International Journal of Engineering Research and General Science Volume 5, Issue 3, May-June, 2017
ISSN 2091-2730

Application of FACTS devices in wind farm

Nancy[1], Nitin Goel[2]

[1](Research scholar, YMCA university of Science and Technology, Faridabad, India)

[2](Associate Professor, YMCA University of Science and Technology, Faridabad, India)

Abstract- The problem of voltage dip due to load is common in the system where wind farm based on SCIG is connected to a weak network and the main reason of problem , reactive power capability of network is insufficient to meet the demand of wind farm. Now a days power electronics based FACTS devices are more popular for reactive power compensation in power system network to provide voltage stability. This paper analysis the application of FACTS devices in wind farm using squirrel cage induction generator. FACTS devices are used to enhance the voltage stability of wind farm based on squirrel cage induction generator and thereby protecting SCIG-based wind farm interconnected to the power system from isolating during and after disturbances. Here we are using STATCOM and SVC to provide reactive compensation for maintaining voltage stability in power system having wind farm connected to a grid system. The power system model is simulated in MATLAB / SIMULINK.

Keywords- Wind Farm, Grid, SCIG, Flexible AC transmission system (FACTS), STATCOM, SVC, voltage stability

I. INTRODUCTION

The concept of wind farm is based on fixed speed wind turbine. A squirrel cage induction generator (SCIG) based wind farm is used .Only very small rotational speed variation is accepted by this generator; therefore these wind turbines are considered to operate at fixed speed .Here we are analyzing a Wind Farm based on squirrel cage induction generator (SCIG) connected to a grid and effect of load that create the problem of voltage stability . Because this generator type can't provide adjustable Reactive power control it can't fulfill the demanding grid code requirements [1] without additional devices. During voltage dips the induction generators may consume a large amount of reactive power as their speed deviates from the synchronous speed, which can lead to a voltage collapse in the network. Due to advance technology in power electronics FACTS devices are invented. FACTS devices used to mitigate the problem of voltage stability and help to protect SCIG based wind farm from tripping due to disturbances. Here we are using FACTS devices like STATCOM and SVC. STATCOM is a type of FACTS device that provide reactive power compensation and improve voltage stability [2] and also help in transient stability. SVC is also a FACTS device that provide reactive power compensation and improve system voltages but STATCOM response to problem faster than SVC.

II. STATIC COMPENSATOR (STATCOM)

STATCOM systems essentially consist of a DC voltage source behind self commutated inverters using insulated gate bipolar transistor (IGBT), gate turn-off (GTO), or gate commutated turn-off (GCT) thyristors and an interconnecting transformer. The voltage source inverter set connects to the power system via a multi-winding or two winding inverter transformer, depending upon the application. The figure here shows the basic STATCOM configuration. An inductor representing the leakage reactance of the transformer connects the two voltage sources. The output voltage phase of the thyristor-based inverter, V_i is controlled in the same way as the system voltage, V_s

The 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 STATCOM is capable of generating continuously variable inductive or capacitive shunt compensation at a level up its maximum MVA rating. It is a power electronic component that can be applied to the dynamic control of the reactive power. The reactive output power of the compensator is varied to control the voltage at given transmission network terminals, thus maintaining the desired power flows during possible system disturbances and contingencies.

