International Journal of Engineering Research and General Science Volume 3, Issue 1, January-February, 2015
ISSN 2091-2730

Performance Analysis of SCIG Coupled With Wind Turbine with and Without Fault Using RLC Load

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Abstract: Wind energy is a form of energy which is pollution free and eco-friendly. In this paper we have introduced a wind power in a power generation and transmission system alongside the programmable 3-phase sources and have simulated its working and performance. The aim of this paper is to provide the basic concepts to understand a wind energy generation system and the way it must be operated to be connected to the utility grid. In this paper we analyze the performance of SCIG when STATCOM and load are connected with WECS: (A) With Fault (B) Without Fault. This also includes simulation of 9MW wind farm power using Squirrel Cage Induction Generator (SCIG) by variable pitch wind turbine. All these scenarios have been simulated with the help of the simulation program using MATLAB and its inbuilt components provided in Simulink library.

Keywords: Squirrel cage Induction Generator (SCIG), RLC Load, Static Synchronous Compensator (STATCOM)

INTRODUCTION

The size of wind turbine has increased from a few kilowatts to several megawatts each. In addition to on-land installation, larger wind turbines have been pushed to offshore location to harvest more energy and reduce their impact on land use and landscape. It covers general background on wind turbine knowledge, not only related to the electrical system, but also to mechanical and aerodynamics characteristics of wind turbines.
A squirrel cage induction generator always consumes reactive powerReactive power consumption of the squirrel
cage induction generatoris nearly partly or fully compensated by capacitors in order to achieve a power factor close to one. It acts as a great way to supply electricity to rural areas. It does not release any harmful emissions or pollutants that enter the atmosphere from using them. SCIG is fairly straightforward technique was first used since it is simple and has rugged construction, reliable operation, and low cost. However, the fixed-speed essential and potential voltage instability problems severely limit the operations of wind turbine. The well-known advantages of SCIG are it is robust, easy and relatively cheap for mass production. In addition, it enables stall-regulated machines to operate at a constant speed when it is connected to a large grid, which provides a stable control frequency. Although the stall control method is usually used in combination with the fixed speed SCIG for power control, the active stall control or pitch control have also been applied.SCIG has two parts, namely stator, rotor. The stator is made of thin silicon steel lamination. The laminations are insulated to minimize iron losses caused by induced eddy currents. The rotor of SCIG is composed of laminated core and rotors bars. The rotors bars are embedded in slots inside the rotor laminations and are shorted on both ends by end rings. When stator winding is connected to 3 phase supply, a rotating magnetic field is generated in the air gap. Rotating magnetic field induces a 3 phase voltage in rotor bars, since rotor bars are shorted, the induced rotor voltage produces rotor current.

SIMULATION OF WIND FARM USING SCIG

Simulation of 9MW wind farm power using Squirrel Cage Induction Generator (SCIG) by variable pitch wind turbine. This model consists of a 9MW wind form which is consisting of six 1.5-MW wind turbines is connected to a 25-kV distribution system exports power to a 120-kV grid through a 25-km 25-kV feeder. The 9-MW wind farm is simulated by three pairs of 1.5 MW wind-turbines. Wind turbines use squirrel-cage induction generators (IG). The stator winding is connected directly to the 60 Hz grid and the rotor is driven by a variable-pitch wind turbine. The pitch angle is controlled in order to limit the generator output power at its nominal value for winds exceeding the nominal speed (9 m/s). In order to generate power the IG speed must be slightly above the synchronous speed. Speed varies approximately between 1 pu at no load and 1.005 pu at full load. Each wind turbine has a protection system monitoring voltage, current and machine speed.

