Review on stability improvement of induction generator based wind turbine using STATCOM

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Abstract- **This paper presents the impact of fault on the system stability by using the fixed speed induction generator (FSIG) based wind farm connected to interconnected power system. Means wind farm connected to SCIG. When the penetration level of wind turbine is high so it effects on power system and this can be done in some countries and network. for power system stability the stable operation of wind turbine systems is very important. Simulations are presented for different cases such as with and without Static Synchronous Compensator (STATCOM) for different symmetrical and unsymmetrical faults.**

Index Terms- **FSIG; WTIG; VOLTAGE STABILITY; STATCOM; FAULTS**

I. INTRODUCTION

Among the some renewable energy technologies being vigorously developed, wind turbine technology has being undergoing a dramatic development and now wind turbine is the world's fastest growing energy source. In 2005, 11, 531 megawatts (MW) of wind turbines were installed worldwide, which represented an increase of 24% in comparison with 2004. The total installed wind power capacity reaches 59, 084 MW worldwide by the end of 2005 [2]. Wind power continuously give variable output power,when combined with induction generators like the fixed-speed squirrel-cage induction generator (SCIG), stator is directly connected to grid and rotor is driven by variable pith of wind turbine, particularly in terms of stability and power quality.

Sometime these induction generators which are usually connected at weak end of a grid or at distribution networks inject large amount of reactive currents during disturbances such as faults[4].

The pitch angle control in order to limit the output power of induction generaentor at a nominal value w hen wind exceeding nominal speed. and also for stabilization of the wind turbine at grid faults. the blade-angle control orders the mechanical system to reduce the wind turbine mechanical power to improve stability When a fault occurs in the external power system, [6]. sometime without disconnecting the wind turbine from the grid it is economically convenient to handle the fault, [9]. It is necessary to study the responses of SCIG wind farm during the faults and possible result on the system stability. the contribution of STATCOM to support the wind farm during different fault locations and durations are studied.

II . WIND TURBINE

Wind turbine converts wind energy into electricity for distribution by mechanical component and electrical generator.when wind passes over the blades the lift and exerting force are generating. in naccle rotating blade turn the shaft and drive train increasing rotational speed and converted into electricity then mechanical power is given. The performance and efficiency of any wind energy conversion system (WECS) depends upon the characteristics of wind turbines.The power in the wind is proportional to the cube of the wind speed and it may be expressed as

$$P_w = 0.5\rho A v_w{}^3$$

Where ρ is air density (kg/m3), A is the area (m3) swept by blades and wv is wind speed (m/s).

A wind turbine can only extract a fraction of the power from the wind which is limited by bitz limit. power coefficient of the turbine and expressed by Cp. The maximum limit of Cp can be 0.59 (Betz limit). Cp is a function of pitch angle β and tip speed ratio λ. Hence mechanical power of the wind turbine is given by

$$P_m = 0.5\rho C_p(\lambda, \beta) A v_w{}^3$$

The tip speed ratio is defined as the ratio between the blade tip speed and the wind speed Vw and is given by $\lambda = \omega R / v_w$ Where ω is turbine rotational speed.

III. INDUCTION GENERATOR

Squirrel Cage Induction Generator (SCIG)

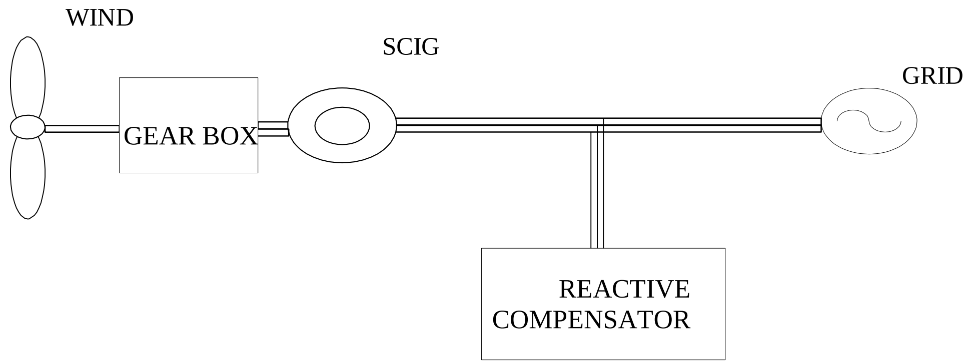


Fig.1:SCIG DIAGRAM.

