International Journal of Electrical and Electronics Research ISSN 2348-6988 (online)
Vol. 3, Issue 1, pp: (6-11), Month: January - March 2015, Available at: www.researchpublish.com

Modeling and Simulation of a Distribution Statcom (D-Statcom) For Power Quality Problems

[1]Pushpa Chakravarty, [2]Dr. A.K. Sharma

[1]M.E. Scholar, Depart. of Electrical Engineering, Jabalpur Engineering College, Jabalpur, India.
[2]HOD, Depart. of Electrical Engineering, Jabalpur Engineering College, Jabalpur, India.

Abstract: **This paper presents the systematic procedure of the modeling and simulation of a Distribution STATCOM (D-STATCOM) for power quality problems & maintains the voltage profile based on Sinusoidal Pulse Width Modulation (SPWM) technique. It also explains the problems that are due to poor Power Quality in electrical systems. In this case, injection of harmonics from power electronics devices into the system also caused some problems which were later overcome by using SATCOM and RLC filters. The obtained results show that STATCOM is very efficient and effective for maintain the voltage profile. It is shown that by using the right technology a variety of Power Quality problems can be solved rendering installations trouble free and more efficient. The major problems dealt here is the voltage sag and swell. To solve this problem, custom power devices are used. One of those devices is the Distribution STATCOM (D-STATCOM), which is the most efficient and effective modern custom power device used in power distribution networks. D-STATCOM injects a current in to the system to correct the voltage sag and swell. STATCOM is one of the key as shunt controllers in flexible alternating current transmission system (FACTS) to control the transmission line voltage and can be used to enhance the load ability of transmission line and extend the voltage stability margin the control of the Voltage Source Converter (VSC) is done with the help of SPWM. The proposed D-STATCOM is modeled and simulated using MATLAB/SIMULINK software.**

Keywords: **Distribution STATCOM (D-STATCOM), Power quality problems, Sinusoidal Pulse, Width Modulation (SPWM), Voltage profile, Voltage, Source Converter (VSC), FACTS devices.**

1. INTRODUCTION

In power distribution networks, reactive power is the main cause of increasing distribution system losses and various power quality problems. Conventionally, Static Var Compensators (SVCs) have been used in conjunction with passive filters at the distribution level for reactive power compensation and mitigation of power quality problems. Though SVCs are very effective system controllers used to provide reactive power compensation at the transmission level, their limited bandwidth, higher passive element count that increases size and losses, and slower response make them inapt for the modern day distribution requirement.

There are a lot of researchers who has analysis with different way as S.Premalatha, shows the modelling of D-statcom system. [1], to show the effect of controller on the voltage sag mitigation and reactive power compensation. Bhim Singh, deals with the power quality improvement. *J. Ganesh Prasad Reddy, & K. Ramesh Reddy* are designed with modern semiconductor devices. These semiconductor devices are less sensitive to voltage fluctuations [2] Ramesh & Sudhakaran used DSTATECOM for enhancement of power quality in power distribution network with unbalanced, nonlinear and variable loads[4] Another compensating system has been proposed by, employing a combination of SVC and active power filter, which can compensate three phase loads in a minimum of two cycles. Thus, a controller which continuously monitors the load voltages and currents to determine the right amount of compensation required by the system and the less response time should e a viable alternative. Distribution Static Compensator (DSTATCOM) has the capacity to overcome the above mentioned drawbacks by providing precise control and fast response during transient and steady state, with reduced foot print and weight.

A DSTATCOM is basically a converter based distribution flexible AC transmission controller, sharing many similar concepts with that of a Static Compensator (STATCOM) used at the transmission level. At the transmission level, STATCOM handles only fundamental reactive power and provides voltage support, while a DSTATCOM is employed at the distribution level or at the load end for dynamic compensation.

Power Quality:

The electric power industry comprises electricity generation (AC power), electric power transmission and ultimately electricity distribution to an electricity meter located at the premises of the end user of the electric power. The electricity then moves through the wiring system of the end user until it reaches the load. The complexity of the system to move electric energy from the point of production to the point of consumption combined with variations in weather, generation, demand and other factors provide many opportunities for the quality of supply to be compromised.