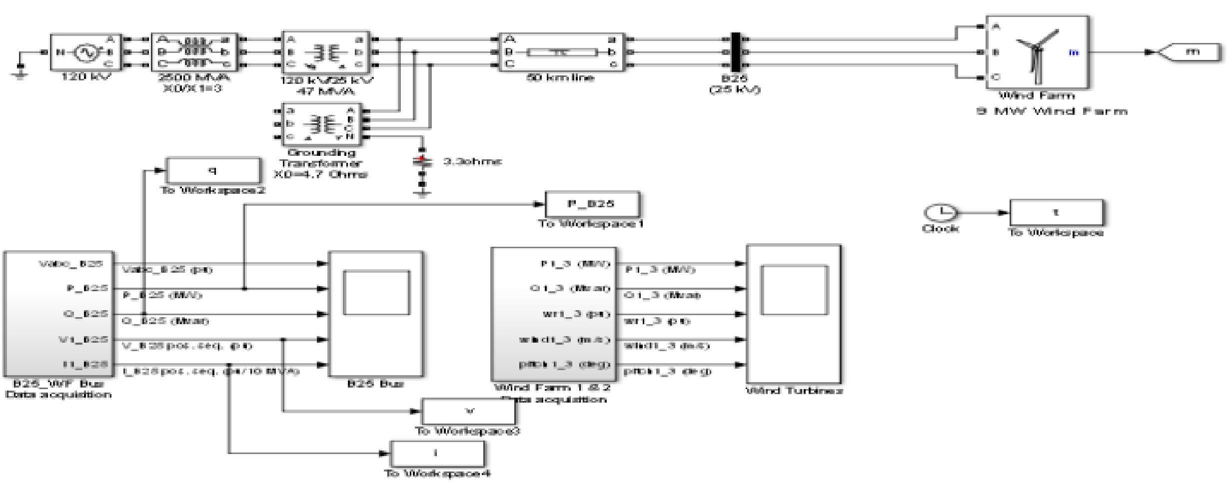


Fig.1 Model of wind farm using SCIG

Simulation of wind power model using three phase parallel RLC load, and phase to phase fault at wind turbine-2

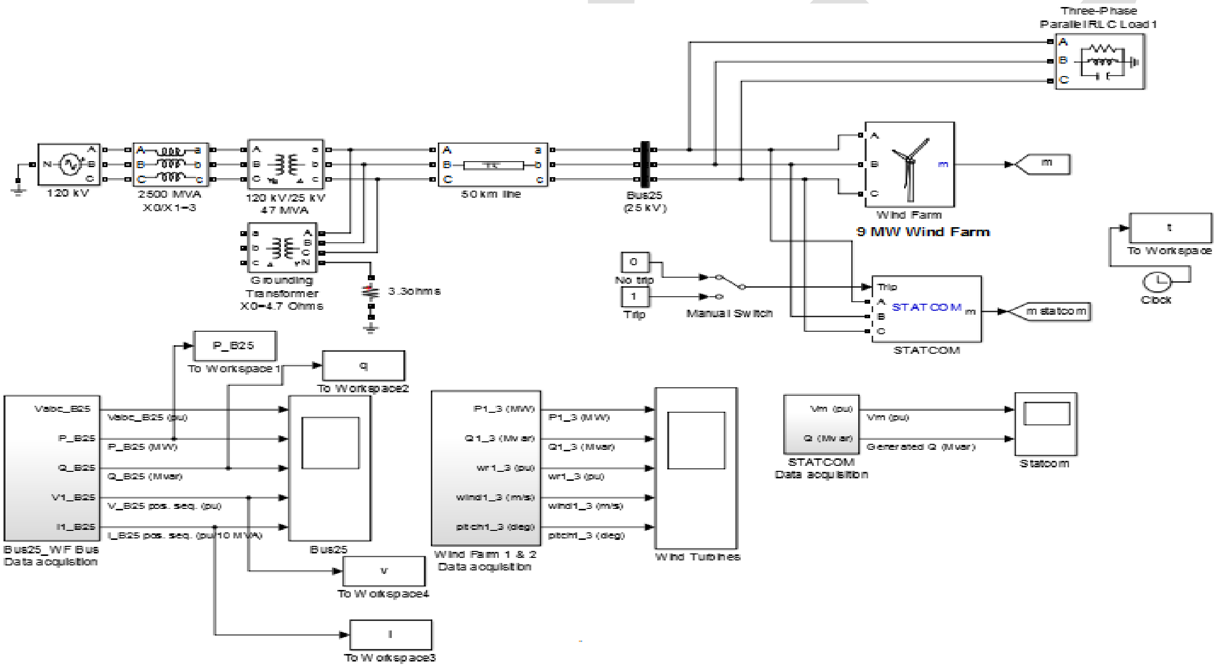


Fig.2: By connecting a three phase RLC load along with the STATCOM, we get following model which is given above

