VOLTAGE STABILITY ENHANCEMENT IN TRANSMISSION LINE USING FACTS DEVICES WITH MULTI-LEVEL INVERTER

[1]V.Seenu, [2]Dr.S.Thangalakshmi

[1]M.E. Scholar, [2]Associate Professor
Department of Electrical and Electronics Engineering
GKM College of Engineering and Technology, Chennai.

***Abstract*-The demand for the quality power is increasing nowadays due to various nonlinear loads. Voltage compensation is the main consideration in the power system because uncompensated system will lead to the system fault and the equipment connected to the power system may damage, hence it is very much necessary to keep the transmission line compensated. The compensation also makes the system stable. The multilevel inverters provide the better compensation than the normal inverter in the compensation unit. Static Synchronous Compensator (STATCOM) is the compensation unit used to compensate the power system. DSTATCOM is the distribution static synchronous compensator placed in the distribution side. This project presents an investigation of nine-Level Cascaded H - bridge (CHB) Inverter as Distribution Static Compensator (DSTATCOM) in Power System for compensation of reactive power and harmonics. The compensations of CHB inverter are low harmonic distortion, reduced number of switches and suppression of switching losses.**

***Key Words:* voltage stability, transmission line, cascade H-bridge inverter, DSTATCOM, multilevel inverter.**

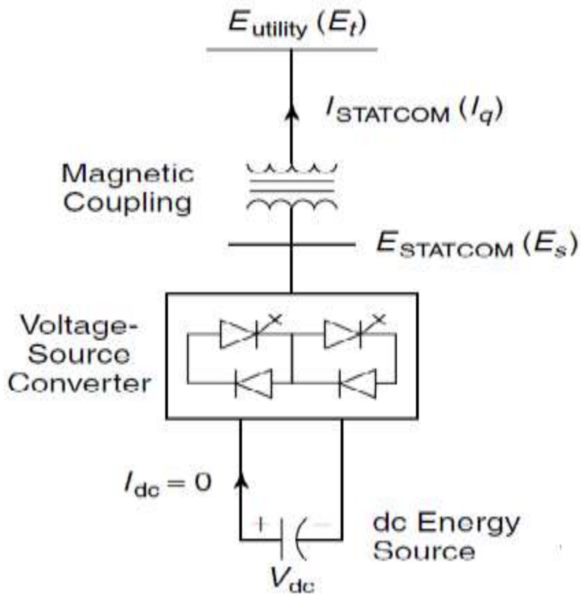
I. INTRODUCTION

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. There are two aspects to the problem of reactive power compensation, load compensation and voltage support. 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 SVC and STATCOM used to reduce the flow of heavily loaded in lines; low system losses improve the stability of the network and increase the efficiency of the power system. [1]. the system is interfaced to the AC grid by the conventional rectifier and transformer, for a large power rating system. Distributed method is used for a PV and battery system. The state of charge (SOC) is not involved into the power management which is a very important factor for battery operation [2].

D-STATCOM model with 8 bus system to protect the utility from voltage sag/flicker which caused by heavy load and also during transient condition. D-STATCOM provide leading (or) lagging reactive power to active power stability, power factor correction, load balancing and harmonic compensation of load. The proposed method improves the power quality but it reduces the reliability [3]. SRF is used to generate current reference for compensation and conventional PI controllers can be used as the controller. The design of the closed loop controllers is kept simple by modeling them as first order systems. Computationally simple and efficient SVM technique used to utilize DC bus voltage more efficiently and generates less harmonic distortion in a three phase voltage source inverter analyzed [4].

To improve the power quality of grid connected wind/PV hybrid energy system by reduction of harmonic content based on STATCOM and UUPQC using different controllers has been discussed [5]. A three-phase bridge inverter circuit that is supplied by two neutral-clamped dc storage capacitors realizes the DSTATCOM. Three filter capacitors, one for each phase, are connected in parallel with the DSTATCOM to eliminate high-frequency switching components. The voltage across the filter capacitor is controlled by a dead-beat controller to maintain the ac bus voltage. The magnitude of the bus voltage is chosen as nominal value, i.e., 1.0 p.u., while its phase angle is obtained through a feedback loop that maintains the voltage across the dc storage capacitors proposed[6].