While "power quality" is a convenient term for many, it is the quality of the voltage—rather than power or electric current—that is actually described by the term. Power is simply the flow of energy and the current demanded by a load is largely uncontrollable.

2. MODELING AND SIMULATION OF D-STATCOM

The modeling and simulation of a Distribution STATCOM (DSTATCOM) for power quality problems, voltage sag and swell based on Sinusoidal Pulse Width Modulation (SPWM) technique. Power quality is an occurrence manifested as a nonstandard voltage, current or frequency that results in a failure of end use equipments. The major problems dealt here is the voltage sag and swell. To solve this problem, custom power devices are used. One of those devices is the Distribution STATCOM (D-STATCOM), which is the most efficient and effective modern custom power device used in power distribution networks. D-STATCOM injects a current in to the system to correct the voltage sag and swell. The control of the Voltage Source Converter (VSC) is done with the help of SPWM.

In this process we are showing the differences between with D-STATCOM and without D-STATCOM.

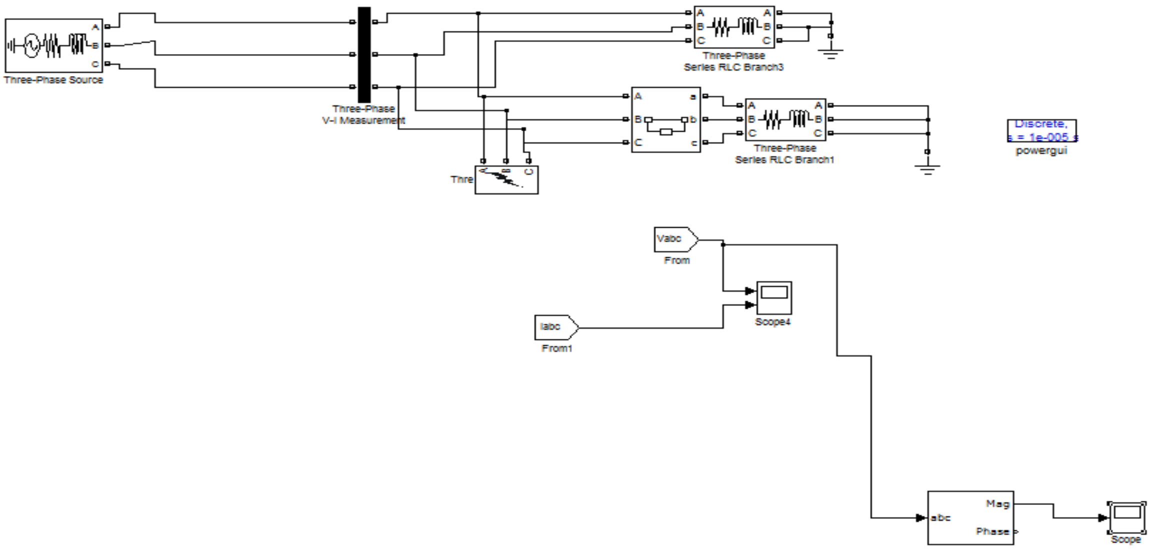

Figure- 1

STATCOM is one of the facts devices it is used to reduce the faults and power quality such as voltage sags, swells and harmonics. Voltage dips are considered to be one of the most severe disturbances to the industrial equipments. Voltage support at a load can be achieved by reactive power injection at the load point of common coupling. D-STATCOM injects a current into the system to correct the voltage sag and swell.

Working process: when power r voltage r current is flowing for one place to other place in this process faults can be occur. In order to reduce these faults we are using FACTS devices.