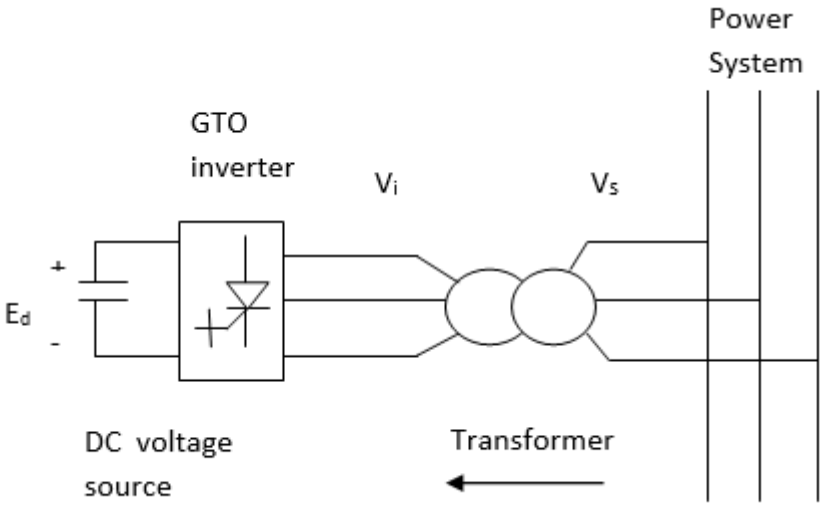

Fig.2.1 Basic arrangement of STATCOM in circuit

VI characteristic of STATCOM

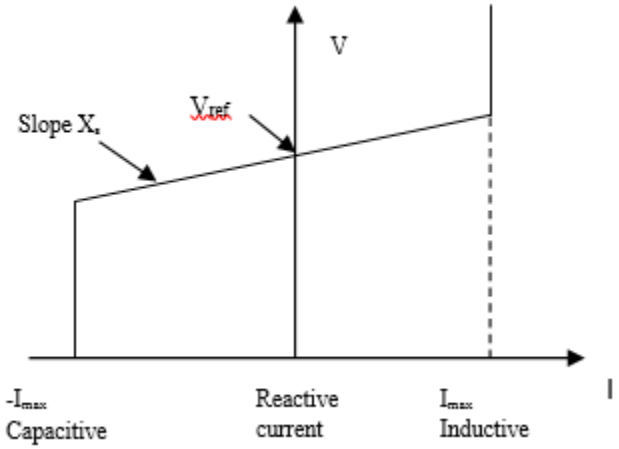

Fig.2.2 VI characteristics of STATCOM

III. STATIC VAR COMPENSATOR (SVC)

A static VAR compensator is a set of electrical devices for providing fast-acting reactive power on high- voltage electricity transmission networks . SVCs are part of the Flexible AC transmission system device family, regulating voltage, power factor, harmonics and stabilizing the system. Unlike a synchronous condenser which is a rotating electrical machine, a static VAR compensator has no significant moving parts (other than internal switchgear). Prior to the invention of the SVC, power factor compensation was the preserve of large rotating machines such as synchronous condenser or switched capacitor banks. The SVC is an automated impedance matching device, designed to bring the system closer to unity power factor

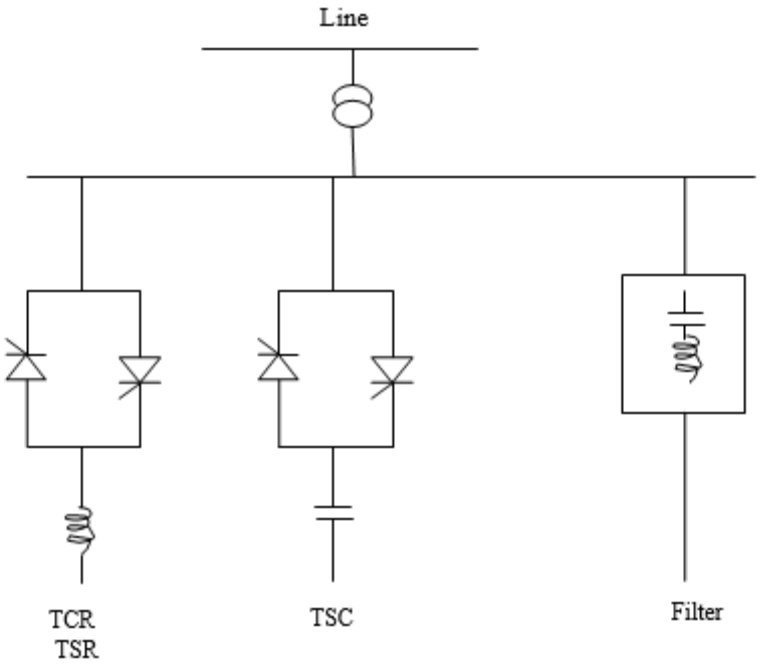

Fig. 3.1 Static Var compensator

VI characteristics of SVC

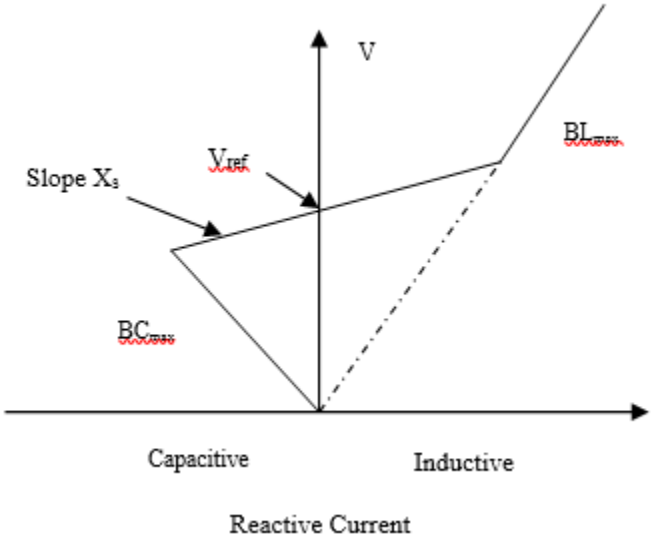

Fig. 3.2 VI Static Var compensator

IV. SINGLE LINE DIAGRAM OF TEST SYSTEM

A 9 MW wind farm is connected to Grid through a 30km line and Grid voltage 132KV is step down to 33KV using transformer of 62.5 MVA rating . Two loads are connected at bus 1 and bus 2. Here we are checking the application of FACTS device STATCOM and SVC in voltage stability and its improvement during different load conditions.