Three Phase RLC LOAD with fault at wind turbine terminal 2 we get the model as:

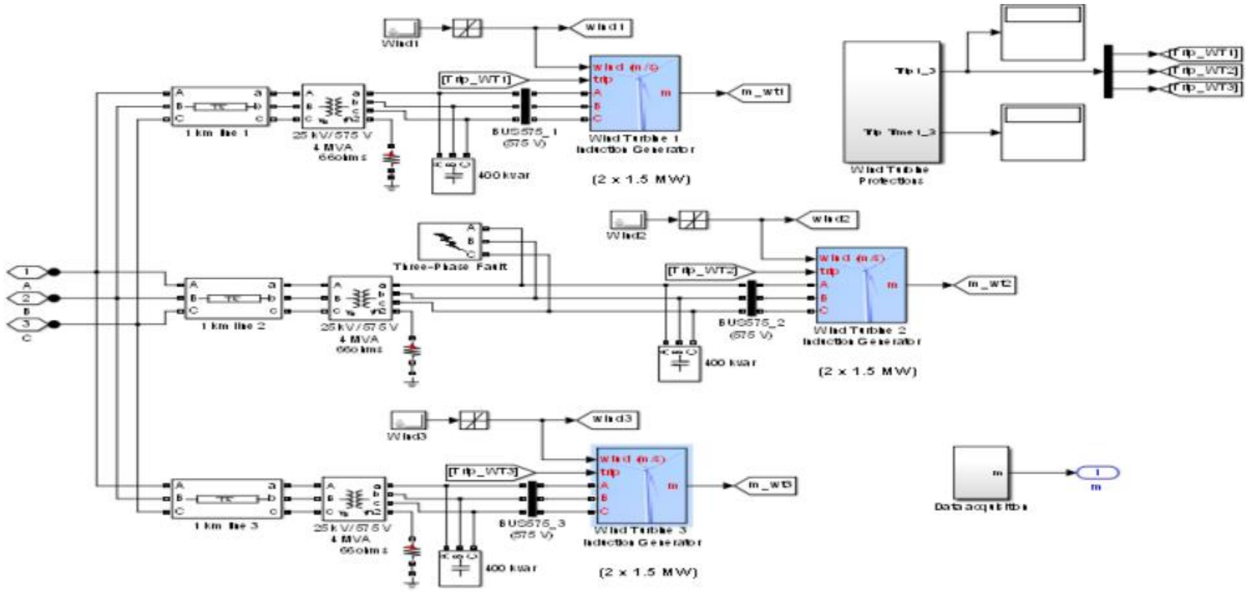
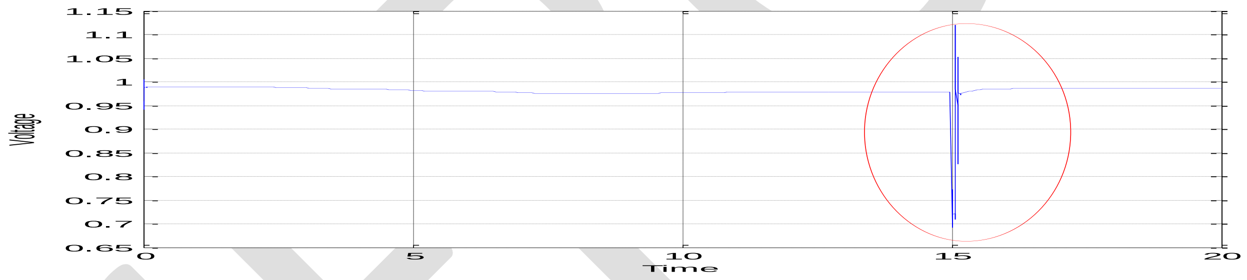
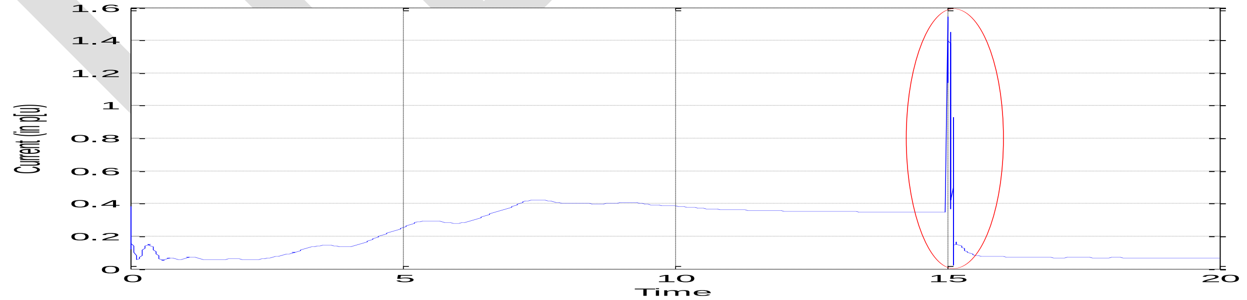