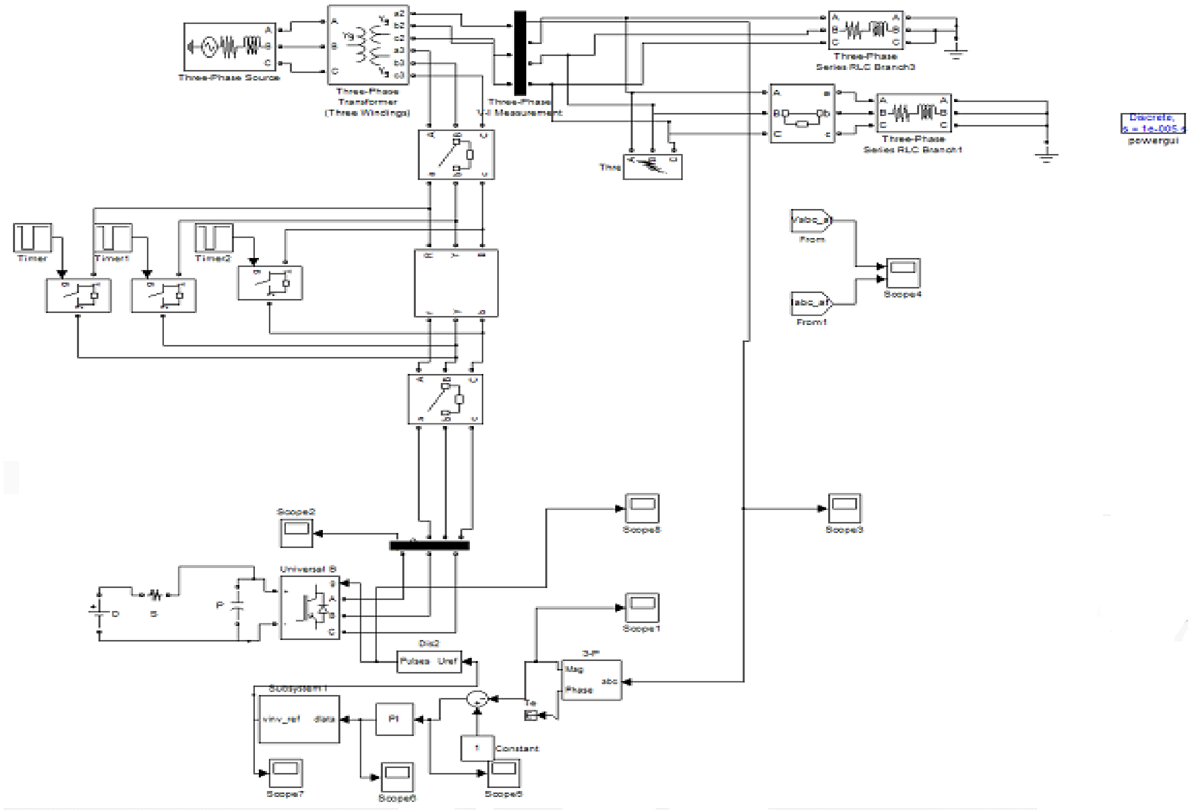

Figure- 2

In facts using STATCOM compensator to reduce power quality problems. in place were faults is occurring we are using facts devices in this project we are using STATCOM to increases the power quality and reduce the reactive power control by using control technique i.e. pi- PWM technique. The place where faults and Power quality problems encompass a wide range of disturbances such as voltage sags, swells, flickers, harmonic distortion, impulse transients, and interruptions.

By using pi –PWM we are comparing the input and output values of voltages in closed loop system finding the error.

Pulse-Width Modulation (PWM):

Pulse-duration modulation (PDM), is a modulation technique used in communications systems to encode the amplitude of a signal into the width of the pulse (duration) of another signal. Although this modulation technique can be used to encode information for transmission, its main use is to allow the control of the power supplied to electrical devices, especially to inertial loads such as motors. In addition, PWM is one of the two principal algorithms used in photovoltaic solar battery chargers, the other being MPPT.

The average value of voltage (and current) fed to the load is controlled by turning the switch between supply and load on and off at a fast rate. The longer the switch is on compared to the off periods, the higher the total power supplied to the load.