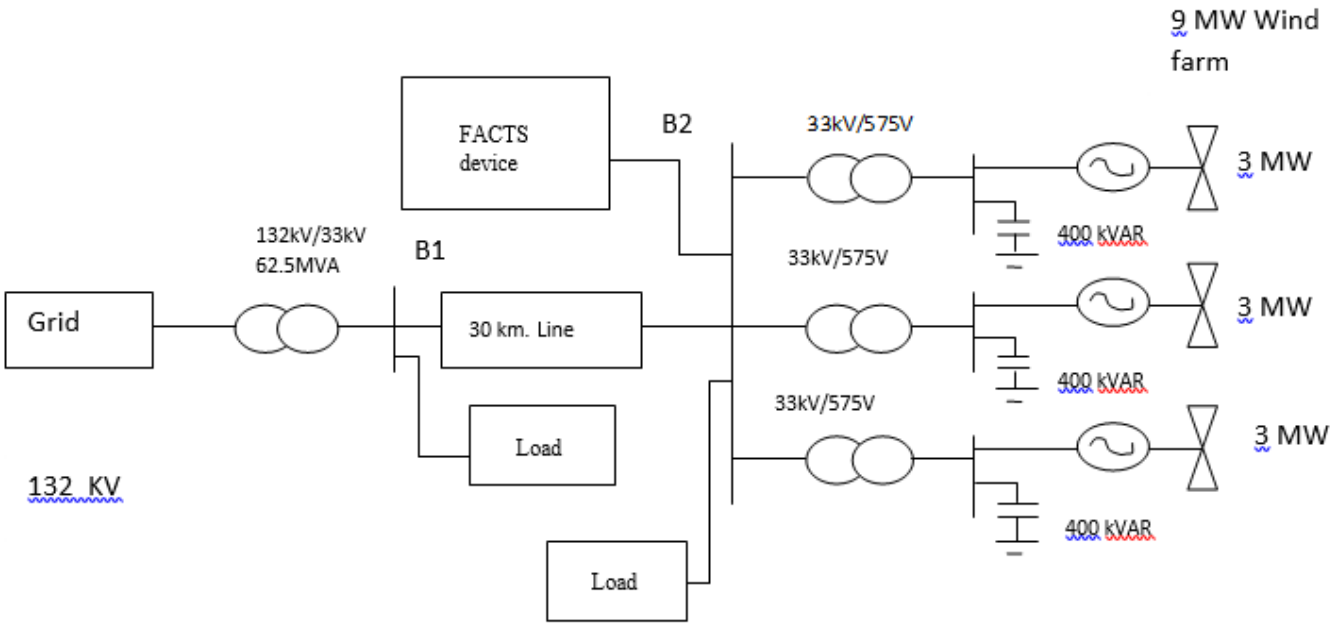

Fig 4.1 Single line diagram of test system

V. SIMULATION RESULTS WITHOUT FACTS DEVICE

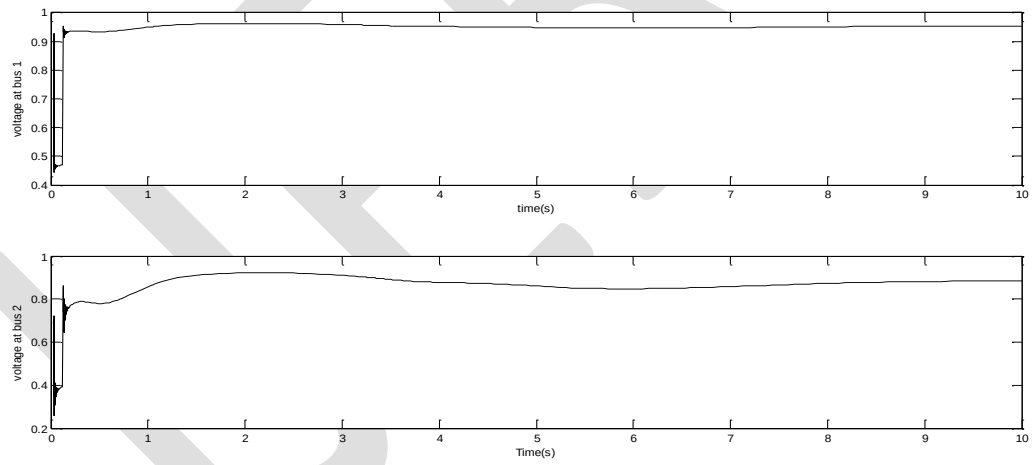

Fig.5.1 Voltage at bus 1 and bus 2 without FACTS device

Output waveform shows when there is no FACTS device is the system then voltage at bus 1 and bus 2 in (pu) respectively are 0.9537 and .88852

