Performance Improvement of Wind Farms Equipped with Six SCIG Generators using STATCOM

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Abstract— The integration of wind energy into existing power system presents a technical challenges and that requires consideration of voltage regulation, stability, power quality problems. The purpose of this paper is to analyze and study stability of a wind farm based on conventional fixed speed Induction generator when it has been integrated with a weak grid. A analysis of the stability improvement of a FSIG wind plant has been done, when it is supported with FACTS like STATCOM. The simulation evaluation of stability of allotted device with WTIG is accomplished using MATLAB/SIMULINK.

Key words: Power System Stability, Reactive Power Compansator, Induction Generator, STATCOM, Wind Farm

I. INTRODUCTION

With the increase in demand of power and decrease of fossil fuels, mankind has been forced to search alternative sources for the generation of electricity. Wind power in spite of being stochastic in nature has proved itself as a viable solution to this problem. As the wind turbine technology is developing at a good pace, more and more wind power plants are being integrated with the conventional form of generation. With the increase in the ratio of wind generation to conventional generation, several problems related with integration of wind farms have emerged. These problems are due to distinct properties of the generators used with the conventional form of generation and wind based generation. In thermal and hydro power based generation synchronous generators are used while in wind based generation mostly induction generators are used.[1]

Induction and synchronous generators do not exhibit similar behaviour during power system stresses. Moreover, increase in wind power based generation requires a reliable transmission system for power evacuation to the load centres. As the wind farms are mainly concentrated in far flung and rural areas their interconnection with the grid becomes a problem. This problem is mainly due to the existence weak transmission grids in the rural areas[2].

Wind energy system converts the obtainable kinetic energy in the wind into mechanical energy that can spur an electrical generator. Predominantly, wind power generators are self excited induction generators. Induction generators characteristics are strongly affected by the massive reactive power absorbed during their normal operating conditions. This reactive power trouble may engender dynamic voltage instability in the system. The needed reactive power of induction generator can be provided either by the grid or self capacitor bank in parallel with the generator stator terminals[3].

The stability of a system determines whether the system can settle down to the original or close to the steady state after the transients disappear. Transient stability refers to the capability of a system to maintain synchronous operation in the event of large disturbances such as multi-phase short-circuit faults or switching of lines. The resulting system response involves large excursions of generator rotor angles and is influenced by the nonlinear power angle relationship. Stability depends upon both the initial operating conditions of the system and the severity of the disturbance. Recent development of power electronics introduces the use of flexible ac transmission system (FACTS) controllers in power systems. FACTS controllers are capable of controlling the network condition in a very fast manner and this feature of FACTS can be exploited to improve the voltage stability, and steady state and transient stabilities of a complete power system [4].

Dynamic reactive power compensators are always required to stabilize the voltage and to supply the desired reactive power at wind generator bus under normal and abnormal operation. Flexible Alternating Current Transmission Systems (FACTS) can be very profitable to simultaneously deliver reactive power and support bus voltage at wind generator interface. The system instability of wind farms based on fixed speed induction generators is largely caused by the excessive reactive power absorption by the fixed speed induction generators after fault due to the large rotor slip gained during fault. The STATCOM considerably improve the system stability during and after disturbances[5].

II. WIND FARM DISTRIBUTION SYSTEM

The MATLAB/SIMULINK can be used for modeling and simulation of the wind farm distribution systems is shown in fig1.

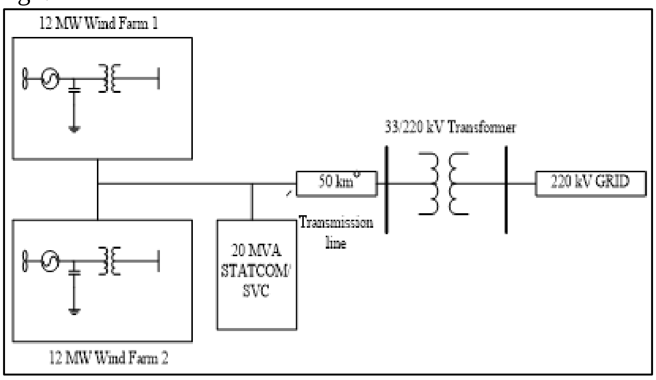

Fig. 1: Wind Farm Distribution system

The system consists of a 220KV,50-Hz, sub transmission system with short circuit level of 2500 MVA, feeds a 33 KV distribution system through 220 kV/33kV step down transformer. A test system consisting two wind farm of 24MW (each 12MW) and each wind farm having three unequal capacity (3 MW,4 MW &5 MW) wind turbine induction generator (WTIGs) are connected to the 33KV distribution system, exports power to 220KV grid through a 50km transmission line and two loads have been connected to the network. A 20MVA FACTS devics is used as reactive power compensator at the common point of coupling.