The STATCOM used in distribution systems is called DSTACOM (Distribution-STACOM) and its configuration is the same, but with small modifications. It can exchange both active and reactive power with the distribution system by varying the amplitude and phase angle of the converter voltage with respect to the line terminal voltage. The harmonic reduction by using STATCOM. It is used for current compensation. The reduction has done effectively by implementing suitable Hysteresis controller. The total harmonic distortion level of load current with and without controller is analysed[7].

Multi-level inverters are the modification of basic bridge inverters. They are normally connected in series to form stacks of level. It should have less switching devices as far as possible. It should be capable of enduring very high input voltage such as HVDC transmission for high power applications. The STATCOM controller for five level H bridge multilevel inverter based STATCOM and also the controller regulate the capacitor voltage of the STATCOM. The voltage profile maintained by compensating the reactive power[8]. The multilevel inverter using cascaded-inverter with separate dc sources (SDCSs) synthesize a favourable voltage from several independent sources of dc voltages, which may be achieved from batteries, solar cells and fuel cells. This structure recently has become very widespread in ac power supply and adjustable speed drive applications. The cascade multilevel inverter with T- STATCOM. Its mainly used to improve the power quality,reduce the number of required switches in the inverter and reduce the switching losses[9]. To improve the power quality and power factor in the distribution network. The STATCOM mainly used to reduce the THD[10][11].

Power Quality plays a vital role in present day development. The current harmonics and reactive power produced by the nonlinear loads have become a serious problem in many countries. Over the past few years the growth in the use of nonlinear loads has caused many power quality problems like high current harmonics, low power factor and excessive neutral current. Nonlinear loads appear to be current sources injecting harmonic currents into the supply network through the utilities Point of Common Coupling. The customers will receive distorted supply voltage, which may cause over heating of power factor correction capacitors, motors, transformers and cables, and mal operation of some protection devices. Therefore, it is important to eliminate the harmonic currents produced by nonlinear loads. To enhancement of voltage sag/swell, harmonic distortion and power factor was proposed[12].

The quality of electric current in the commercial and industrial electric installation is degraded incontestably because of two major reasons such as external disturbances due to cuts, the hollow and the points caused by communications and atmospheric phenomena and internal causes specific to each site, which combines both linear and nonlinear load. STATCOM is used for harmonic reduction in a grid connected wind energy system. STATCOM uses hysteresis and PI controller for reduction of THD[13]. Proportional and Integral (PI) controllers were developed because of the desirable property that systems with open loop transfer functions of type 1 or above have zero steady state error with respect to a step input. The K_P and K_I, gain value play a more important in the PI controller. The proportional responses can be adjusted by multiplying the error by constant K_p, called proportional gain.The contribution from integral term is proportional to both the magnitude of error and duration of error. To Oscillation stability is an important issue in order to ensure voltage stability and reduces sag swell and reduces the losses[14]. A STATCOM with self-oscillating bidirectional dc-dc converter for interfacing battery energy storage in a stand -alone induction generator system. This proposed method improves the power quality[15]. FACTS controllers have been mainly used for solving various power system stability control problems proposed [16] .The design of combined operation of unified power quality conditioner and a hybrid power generation is proposed. The proposed system is composed of PV array and WECS connected to DC link and it is able to inject the active power to grid in addition to its ability in improvement of power quality in distribution system[17]. The power electronic based power conditioning using custom power devices like STATCOM can be effectively utilized to improve the quality of power supplied. It has a capability to cancel out the harmonics of the load current[18].

II. PROBLEM STATEMENT

Reactive power is the power that supplies the stored energy in reactive elements. Power, as we know, consists of two components, active and reactive power. The total sum of active and reactive power is called as apparent power. In AC circuits, energy is stored temporarily in inductive and capacitive elements, which results in the periodic reversal of the direction of flow of energy between the source and the load. The average power after the completion of one whole cycle of the AC waveform is the real power, and this is the usable energy of the system and is used to do work, whereas the portion of power flow which is temporarily stored in the form of magnetic or electric fields and flows back and forth in the transmission line due to inductive and capacitive network elements is known as reactive power. The Controlling active and reactive powers as well as damping power system oscillation in transient mode has been dealt[19].