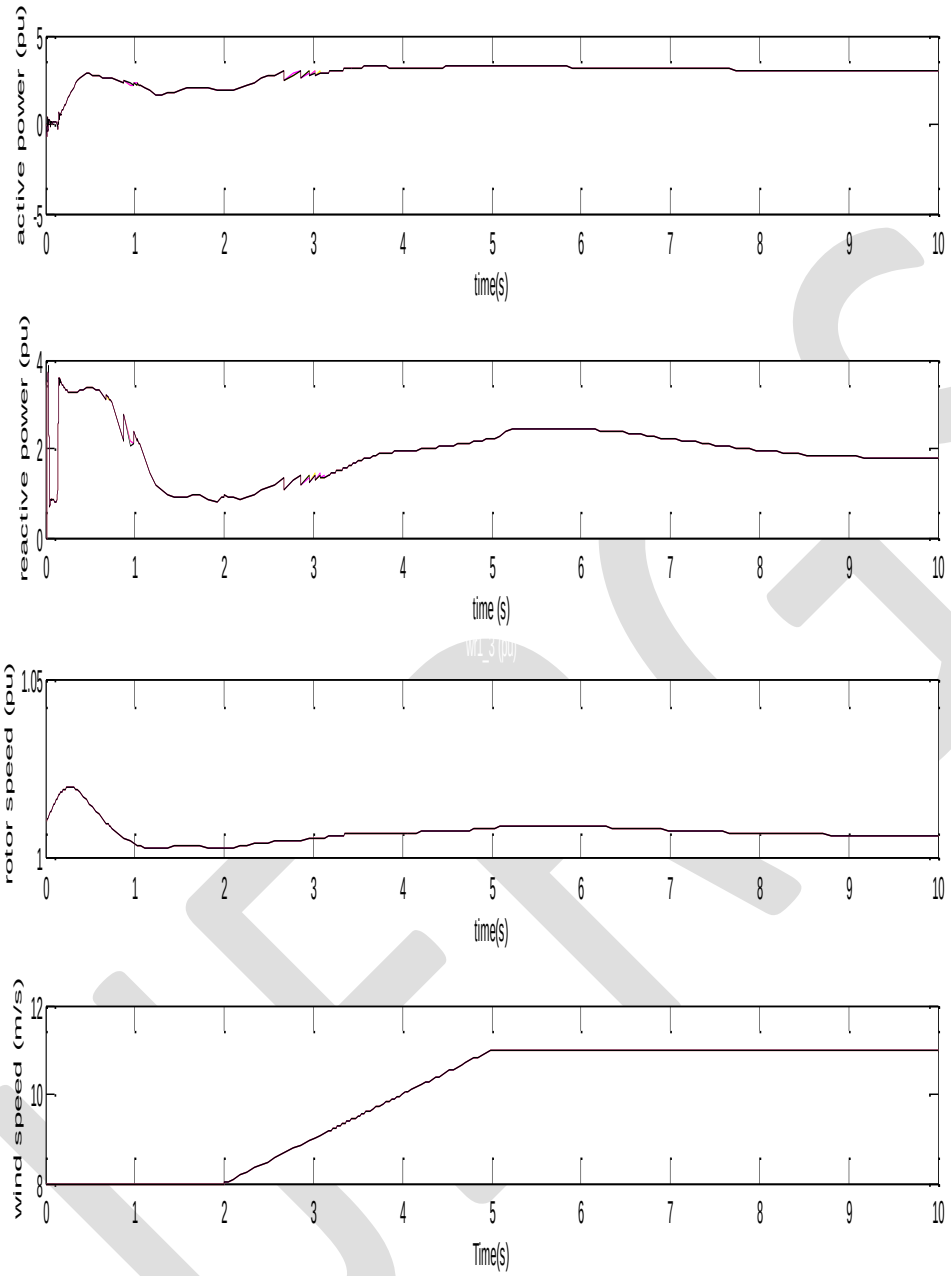

Fig.5.2 Active power, reactive power, rotor speed and wind speed without FACTS device

