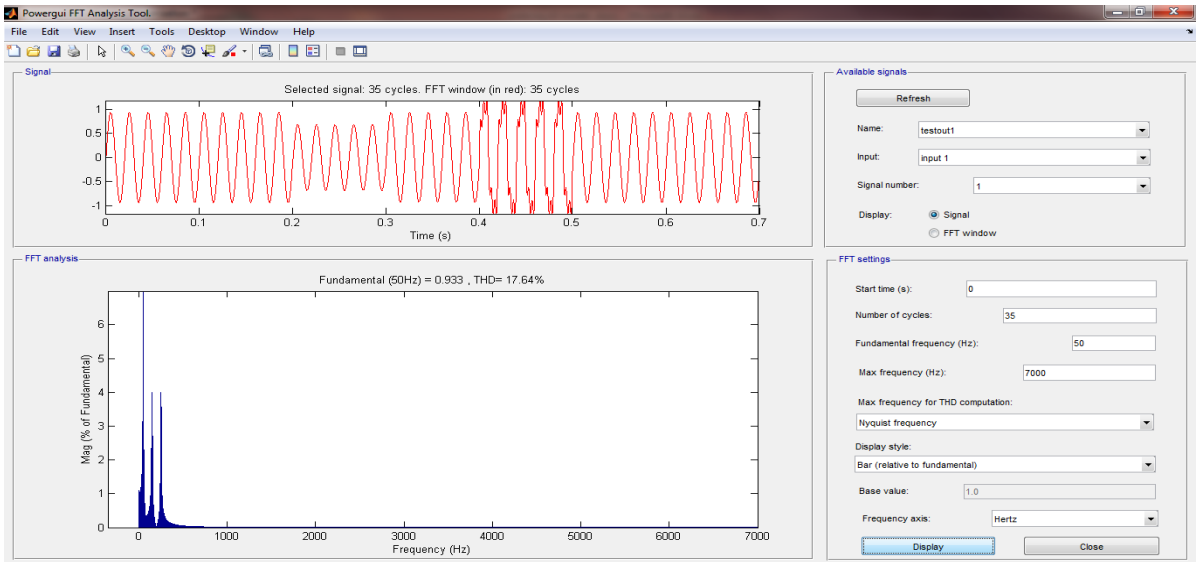

Figure 6 FFT Analysis

So from above FFT analysis we find that how much distorting .here we got THD =17.54% and voltage magnitude is 0.993 pu.

Case II: WITH DSTATCOM

The scope result is given below of compensated load

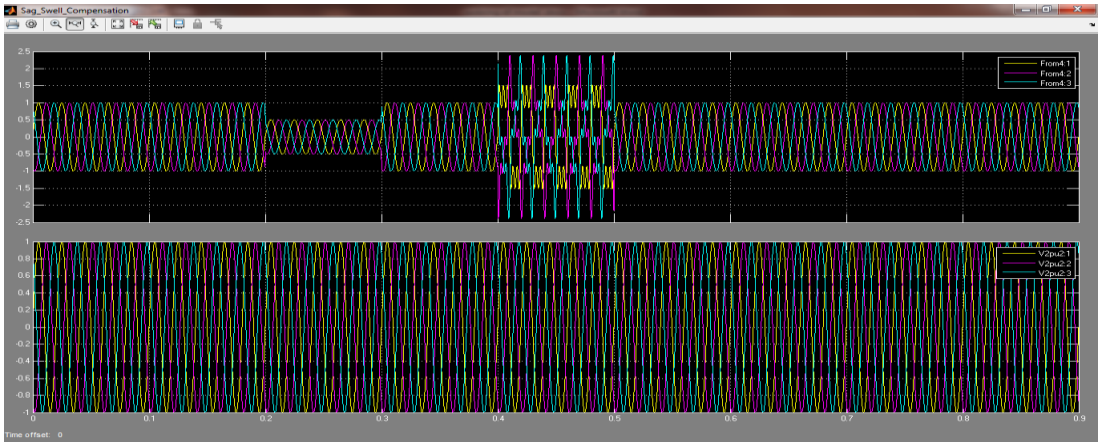

Figure 7 Load current with DSTATCOM

The firing angle of the Inverter is given below.