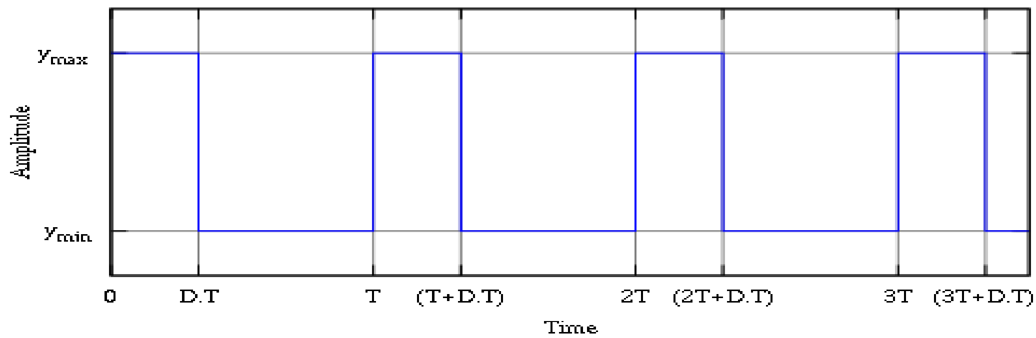

Figure- 3

The PWM switching frequency has to be much higher than what would affect the load (the device that uses the power), which is to say that the resultant waveform perceived by the load must be as smooth as possible. Typically switching has to be done several times a minute in an electric stove, 120 Hz in a lamp dimmer, from few kilohertz (kHz) to tens of kHz for a motor drive and well into the tens or hundreds of kHz in audio amplifiers and computer power supplies.

The term *duty cycle* describes the proportion of 'on' time to the regular interval or 'period' of time; a low duty cycle corresponds to low power, because the power is off for most of the time. Duty cycle is expressed in percent, 100% being fully on.

The main advantage of PWM is that power loss in the switching devices is very low. When a switch is off there is practically no current, and when it is on and power is being transferred to the load, there is almost no voltage drop across the switch. Power loss, being the product of voltage and current, is thus in both cases close to zero. PWM also works well with digital controls, which, because of their on/off nature, can easily set the needed duty cycle.

PWM has also been used in certain communication systems where its duty cycle has been used to convey information over a communications channel.

Pulse-width modulation uses a wave whose pulse width is modulated resulting in the variation of the average value of the waveform. If we consider a pulse waveform $f(t)$, with period T, low value y_{min}, a high value y_{max} and a duty cycle D (see figure 1), the average value of the waveform is given by:

$$\bar{y} = \frac{1}{T}\int_0^T f(t)\,dt.$$

As $f(t)$ is a pulse wave, its value is y_{max} for $0 < t < D \cdot T$ and y_{min} for $D \cdot T < t < T$. The above expression then becomes:

$$\begin{aligned}\bar{y} &= \frac{1}{T}\left(\int_0^{DT} y_{max}\,dt + \int_{DT}^{T} y_{min}\,dt\right)\\ &= \frac{D \cdot T \cdot y_{max} + T\,(1-D)\,y_{min}}{T}\\ &= D \cdot y_{max} + (1-D)\,y_{min}.\end{aligned}$$

This latter expression can be fairly simplified in many cases where $y_{min} = 0$ as $\bar{y} = D \cdot y_{max}$. From this, it is obvious that the average value of the signal ($\bar{y}$) is directly dependent on the duty cycle D.