III. SIMULATION RESULTS

The dynamic behaviors of the wind farm distribution network with and without the application of an external three-phase fault with and without reactive power compensation are investigated for 'the constant wind speed'. The dynamic performance of WTIG for the constant wind speed is analyzed for different cases:

1) Case 1: without Fault and without STATCOM
2) Case 2: without fault and with STATCOM
3) Case 3: with fault and without STATCOM
4) Case 4: with fault and with STATCOM

A consistent wind velocity of 11 m/s is applied to the wind turbine. The reaction of the lively electricity injected into the network is low in the case1 because no reactive energy assist in the community, because of insufficient reactive power reimbursement WTIG machine stability is lost. The active electricity is injected to the distribution network reduces considerably for the cases3 when a 3 phase fault is applied at t=3 sec. and cleared 3.1sec. For the case of machine without STATCOM, the active strength injected will become very low with and without fault. However, for the cases2&4 of system with STATCOM, due to the reactive electricity support, the stability of the machine is maintained and the WTIGs keep to deliver the approximate rated electricity to the distribution network after the fault clearance.

The reaction of the WTIG speed will increase, for the case1 and while a three segment fault is carried out at t=3sec. And cleared 3.1sec.For case3 of device without STATCOM, the system looses balance and the velocity of the WTIG maintains to growth. For the machine with STATCOM (case2&4), the steadiness of the system is maintained after the fault clearance. This is due to the fact that, the reactive power supplied through the STATCOM. The reaction of the WTIG terminal voltage drops drastically for the cases1 and the low voltage condition starts at t=3sec, at which the fault is implemented and lasts for 3.1sec .The length of the fault for case3. For case of system without STATCOM, the WTIG terminal voltage drops straight away after the fault clearance. For the device with STATCOM due to reactive energy help, the WTIG terminal voltage is slightly accelerated at once after the fault clearance. So the system maintains stability and finally the WTIG terminal voltage recovers for both the cases2&4.The results are shown in fig2 to 5.

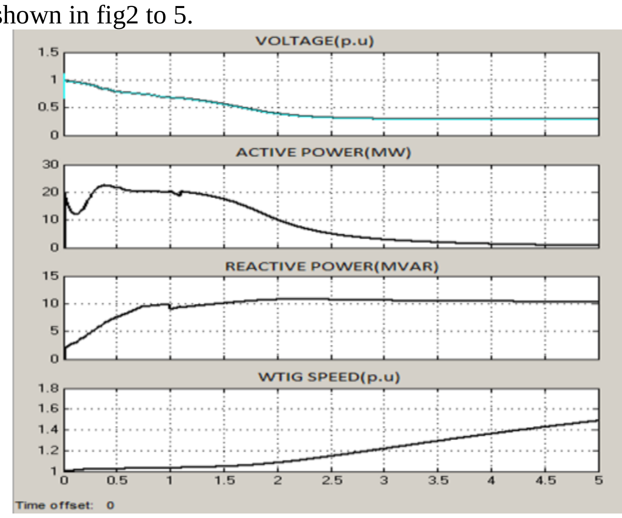

Fig. 2: Case1 (without Fault and without STATCOM)

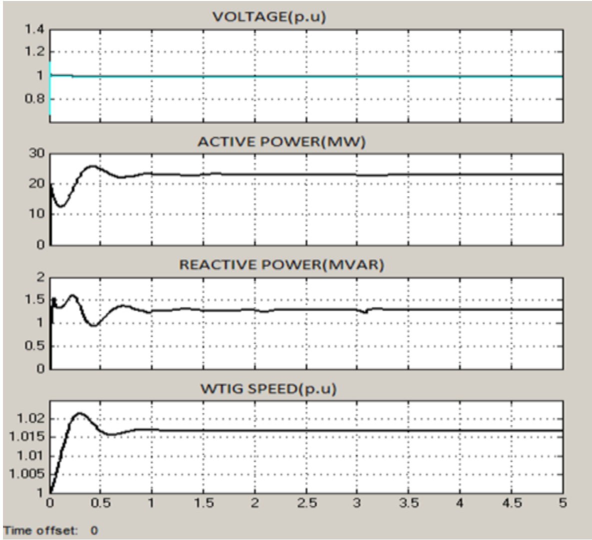

Fig. 3: Case2 (Without Fault and with STATCOM)

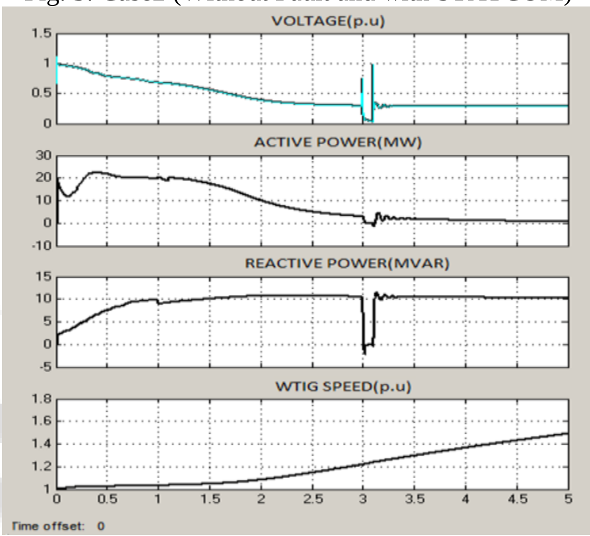

Fig. 4: Case3 (With Fault and without STATCOM)