Fig.3: Subsystem model with three phase Fault at terminal of wind turbine-2

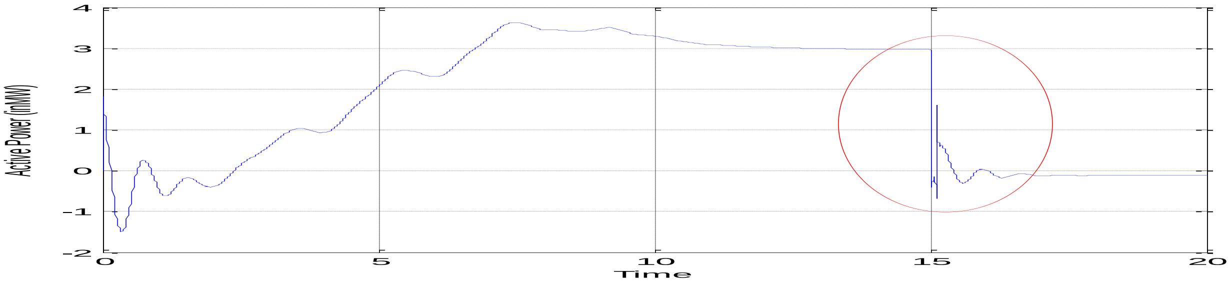
Waveform of output voltage and current



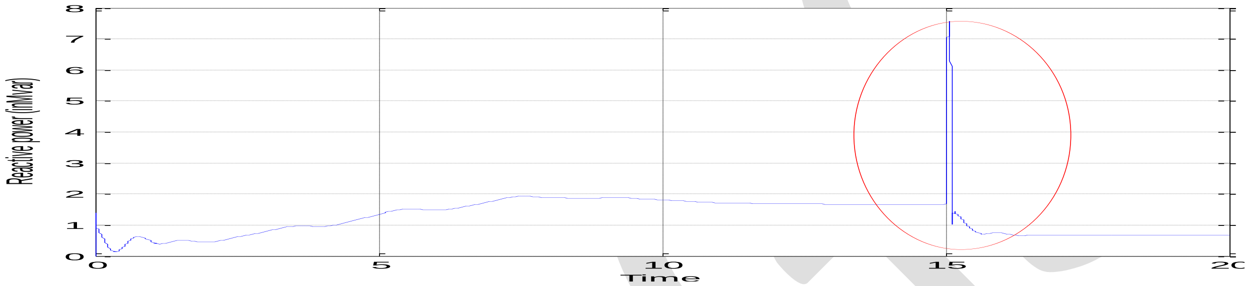
When three phase load, STATCOM is connected and phase to phase fault is occurred at the terminal of wind turbine-2, then voltage waveform, we get as shown in above fig. At t=15s (at the time of fault) voltage decreases to.7pu (shown inside the ellipse) and finally becomes to .998pu.