In an inductive circuit, we know the instantaneous power to be:

$$p = V_{max}\, I_{max} \cos\omega t \cos(\omega t - \theta)$$

The instantaneous reactive power is given by:

$$P = \frac{VmaxImax}{2} cos\theta(1 + cos2\omega t) + \frac{VmaxImax}{2} sin\theta sin2\omega t$$

Where,

p = instantaneous power

Vmax = Peak value of the voltage waveform

Imax = Peak value of the current waveform

ω = Angular frequency

2πf where f is the frequency of the waveform.

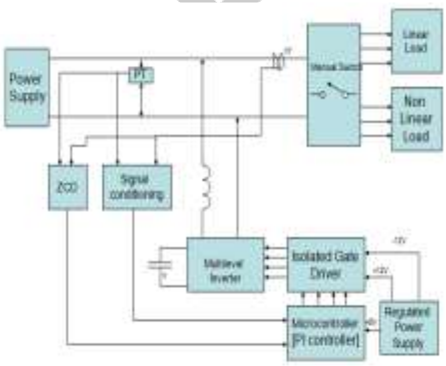
t = Time period

θ = Angle by which the current lags the voltage in phaseFrom here, we can conclude that the instantaneous reactive power pulsates at twice the system frequency and its average value is zero and the maximum instantaneous reactive power is given by:

$$Q = |V|\,|I| \sin\theta$$

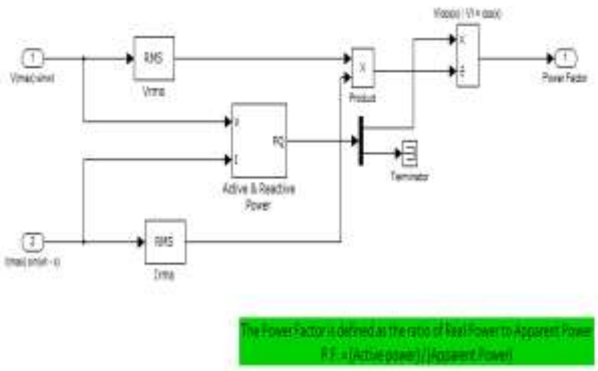
The zero average does not necessarily mean that no energy is flowing, but the actual amount that is flowing for half a cycle in one direction, is coming back in the next half cycle.

III.EXPERIMENTAL ANALYSIS



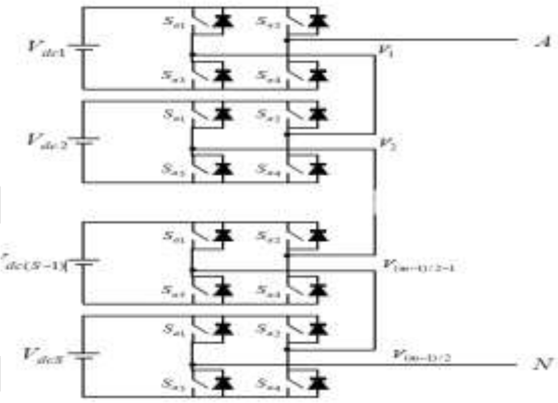
A STATCOM consists of a three phase inverter (generally a PWM inverter) using SCRs, MOSFETs or IGBTs, a D.C capacitor which provides the D.C voltage for the inverter. A link reactor which links the inverter output to the a.c supply side, filter components to filter out the high frequency components due to the PWM inverter. The STATCOM operates according to voltage source principles, combining unique PWM (Pulsed Width Modulation) switching in MOSFET. The device’s effective rating and response speed are unequalled, and can be dedicated to active harmonic filtering and voltage flicker mitigation.