VI. SIMULATION RESULTS WITH STATCOM

Output waveforms of voltages at bus 1 and bus 2 with STATCOM are observed as

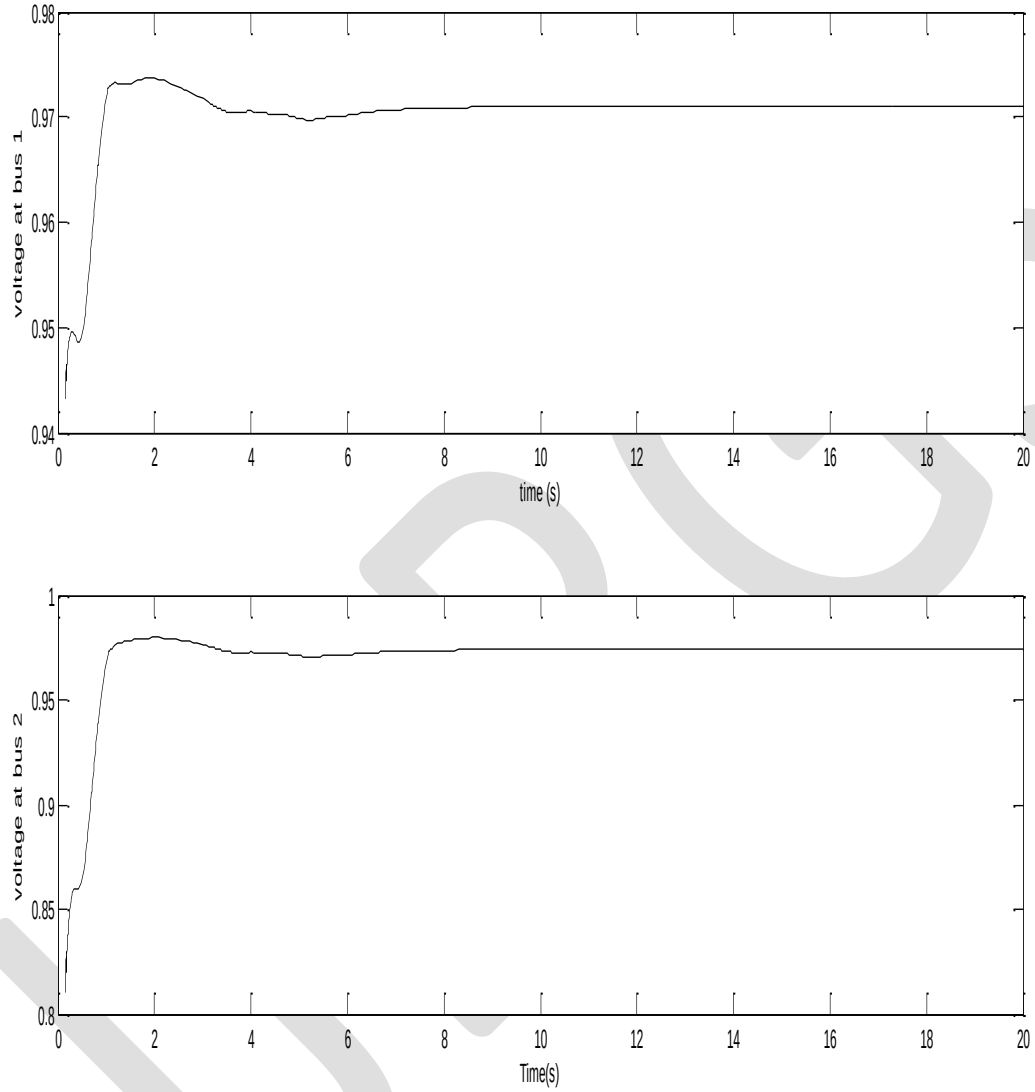

Fig.6.1 Voltage at bus 1 and bus 2 with STATCOM

Output waveform shows Effect of STATCOM in the system. The voltage at bus 1 and bus 2 in (pu) respectively are 0.9711 and .9743. This can be compared to voltage of system without FACTS device and we can see voltage at both bus 1 and bus 2 is improved