When three phase load, STATCOM is connected and phase to phase fault is occurred at the terminal of wind turbine-2, then current waveform, we get as shown in above fig. At t=15s (at the time of fault) current increases to1.6pu (shown inside the ellipse) and finally becomes to .1pu.



When three phase load, STATCOM is connected and phase to phase fault is occurred at the terminal of wind turbine-2, then active power waveform, we get as shown in above fig. At t=15s (at the time of fault) power decreases to-.7pu (shown inside the ellipse) and finally becomes to -.01MW.



When three phase load, STATCOM is connected and phase to phase fault is occurred at the terminal of wind turbine-2, then reactive power waveform, we get as shown in above fig. At t=15s (at the time of fault) power increases to7MVAr (shown inside the ellipse) and finally becomes to .7MVAr

RESULTS AND CONCLUSIONS

RESULT OF OUTPUT WAVEFORM WITH FAULT AND WITHOUT FAULTUSING STATCOM AND THREE PHASE RLC LOAD

1. Without fault (with the time of introduction of turbine being t=12 seconds)

(a). At t=0s, V=.989pu,

At t > = 12s,V=.979pu

(b).At t=0s, i=.15pu,

At t > = 12s, i=.3pu,

(c).At t=0s, P=1.5MW'

At t > =12s P=3MW'

(d). At t=0s, Q=.8Mvar,

At t > = 12s, Q=1.7Mvar

Thus we observe that the introduction of turbine at t=12 seconds brings an improvement in the current, real power and reactive power.

2. With Fault

(a). At t=0s, V=.98pu,

At t = 15s, V=.7pu

(b).At t=0s, i=.1pu,

At t = 15s, i=1.6 pu,

(c).At t=0s, P=1.4MW'

At t =15s P=-.5MW'

(d). At t=0s, Q=.8Mvar,

At t = 15s, Q=7.5Mvar

Thus we observe that the introduction of fault at wind turbine terminal two at t=15 seconds, we see that voltage reduces suddenly and reactive power increases rapidly. Also in general three phase fault voltage reduces rapidly

RESULT OF OUTPUT WAVEFORM WITH FAULT AND WITHOUT FAULT, WITHOUT STATCOM AND WITHOUT THREE PHASE RLC LOAD

1. Without Fault

(a). At t=0s, V=.68pu,

At t > = 15s,V=.98pu

(b).At t=0s, i=1.35pu,

At t > = 15s, i=.7pu,

(c).At t=0s, P=8.2MW'

At t > =15s P=6MW'

(d). At t=0s, Q=1.1Mvar,

At t > = 14s, Q=2.1Mvar

WITHOUT STATCOM AND WITHOUT THREE PHASE RLC LOAD, we see that voltage and reactive power reduces as compared to case with load and STATCOM. We have used statcom which compensate the reactive power generated by 9 MW wind turbine

2.With Fault

(a). At t=0s, V=.7pu,

At t = 15s, V=.90pu

(b).At t=0s, i=.1pu,

At t = 15s, i=1.6 pu,

(c).At t=0s, P=8.2MW'

At t =15s P=1.5MW'

(d). At t=0s, Q=11Mvar,

At t = 15s, Q=7.9Mvar

Thus we observe that the introduction of fault at wind turbine terminal two at t=15 seconds, we see that voltage reduces suddenly and reactive power increases rapidly. Also in general three phase fault voltage reduces rapidly, but the variation in voltage dip is more than above cases, in which STATCOM is used.