From the above diagram we can say that it is the simple connection of wind turbine with SCIG.in this system stator is connected to grid and rotor is driven by pith of variable wind turbine. In this configuration rotor of SCIG is directly connected to the turbine through the multistage gearbox. Stator is connected to the grid through the coupling transformer. A cage rotor induction generator for wind turbines operates normally at high speed. The low rotational speed of the turbine rotor is translated into the high generator rotational speed by a gear box. A cage rotor induction generator may be directly connected to the grid. The frequency of the grid determines the air gap flux speed, the synchronous speed. The mathematical expression of IG is

Stator voltage equation

Vds = -Rsids – Ws Ψqs +1/wb*d/dt Ψds
Vqs = -Rsiqs – Ws Ψds +1/wb*d/dt Ψds

Rotor equation

Vdr = -Rridr – sWs Ψqr +1/wb*d/dt Ψdr
Vqr = -Rriqr + sWs Ψdr +1/wb*d/dt Ψdr

Flux equation
Ψds = -Xssids +Xm idr
Ψqs = -Xssiqs +Xm iqr
Ψdr = Xrridr -Xm ids
Ψqs = Xrrids -Xm iqs
Active power
Ps = Vds Ids +Vqs Iqs

Reactive power
Qs = Vqs Ids –Vqs Iqs

Torque and speed equation are given as follows

Te = Ψds ids –Vqs Iqs
Dwm/dt = 1/2H (Tm-Te)

IV FSIG WIND TURBINE

Generator connected to the infinite bus

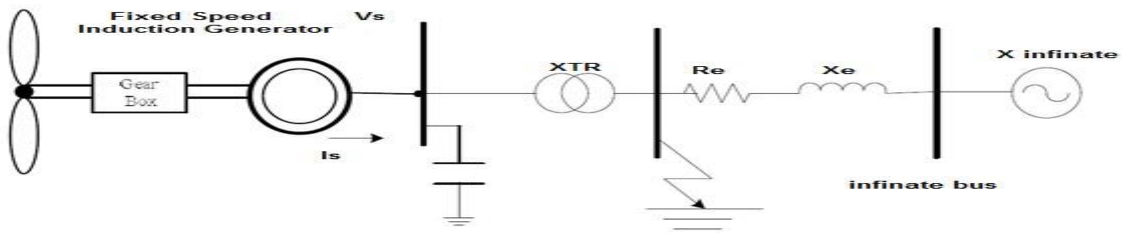


Fig 2. Schematic of a FSIG wind turbine generator connected to the infinite bus

The bove Fig.1 shows the FSIG with wind turbine connected to infinite bus. The wind turbine generating system consist of squirrel cage induction generator in which the stator windings are directly connected to the three phase grid and rotor windings are short circuited. The slip of the induction generator varies with the amount of power generated. An induction generator may be directly connected to the grid through bus. The low rotational speed of the turbine rotor is translated into the high generator rotational speed by a gear box. The frequency of the grid determines the air gap flux speed, the synchronous speed. The rotor speed of the induction machine is different from the synchronous speed. It can be seen that, in the range of stable operation, if the slip increases, the electrical power and torque of the machine increase as well. Therefore the variation of the slip and speed is directly related to the change of the generated power from an induction machine. The features of this type of system are the simple and cheap construction and no synchronization device is required. The high starting currents of induction generators are usually limited by a thyristor soft-starter, and the demand for reactive power is normally met by capacitor banks that may be switched in or out according to the real power production.