POWER FACTOR MEASUREMENT



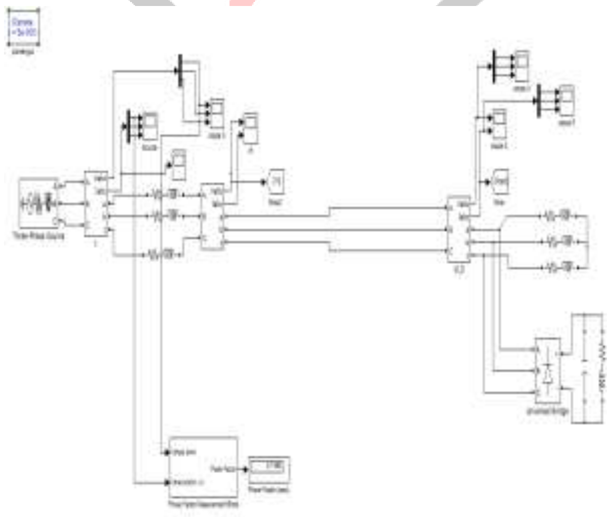
CASCADED H-BRIDGE INVERTER TOPOLOGY

The N-level cascaded H-bridge multilevel inverter comprises of (N-1)/2 series connected single phase H-bridges per phase, for which each H-bridge has its own isolated dc source shows in the fig one phase of a n-level cascaded H-bridge inverter.



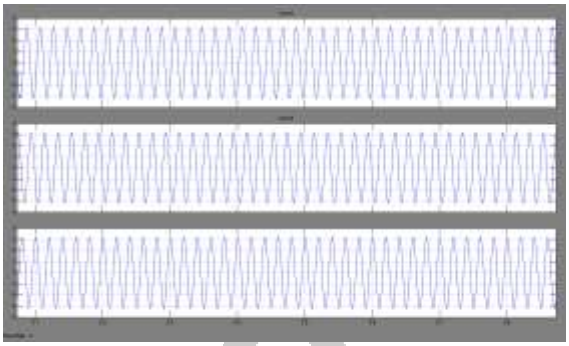
The cascaded H-bridge multilevel inverter is based on multiple two level inverter outputs (each H-bridge), with the output of each phase shifted. Despite four diodes and switches, it achieves the greatest number of output voltage levels for the fewest switches. Its main limitation lies in its need for isolated power sources for each level and for each phase, although for VA compensation, capacitors replace the dc supplies, and the necessary capacitor energy is only to replace losses due to inverter.

SIMULATION CIRCUIT OF WITHOUT COMPENSATION



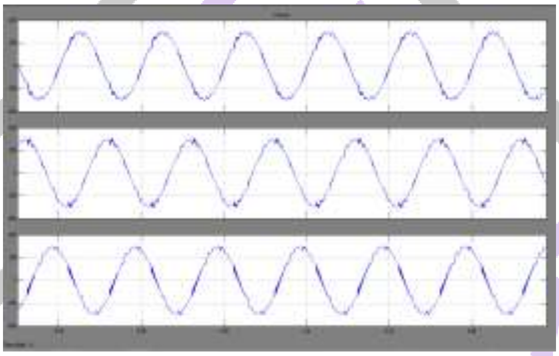
Reactive power is the power that supplies the stored energy in reactive elements. Power, as we know, consists of two components, active and reactive power. The total sum of active and reactive power is called as apparent power. In AC circuits, energy is stored temporarily in inductive and capacitive elements, which results in the periodic reversal of the direction of flow of energy between the source and the load. The average power after the completion of one whole cycle of the AC waveform is the real power, and this is the usable energy of the system and is used to do work, whereas the portion of power flow which is temporarily stored in the form of magnetic or electric fields and flows back and forth in the transmission line due to inductive and capacitive network elements is known as reactive power.

SOURCE CURRENT WAVEFORM

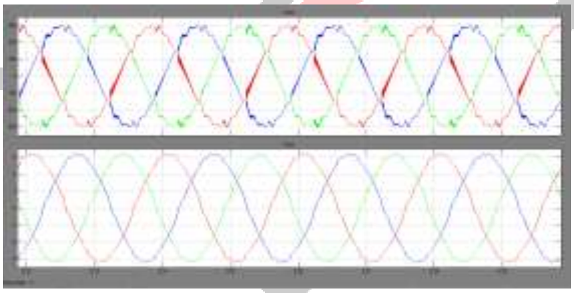


The voltage source waveform in without compensation. In this wave form some distortion was occurred.