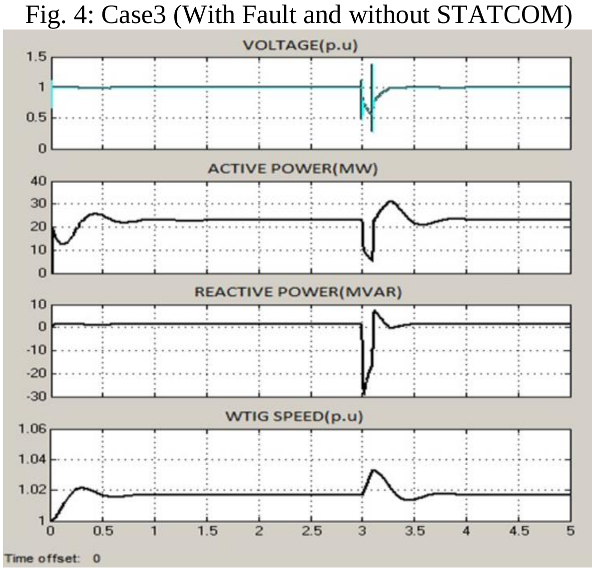

Fig. 5: Case3 (with Fault and with STATCOM)

IV. CONCLUSION

This paper investigates the effect of reactive power compensator in wind energy connected distribution network. The stability improvement of a distribution system connected with WTIG is studied. The dynamic behaviours of the wind farm distribution system with and without the application of an external three-phase fault with and without STATCOM are investigated. The amount of active power supplied to the grid is more and reactive power supplied by grid is low for the cases with STATCOM than for the cases without STATCOM. It is also found that the WTIG with no STATCOM has lower value of rotor speed and has higher value on terminal voltage than with STATCOM.

APPENDIX

1) Parameters of the wind Generator: Stator resistance=0.016 p.u., Rotor resistance=0.015 p.u., Stator leakage inductance= 0.06 p.u., Rotor leakage inductance= 0.06 p.u., Mutual inductance= 3.5 p.u., lumped inertia constant=2S.
2) Parameters of SVC: Nominal Voltage= 33 KV, Reactive Power limits= +/-20 MVAr, Frequency= 50HZ, Kp, Ki= 0,300.
3) Parameters of STATCOM: Nominal Voltage= 33 KV, Converter rating= 20 MVA, D.C link Nominal Voltage= 40,000, Frequency= 50 Hz, Kp, Ki= 5, 1000.

REFERENCES

[1] Rajiv Singh, Asheesh Kumar Singh, and Ashutosh Kumar Singh “Transient Stability Improvement of a FSIG Based Grid Connected wind Farm with the help of a SVC and a STATCOM: A Comparison”. International Journal of Computer and Electrical Engineering, Feb 2012. Vol.4, No.1,
[2] Qusay.Salem “Overall Control Strategy of Grid Connected to Wind Farm Using FACTS” Bonfring International Journal of Power Systems and Integrated Circuits, , Feb 2014,Vol. 4, No.1.
[3] S.N. Deepa1, J. Rizwana, S.N. Deepa et.al“Multi-Machine Stability of a Wind Farm Embedded Power System using FACTS Controllers” Anna University Regional Centre, Coimbatore, Tamilnadu, India International Journal of Engineering and Technology (IJET) ISSN : 0975-4024 Oct-Nov 2013.Vol 5 No 5.
[4] Sidhartha Panda and N.P.Padhy“Investigating the Impact of Wind Speed on Active and Reactive Power Penetration to the Distribution Network” International Journal of Electrical and Electronics Engineering 1:1 2008
[5] B. T. Ramakrishna Rao , P. Chanti, N. Lavanya, S. chandra Sekhar, Y. Mohan kumar “ Power System Stability Enhancement Using Fact Devices” Int. Journal of Engineering Research and Applications ISSN : 2248-9622, April 2014, Vol. 4, Issue 4(Version 1), pp.339-344
[6] N.Kamaraj S.Vijayarajan,G. Lakshmi Thilagam “Reactive Power Control of A Grid Connected Wind Turbine Induction Generator”IEEE transactions
[7] N. G. Hingorani and L. Gyugyi, Understanding FACTS: Concepts and Technology of Flexible AC Transmission System. IEEE Press. 2000.