BLOCK DIAGRAM WIND TURBINE CONNECTED GRID

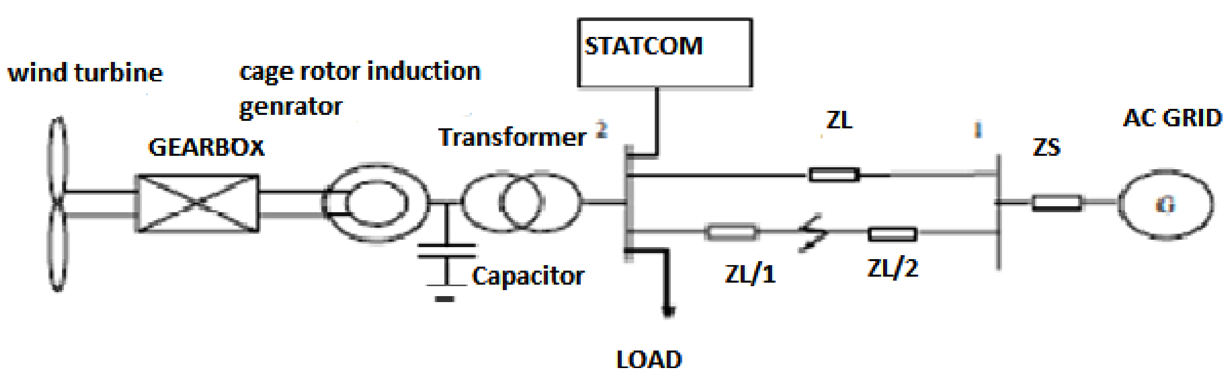


Fig.3 BLOCK DIAGRAM OF WIND TURBINE CONNECTED GRID

V. PROBLEMS IN WIND TURBINE CONNECTED GRID

1] When a fault occurs in the external power system, the blade-angle control orders the mechanical system to reduce the wind turbine mechanical power to improve stability.

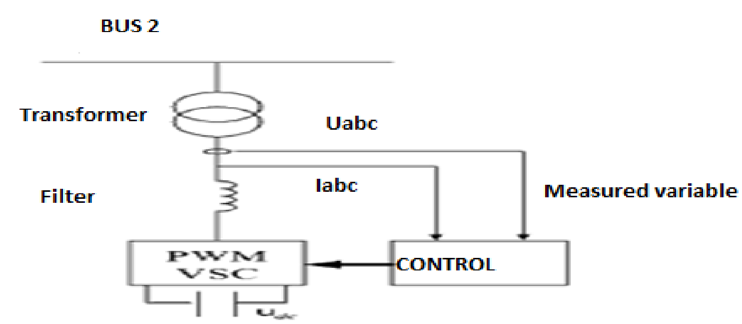
2] Squirrel cage induction generators can become easily unstable under low voltage conditions, as low terminal voltage lead to: larger rotor slip, larger reactive power consumption, further lowering of terminal voltage, and this may lead to disconnecting the turbine.

3] Since the induction generators do not perform voltage regulation and absorb reactive power from the utility grid, they are often the source of voltage fluctuations [8].

4] Reactive power is one of the major causes of voltage in the network

5] The effect of fault location and its duration on the stability of the wind farm connected grid are studied for different fault types as single line to ground fault, double line to ground fault and three-line to ground fault.

VI STATCOM



STATCOM with transformer

Fig.4 STATCOM with transformer

A STATCOM consists of a PWM voltage source converter (VSC). The VSC can provide a controllable voltage matching the grid voltage in frequency, with the amplitude and phase being continuously and rapidly controlled, so that the VSC can absorb or generate reactive power to control the voltage at the wind farm terminal. The converter can be multiple level or multiple pulses for high power and low harmonic operation. However, only a simple six-pulse PWM voltage source converter is presented here to illustrate the principle. A STATCOM may be applied at any voltage level with a coupling transformer. In the studied system, the STATCOM is connected in shunt to the point of common coupling (bus 2) through atransformer as shown in Fig4.Usually, the STATCOM is applied to voltage support goals. At system voltage is a decrease, the STATCOM inject reactive power (STATCOM capacitive). At system voltage is increases; it absorbs reactive power (STATCOM inductive) . Statcom is installed to support electricity network that have poor power factor and poor voltage regulation. The STATCOM, consisting of a voltage source converter, uses advanced power switches to provide fast response and flexible voltage control for power quality improvement, which is suitable to application with rapidly fluctuating loads. STATCOM unit is developed to inject reactive power to mitigate power quality problems and to get stable grid operation. Due to continuously varying wind speed components, the active and reactive power along with terminal voltage fluctuates continuously. By connecting STATCOM into the grid, the active power, reactive power and terminal voltage is maintained constant. STATCOM is an effective power electronic system which can provide reactive power control quickly, therefore can help to rebuild the voltage of the wind generators and quickly restore the system voltage level after the clearance of a fault. This paper studies the effectiveness of a STATCOM on supporting the stability of an induction generator based wind turbines system. The influences of various factors, such as system impedance, fault resistance, and STATCOM capacity,are studied.