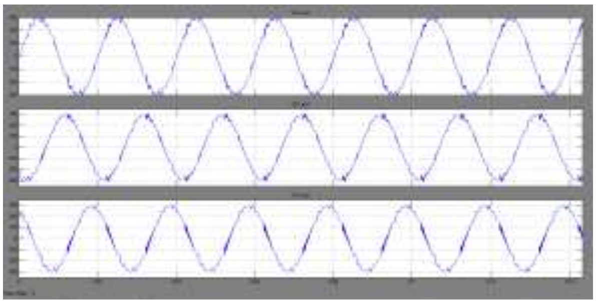
SOURCE VOLTAGE WAVEFORM



LOAD VOLTAGE WAVEFORM

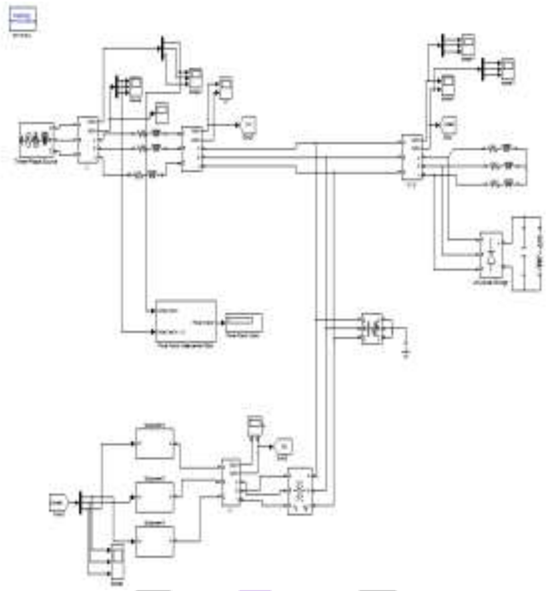


THREE PHASE VOLTAGE MEASUREMENT



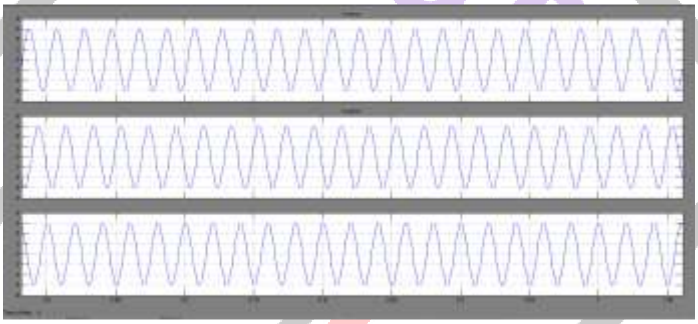
The three phase voltage waveform measured during the without compensation. The each phase are having some distortion

TRANSMISSION LINE USING STATCOM WITH MULTILEVEL INVERTER

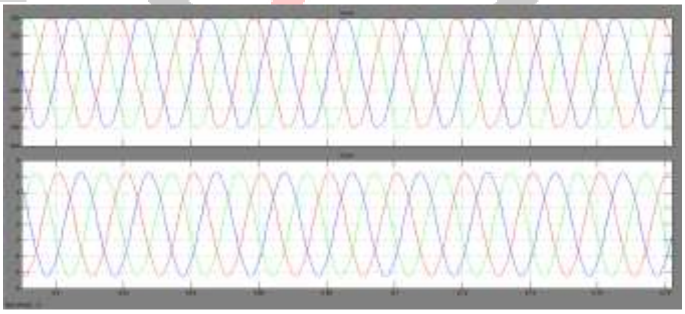


This is the three phase transmission line, the STATCOM with multilevel inverter connected in the transmission line.Here, the multilevel inverter is the nine level H bridge topology and the STATCOM is a energy storage device it will operate at based on voltage source control principle.