Wind farm output Active power , Reactive power , rotor speed and wind speed

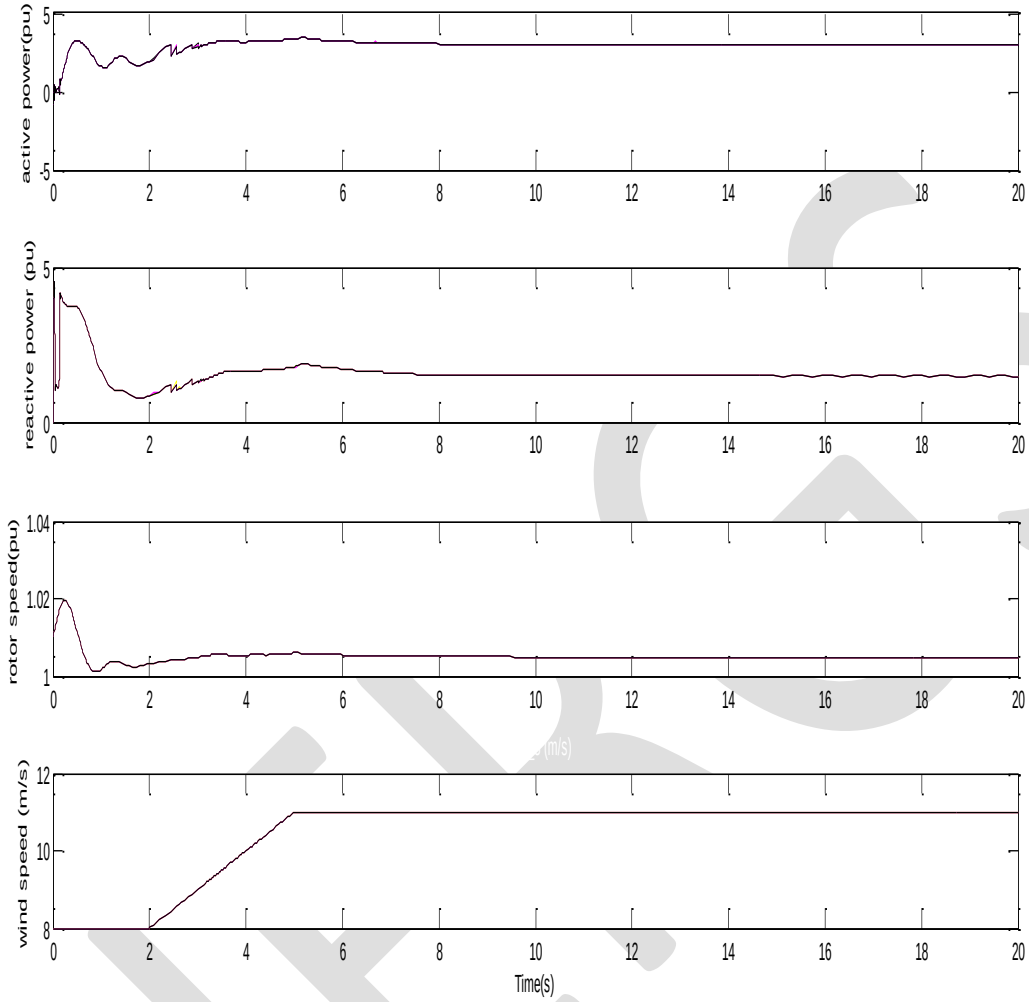

Fig.6.2 Active power, reactive power, rotor speed and wind speed with STATCOM

Output waveform shows when STATCOM is used in system then Active and reactive power of wind farm in (pu) respectively are 3 .0 and 1.486.