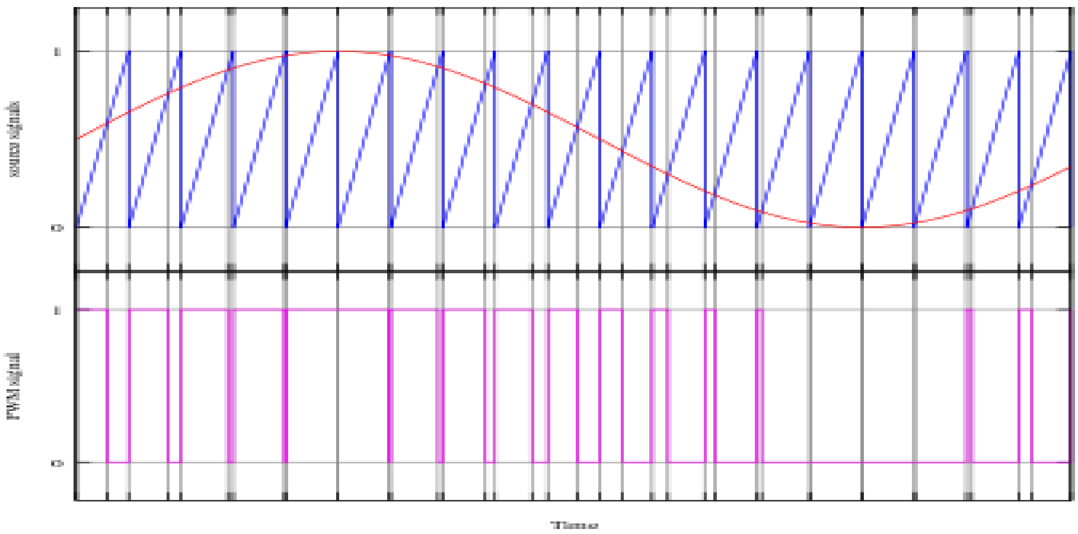

Figure- 4

Fig. 2: A simple method to generate the PWM pulse train corresponding to a given signal is the interceptive PWM: the signal (here the red sine wave) is compared with a saw tooth waveform (blue). When the latter is less than the former, the PWM signal (magenta) is in high state (1). Otherwise it is in the low state (0).

The simplest way to generate a PWM signal is the interceptive method, which requires only a saw tooth or a triangle waveform (easily generated using a simple oscillator) and a comparator. When the value of the reference signal (the red sine wave in figure 2) is more than the modulation waveform (blue), the PWM signal (magenta) is in the high state, otherwise it is in the low state.