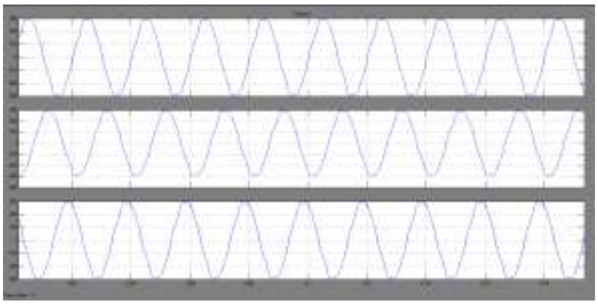
SOURCE CURRENT WITH CMPENSATION



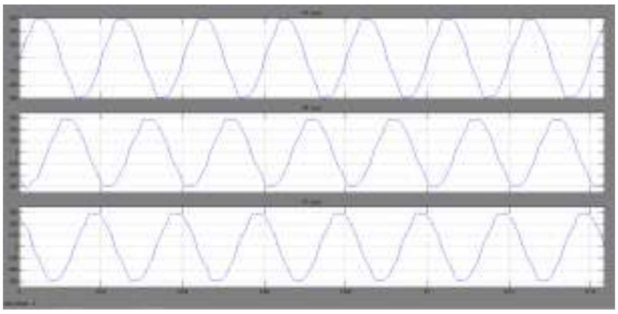
LOAD VOLTAGE WITH COMPENSATION



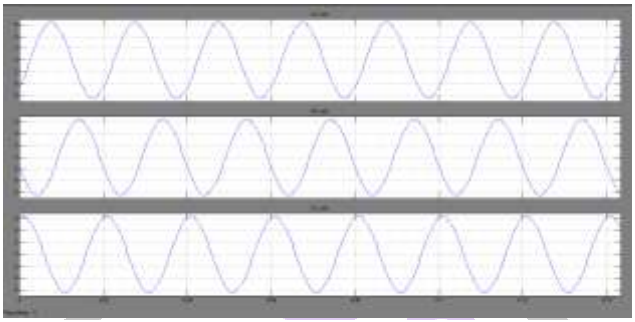
SOURCE VOLTAGE WITH COMPENSATION



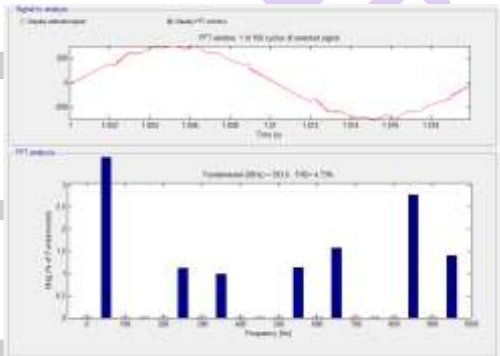
THREE PHASE VOLTAGE MEASUREMENT



SOURCE CURRENT MEASUREMENT



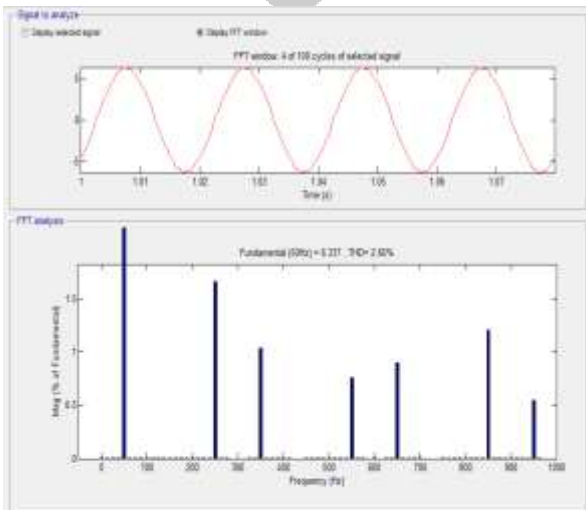
FFT ANALYSIS- BEFORE COMPENSATION



The Total Harmonic distortion in the source Current has been calculated as 4.73%

Before compensation **THD= 4.73%.**

FFT ANALYSIS-AFTER COMPENSATION



The Total Harmonic distortion in the load Current has been calculated as 2.65%

Before compensation **THD= 2.65%**

V.CONCLUSION

In this paper, an improvement of voltage stability using FACTS device with multilevel inverter was obtained. The source voltage, load voltage, source current, load current, power factor simulation results under nonlinear loads are presented. The nine level multilevel inverter of H bridge topology with FCTS devices is used to reduce the Total Harmonic Distortion and Improve the power factor. To maintain voltage stability of power system effectively. The performance with and without FACTS devices was implemented using MATLAB Simulation has been studied .