VII. SIMULATION RESULTS WITH SVC

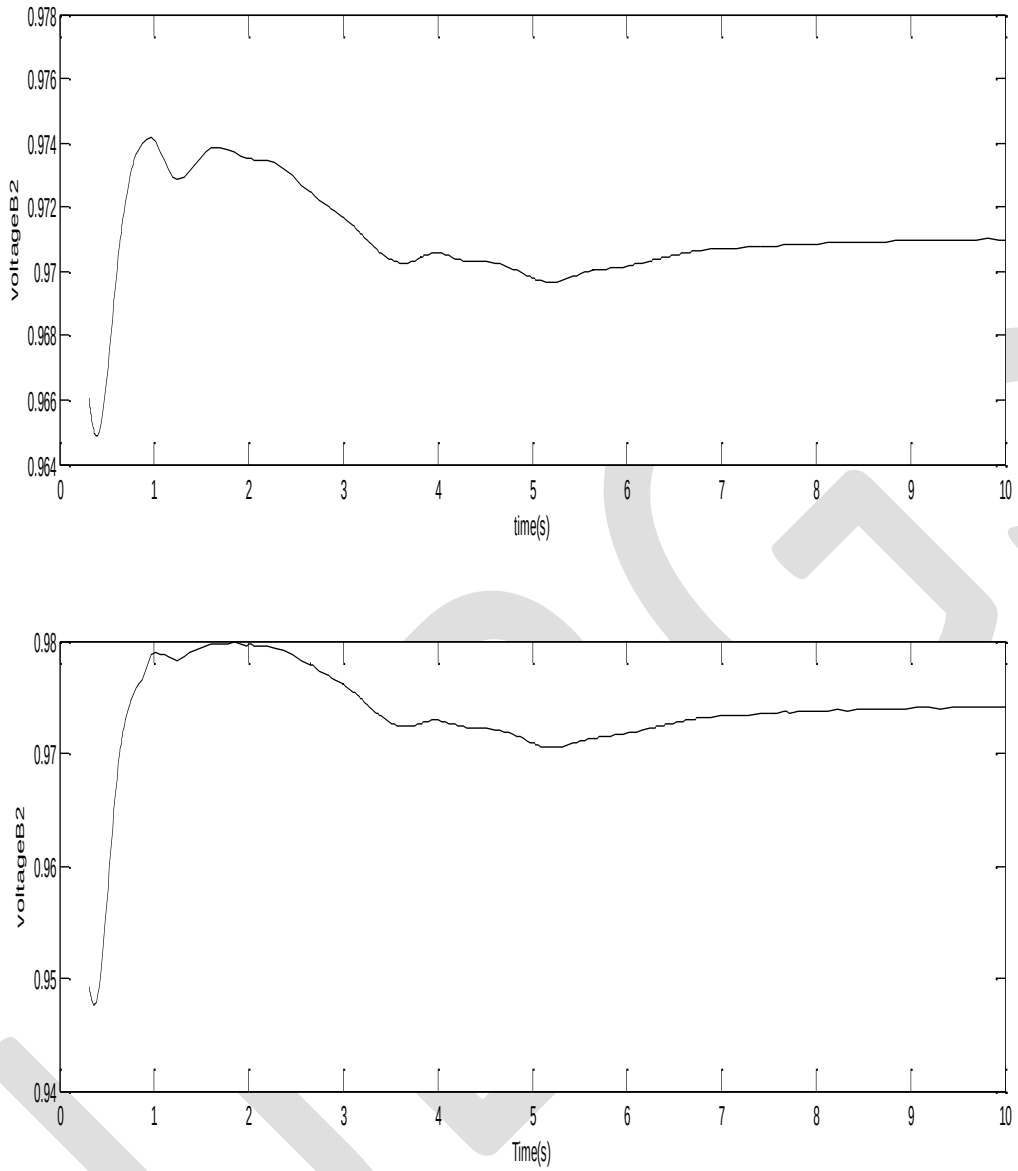

Fig.6.1 Voltage at bus 1 and bus 2 with SVC

Output waveform shows Effect of SVC on the system voltage at bus 1 and bus 2 .Results shows that initially fluctuation in voltages is more compared to STATCOM effect but voltage level improved as compared to without FACTS device.