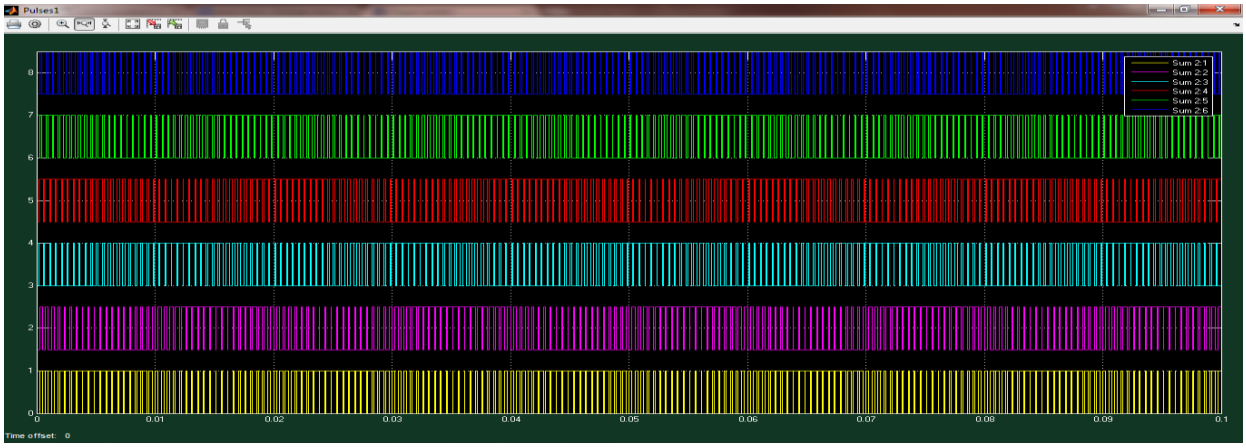

Figure 8 Firing Pluses to IGBT

The above graph show the firing angle of the IGBT as our system consist of 3 arm 6 IGBT so we need to trigger it. So from above it is clear that how it control the firing at 2000 Hz.as it provide the compensation for sag, swell and harmonics

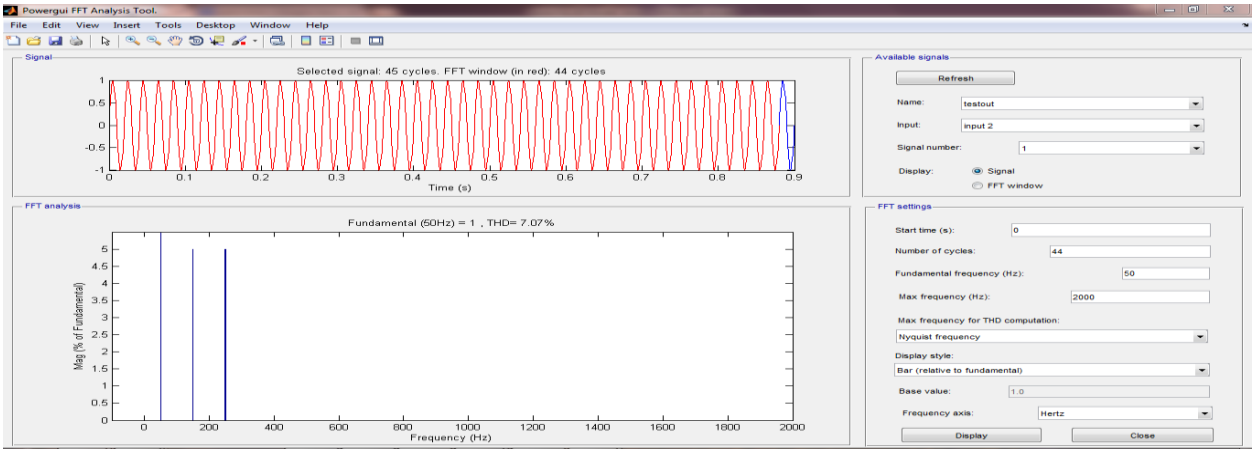

Figure 9 FFT Analysis with compensated Load

So from above FFT analysis it is observe that the THD is reduce to 75% and also voltage level increase to 1pm which is before 0.993 pu.

So from this observation it is clear that the using of Statcom results in reduction of THD and hence improves the power quality of the system.

VI CONCLUSION

In this work, a fast and cost effective D-statcom is proposed to mitigate the voltage sag, swell and other fault condition in distribution system consisting of inductive load.

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, swell and harmonics conditions are mitigated. D-STATCOM is proved to compensate current. Current harmonics has been reduced considerably. Harmonics generated at load side has THD of 17.54% and voltage magnitude is 0.933 pu which has been compensated to 7.07% and also voltage level increase to 1pu which is before 0.993 pu. So from this observation it is clear that the using of D-Statcom results in reduction of THD and hence improves the power quality of the system.

VII REFRENCES

[1] B.N.Singh, A.Adya, A.P.Mittal, Bhim Singh, "Application of DSTATCOM for Mitigation of Voltage Sag for Motor Loads in Isolated Distribution Systems," IEEE ISIE 2006, July 9-12 2006, pp.1806- 1811.

[2] R. Chiumeo, C. Gandolfi, "Simulations of a possible configuration of Premium Power Park", International Conference on Renewable Energies and Power Quality (ICREPQ'10) Granada (Spain), 23-25th March, 2010

[3] B. Singh and J. Solanki, "A comparative study of control algorithms for DSTATCOM for load compensation," in Proc. IEEE ICIT, Dec.15–17, 2006, pp.1492–1497.

[4] Soo-Young Jung, Tae-Hyun Kim, Seung-II Moon, Byung-Moon Han, "Analysis and Control of DSTATCOM for a line Voltage Regulation," in Proc. IEEE, 2002, pp.729- 734.

[5] Dinesh Kumar and Rajesh, "Analysis and modelling of Distribution Static Compensator for unbalance and Non-Linear Load,'' IEEE Press, 2005, pp.1-6.

[6] M.G. Molina and P.E. Mercado, "The Dynamic Performance of a Distribution Static Compensator Coupled with an Energy Storage System for Power Quality Improvement,'' IEEE Press, 2006, pp.1-7.

[7] Sunil Kumar and Bhim Singh, "Modified Power Balance Theory for Control of DSTATCOM,'' IEEE Press, 2010, pp.1-8.

[8] Gerard Ledwich and ArindamGhosh, "Load Compensating DSTATCOM in WeakAC systems,'' IEEE Transactions on Power Delivery, vol.18, no.4, October 2003,pp.1302-1309.