3. SIMULATION RESULTS

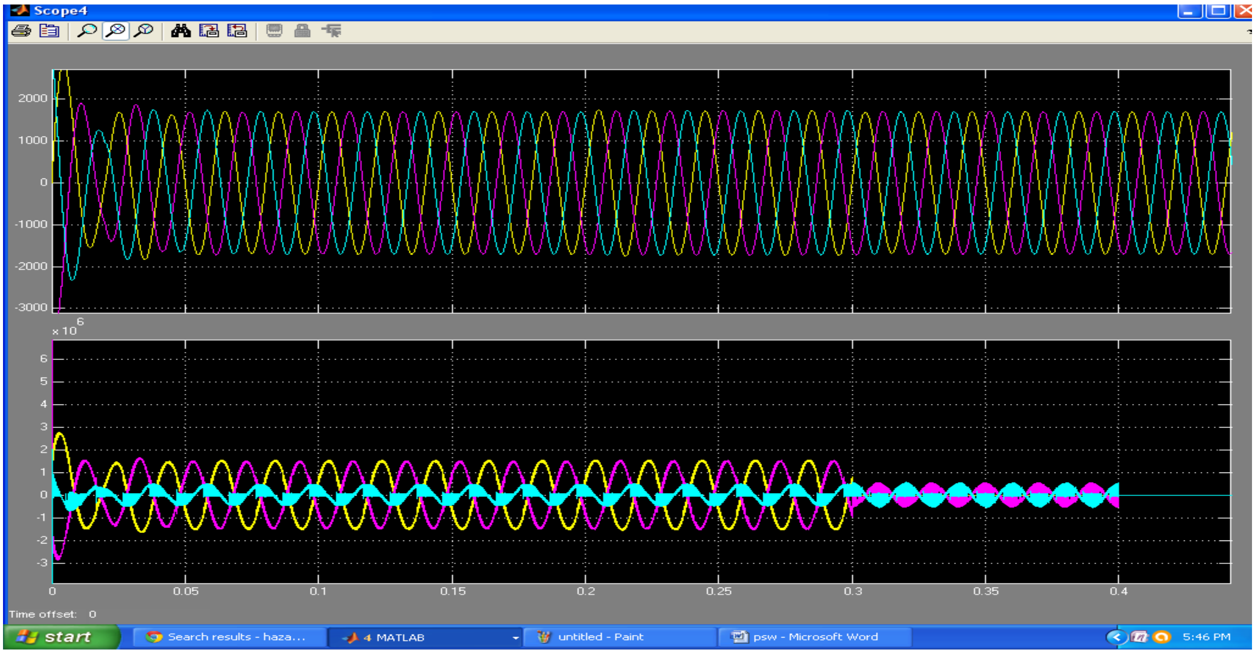

Figure- 5 Voltages and current graphs

X axis: time

Y axis: voltage or current

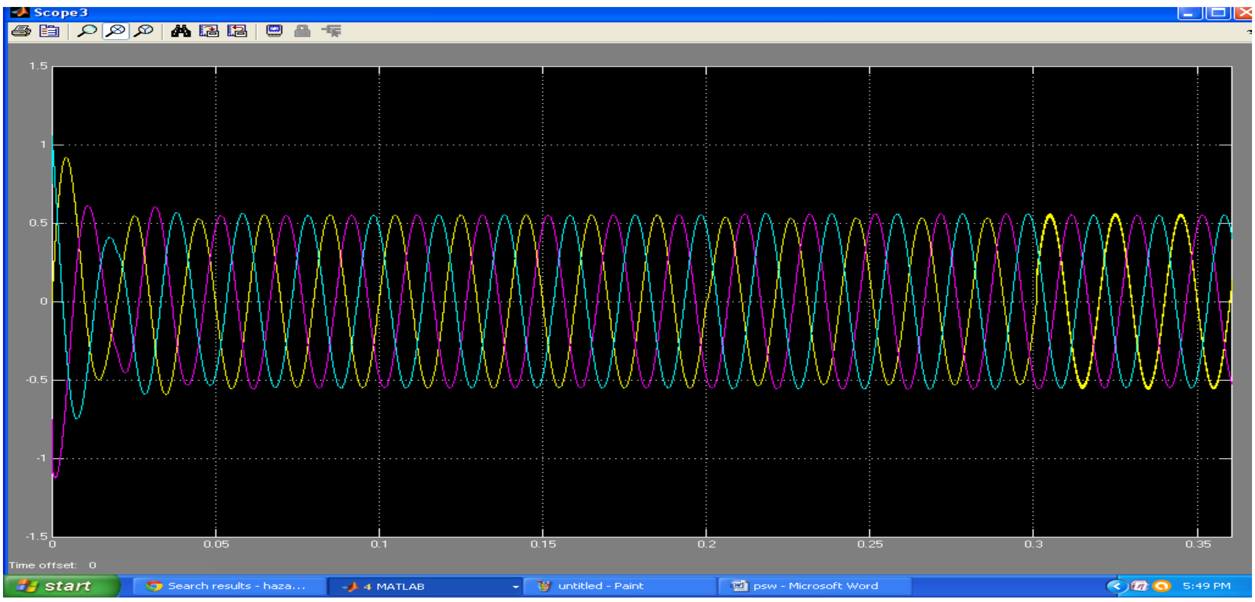

Figure- 6 Voltage graphs at load

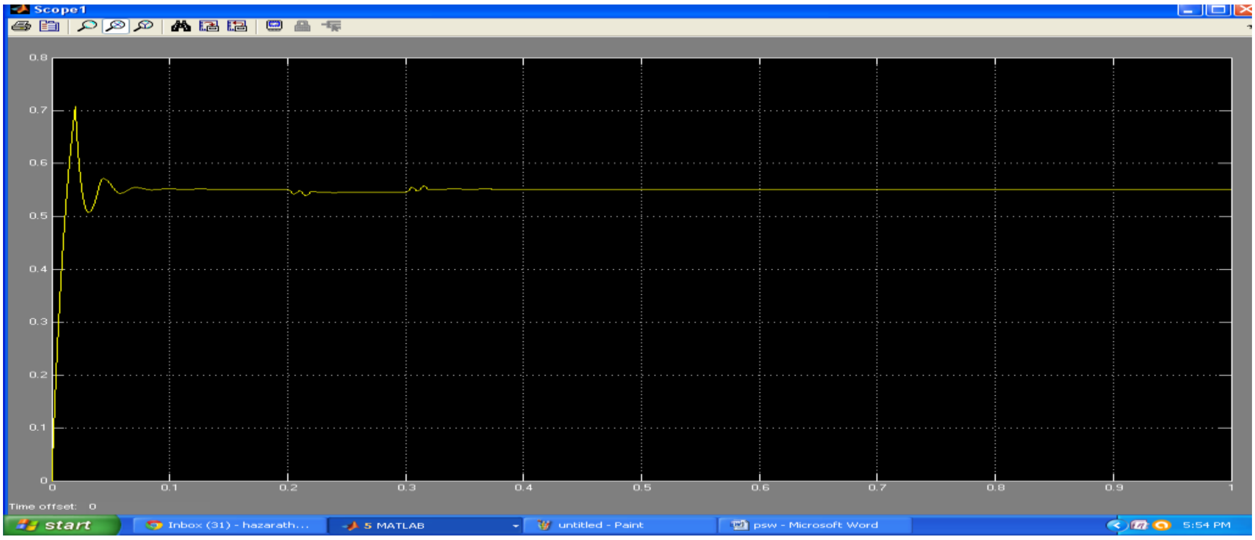

Figure- 7 Magnitude graph

4. CONCLUSION

This paper has presented the power quality problems such as voltage sags and swell and improves voltage profile of distributed power network. Compensation techniques of custom power electronic device D-STATCOM was presented. The design and applications of D-STATCOM for voltage sags or swells and comprehensive results were presented. The Voltage Source Convert was implemented with the help of Sinusoidal Pulse Width Modulation. For modelling and simulation of a D-STATCOM by using the highly developed graphic facilities available in MATLAB/SIMULINK were used. The simulations carried out here showes that the D-STATCOM has better voltage regulation capabilities.

REFERENCES

[1] S.Premalatha, G.PunithaValli, “Digital Simulation of D-statcom System for Improving Power Quality” EEE Department, Anna University Velammal Engineering College, Chennai,Tamilnadu, India 2012 IEEE.

[2] J. Ganesh Prasad Reddy, & K. Ramesh Reddy,“Power Quality Improvement Using Neural Network Controller Based Cascaded H-Bridge Multilevel Inverter Type D-STATCOM EEE, JNTUH, Hyderabad, India 2012.