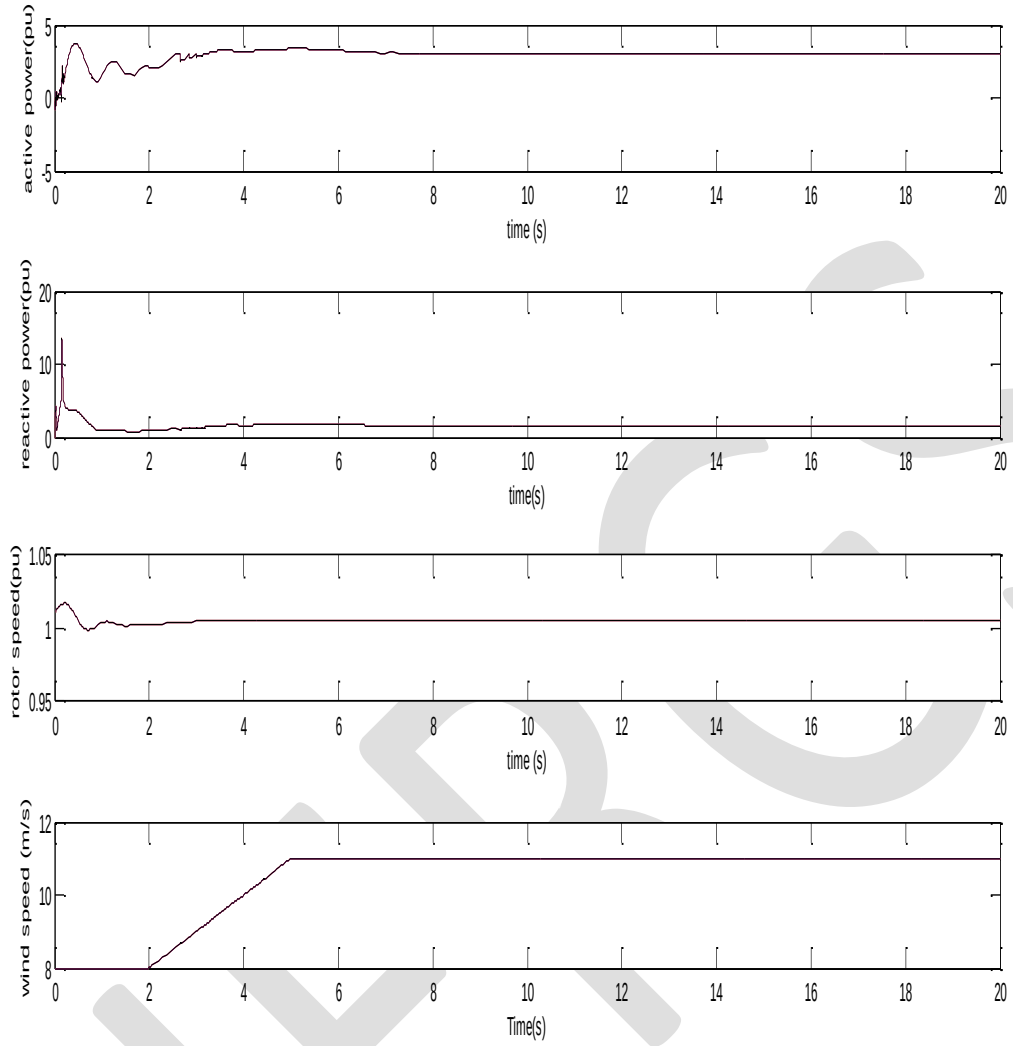

Fig.6.1 Active power, reactive power, rotor speed and wind speed with SVC

VII. CONCLUSION

Simulation results without FACTS device and with FACTS device is presented in this paper. When a wind farm is connected to a weak power grid, it is necessary to provide efficient power and voltage control during normal operating conditions and enhanced support during load changes. FACTS devices are very advantageous in Wind Farm consists of SCIG that operate at fixed wind speed connected to a Grid system to improve voltage stability at bus bar. There is need to study the system during different loads condition .Study includes the FACTS devices that are used in this paper are STATCOM and SVC .Output waveforms for voltages , active power reactive power ,rotor speed and wind speed are shown without FACTS devices and with FACTS devices . Voltage profile at bus 1and 2 is observed and Active power, reactive power , rotor speed and wind speed are observed for wind farm and waveform clearly shows that FACTS device help in maintaining voltage stability at the bus 1 and 2 and provide reactive support to the wind farm .Model is simulated in MATLAB/SIMULINK

REFERENCES:

[1] M. Tsili and S. Papathanassiou, "A review of grid code technical requirements for wind farms," Renewable Power Generation, IET, vol. 3,no. 3, pp. 308-332, Sept. 2009.

[2] Mr. M.Vimalraj , Mr.B.Alex and Ms.M.Tamilarasi ,"STATCOM Control For Voltage Stability Improvement at a Fixed Speed Wind Farm under Unbalanced Faults", ISBN No.978-1-4799-3834-6/14.

[3] Omar Noureldeen,"Low Voltage Ride through Strategies for SCIG Wind Turbines Interconnected Grid'', International Journal of Electrical & Computer Sciences IJECS-IJENS Vol: 11 No: 02, april 2011.

[4] T. Sun, Z. Chen and F. Blaabjerg, " Voltage Recovery of Grid-Connected Wind Turbines with DFIG After a Short-circuit Fault", 2004 35th Annual lEEE Power Electronics Specialists Conference.

[5] Yongning Chi, Yanhua Liu, Weisheng Wang and Huizhu Dai, "Voltage Stability Analysis of Wind Farm Integration into Transmission Network", 2006 International Conference on Power System Technology 1-4244-0111-9/06.

[6] A. S. A. Awad, M. M. A. Salama, Fellow, and Ramadan El Shatshat, " STATCOM modeling Impact on Wind Turbines Low Voltage Ride Through Capability".

[7] Omar AL-Masari and Musa AL-Masari, "Influence of a Wind Farm on Power System Oscillatory Stability", International Journal of Inventive Engineering and Sciences (IJIES) ISSN: 2319–9598, Volume-2 Issue-9, August 2014.

[8] Yuvaraj and Dr.S.N.Deepa, " Improving Grid Power Quality With FACTS Device on Integration of Wind Energy System", STUDENT PULSE, APRIL 2011 , VOL. 3, ISSUE 4.

[9] M. Tarafdar Hagh, A. Roshan Milani, and A. Lafzi, "Dynamic Stability Improvement of a Wind Farm Connected to Grid Using STATCOM", Proceedings of ECTI-CON 2008.

[10] Marta Molinas, Jon Are Suul, and Tore Undeland, " Low Voltage Ride Through of Wind Farms With Cage Generators: STATCOM Versus SVC", IEEE TRANSACTIONS ON POWER ELECTRONICS, VOL. 23, NO. 3, MAY 2008.

[11] Kadam D. P and Dr. Kushare Dr. Kushare, "Reactive power Improvement in Wind Park system using FACTS", 2013 International Conference on Power, Energy and Control (ICPEC).

[12] B.P. Numbi, D.W. Juma, .J.L. Munda, A.A. Jimoh, "Optimal Reactive Power Control in Transmission Network With a Large Wind Farm Connection", IEEE Africon 2011 - The Falls Resort and Conference Centre, Livingstone, Zambia, 13 - 15 September 2011.