REFERNCE

[1] Sarita S. Bhole , Prateek Nigam" Improvement of Voltage Stability in Power System by Using SVC and STATCOM" *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (An ISO 3297: 2007 Certified Organization) Vol. 4, Issue 2, February 2015.*

[2] M.N.Slepchenkov, K.M.Smedly, J.Wen" Hexagram-converter based statcom for voltage support in fixed-speed wind turbine generation system"IEEE(2013)

[3]P.Venkata Kishore et al " Voltage sag mitigation in eight bus system using d-statcom for power quality improvement"IEEE (2010).

[4] Jeeva S. Pridaaa, P. Tamizharasi and J. Baskaran, "Synchronous reference frame strategy based shunt active filter"IEEE(2011).

[5] V.Kalaimagal, P.Tamizharasi,Dr.J.Baskaran "comparison of statcom and upqc performance in grid connected hybrid system using synchronous reference frame theory"(2015).

[6] Mahesh K. Mishra, Student Member, IEEE, Arindam Ghosh, Senior Member, IEEE, and Avinash Joshi" Operation of a dstatcom in voltage control mode"

[7]K.Udhaya ,P.Tamizharasi, Dr.J.Baskaran"Hystresis current control based harmonic compensation using statcom"(2013).

[8] Vishakha Tiwari" Performance Analysis of Multilevel Converter Based On Statcom Configuration" *International Journal of Electrical and Electronics Research Vol. 2, Issue 2, pp: (47-55), Month: April - June 2014* (2014).

[9] P.Adhityan, M.Rajkumar, M.R.Neetu singh" Improvement of power quality using cascaded multilevel inverter in t-statcom based system" *IRF International Conference*(2015)

[10] S.K.Meeravali, K.Chandrasekhar" Power Quality Enhancement Using Multi-Level Cascaded H-Bridge Based D-STATCOM with IRP Theory" *International Electrical Engineering Journal (IEEJ) Vol. 6 (2015) No.2, pp. 1756-1764 ISSN 2078-2365*

[11] Dr.C.Nagarajan, G.Neelakrishnan, P.Ganeshkumar, D.Vinoth" Power Quality Improvement Using Multi Level Inverter Operated In Grid Connected Mode" *International Journal of Innovative Research in Science, Engineering and Technology Vol. 4, Special Issue 6, May* (2015).

[12] Sai Kiran Kumar.Sivakoti, Y.Naveen Kumar, D.Archana" Power Quality Improvement In Distribution System Using D-Statcom In Transmission Lines" *International Journal of Engineering Research and Applications* (IJERA) Vol. 1, Issue 3, pp.748-752.

[13]Ananthi,P.Tamizharasi,Dr.J.Baskaran"Harmonic compensation in grid connected hybrid energy system using statcom"*fifth international conference on control,communication and power engineering*(2014).

[14] H.F Wang, P.C Krause" power quality benefits of utlizing facts devices and improve oscillation stability in power system"IEEE(2013).

[15] J.A.Barrado, R.Grino, Member IEEE and H.Valderrama-BlawiMember IEEE "power quality improvement of a stand alone induction generator using a statcom with bess"IEEE(2010).

[16]S.Shahabi, Costas Vournas" Voltage stability of electrical power system"IEEE(2012).

[17] C.K.Sunderbalan,P.Sathishbabu"Unified power quality conditioner for enhancement of power quality and hybrid power generation injection to grid"*International Journal of Modern Engineering Research* ,IJMER(2012).

[18] MeeraShareefShaik, ratnaRaju "Effective integration of wind generating station to power grid with statcom", IEEE (2012).

[19]L.Gyugyi, E.L.Zonkoly" Dynamic compensation of ac transmission line by solid state synchronous voltage sources"IEEE(2014).

[20]J.Sujitha, P.Tamizharasi, ,Dr.J.Baskaran **"**Harmonic compensation using STATCOM(2013)".