[3] Guohong Wu, Kazutoshi Chubachi, Chung-Neng Huang ,Longyun Kang “An Approach to Voltage Quality Improvement by Introduction of STATCOM for Distribution System with Renewable Power Generations”, IEEE PES ISGT ASIA 2012 15691

[4] Ramesh J., Sudhakaran M., “Enhancement of Power Quality using Three Phase DSTATCOM for Variable Load”, 978-1-4673-4634-4/12/$31.00 ©2012 IEEE.

[5] Abdelazeem A. Abdelsalam, Adel M. Sharaf, “A NOVEL FACTS COMPENSATION SCHEME FOR POWER QUALITY IMPROVEMENT IN WIND SMART GRID”, 978-1-4673-1433-6/12/$31.00 ©2012 IEEE

[6] Bhim Singh, Gaurav Kumar Kasal, and Sanjay Gairola, Bhim Singh, “Power Quality Improvement in Conventional Electronic Load Controller for an Isolated Power Generation, IEEE TRANSACTIONS ON ENERGY CONVERSION’’, VOL. 23, NO. 3, SEPTEMBER 2008

[7] Yunwei Li, D. Mahinda Vilathgamuwa, Poh Chiang Loh, “Microgrid Power Quality Enhancement Using a Three-Phase Four-Wire Grid-Interfacing Compensator”. IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS, VOL. 41, NO. 6, NOVEMBER/DECEMBER 2005.

[8] Siyu Leng, II-Yop Chung, and David A. Cartes, “Distributed Operation of Multiple Shunt Active Power Filters Considering Power Quality Improvement Capacity”. 2010 2nd IEEE International Symposium on Power Electronics for Distributed Generation Systems.

[9] Sagnika Ghosh, Mohd. Hasan Ali, “Load Angle Based Optimal Reclosing Technique of Circuit Breakers for Power Quality Enhancement”. 978-1-4799-0053-4/13/$31.00 ©2013 IEEE.