IV. CONCLUSION

This paper explain the basic concept of squirrel cage induction generator with wind trbine connected to grid.In this system many problems occour and this problem compensated by using STATCOM. It full fill the reactive power requirement of the system at the time of fault occour in the system.because when fault occour on system then volage low and system get unstable so in that case STATCOM help the system.

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REFERENCES

[1] paresh p. Luhana" stability improvement of fixed speed induction generator based wind farm using statcom For different types of fault" p.g. scholar, m&v patel department of electrical engineering, c.s. patel institute of technology, charusat, changa, gujarat, india 2016

[2] Z. Chen, Y. Hu and F. Blaabjerg" stability improvement of induction generator-based wind turbine systems" IET Renew. Power Gener., Vol. 1, No. 1, March 2007

[3] Z. Chen, E" issues of connecting wind farms into power systems" Senior Member, IEEE2005 IEEE/ PES Transmission and Distribution Conference & Exhibition: Asia and Pacific Dalian, China

[4] IEC 61400-21: Power quality requirements for wind whines. (2001).

[5] Akhmatov V, Knudsen H, Nielsen AH, Pedersen JK, Poulse NK. Modelling and transient stability of large wind farms. Int J Elect Power Energy Syst 2003; 25(2):123–44.

[6] Chen Z, Hu Y, Blaabjerg F. ‘’Stability improvement of induction Generator-based wind turbine systems," IET Renew Power Generat 2007;1(1):81–93.

[7] Chen, Z., Blaabjerg, F., and Hu, Y.: ‘Stability improvement of wind turbine systems by STATCOM’. Proc. 32nd Annual Conf. IEEE Industrial Electronics, Society, IECON 2006, pp. 4213–4218

[8] Saad-Saoud, Z., Lisboa, M.L., Ekanayake, J.B., Jenkins, N., and Strbac, G.: ‘Application of STATCOMs to wind farms’. IEE Proc., Gener. Trans. Distrib., 1998, 145, (5), pp. 511–516

[9] El-Sattar AA, Saad NH, Shams El-Dein MZ. Dynamic response of doubly fed induction generator variable speed wind turbine. Elect Power Syst Res 2008(78):1240–6.

[10] Z Chen"STATCOM's Effects on Stability Improvement of Induction Generator based Wind Turbine System" Institute of Energy Technology Aalborg University Aalborg, DK-9220, Denmark zch@iet.aau.dk

[11] Chen, Z., Blaabjerg, F., and Hu, Y.: ‘Voltage recovery of dynamic slip control wind turbines with a STATCOM’. Proc. 2005 Int. Power Electronics Conf. IPEC 2005, pp. 1093–1100

[12]Estanqueiro, A.I., Ferreira de Jesus, J.M., and Saraiva, J.A.G.: ‘A wind park grid integration model for power quality assessment’. Proc. European Union Wind Energy Conf., Goteborg, Sweden May/96, pp. 436–439

[13] S.K. Salman, A.L.J. Teo, "Windmill modelling consideration and factors influencing the stability of a Grid-connected wind power-based embedded generator", IEEE Transactions on Power Systems, Volume: 18 , Issue: 2 , May 2003 Pages:793 – 802.

[14] J. Wiik, J. O.Gjerde, M. Gustafsson, and T. Gjengedal, "Dynamic simulations of wind power turbines in weak power systems ," Wind power for the 21st century, Kassel, 2000.

[15] Patel MR. Wind and solar power systems. Kings Point, New York: U.S. Merchant Marine Academy; 1999.

[16] N. G. Hingorani, L. Gyugyi, "Understanding FACTS; Concepts and Technology of Flexible AC Transmission Systems", IEEE Press book, 2000.