A COMPARATIVE TABLE SHOWING THE PERFORMANCE ANALYSIS FOR EACH OF THE DISCUSSED CASE

Parameter	condition	Voltage	Current	Active power	Reactive power
STATCOM and three phase load					
With fault	T=0s	0.98pu	0.1pu	1.4MW	0.8Mvar
	T=15s	0.7pu	1.6pu	-0.5MW	7.5Mvar
Without fault	T=0s	0.989pu	0.15pu	1.5MW	0.8Mvar
	T>=12s	0.979pu	0.3pu	3MW	1.7Mvar
Without STATCOM& with load					
With fault	T=0s	0.7pu	0.1pu	8.2MW	11Mvar
	T=15s	1.08pu	1.6pu	1.5MW	7.9Mvar
Without fault	T=0s	0.68pu	1.35pu	8.2MW	1.1Mvar
	T>=14s	0.98pu	0.7pu	6MW	2.1Mvar
Three phase load without STATCOM					
With fault	T=0s	0.68pu	1.5pu	-3MW	10Mvar
	T=15s	0.65pu	1.6pu	-3MW	8Mvar
Without fault	T=0s	0.70pu	0.15pu	-3MW	10Mvar
	T=15s	0.90pu	0.25pu	0.3MW	2.2Mvar

CONCLUSION

We observe that without fault using STATCOM and RLC Load the introduction of turbine at t=12 seconds brings an improvement in the voltage, real power and reactive power. And with fault we observe that at t=15 seconds, we see that voltage reduces suddenly and reactive power increases rapidly. Also three phase fault voltage reduces rapidly. Without STATCOM and without load, we see the voltage and reactive power reduces as compared to with load and STATCOM.

REFERENCES:

[1]. E. J. Bueno, S. Cóbreces, F. J. Rodríguez, A. Hernández, and F. Espinosa, Design of a Back-to-Back NPC Converter Interface for Wind Turbines with Squirrel-Cage Induction Generator, IEEE Transactions on Energy Conversion, Vol. 23, No. 3, 932-945, 2008.

[2]. D. Burnham, S. Sanioso, and E. Muljadi, Variable Rotor-Resistance Control of Wind Turbine Generators, in IEEE Power and Energy Society General Meeting (PES), 2009.

[3]. S. Müller, M. Deicke, and R. W. de Doncker, Doubly Fed Induction Generator Systems for Wind Turbines, IEEE Industry Applications Magazine, Vol. 8, No. 3, 26-33, 2002.

[4] D. Ehlert, and H. Wrede, Wind Turbines with Doubly-Fed Induction Generator Systems with Improved Performance due to Grid Requirements, in IEEE Power Engineering Society General Meeting, pp. 1-7, 2007.

[5]. X. Xiong, and H. Xin, "Research on Multiple Boost Converter Based on MW-Level Wind Energy Conversion System, in Proceedings of the Eighth International Conference on Electrical Machines and Systems (ICEMS), Vol. 2, 1046-1049, 2005.

[6]. Apoorva Srivastava¹, Rakesh Sharma², Virendra Kr. Maurya³ Performance Analysis of SCIG Coupled With Wind Turbine with and Without Fault Vol. 2, Issue 1, and January -2015 in International Journal of Advance Engineering and Research Development.

[7]. Rakesh Sharma, Kuldeep Sahay, Sateyndra Singh Effects of Varying Load on DC- Link Voltage in DFIG Based Wind Energy Conversion System Vol. 3, Issue 5, May 2014 International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering.

[8]. F. Blaabjerg and Z. Chen, Power Electronics for Modern Wind Turbines, Morgan & Claypool, 2006.

[9]. E. Diaz-Dorado, C. Carrillo, and J. Cidras, Control Algorithm for Coordinated Reactive Power Compensation in a Wind Park, IEEE Transactions on Energy Conversion, Vol. 23, No. 7, 1064-1072, 2008.

[10]. Active Power Control in Wind Driven Variable Speed Squirrel-Cage Induction Generator Vol. 1, Special Issue, December 2011 Bonfring International Journal of Power Systems and Integrated Circuits,

[11]. J. Luis Domínguez-García, O. Gomis-Bellmunt, L. Trilla-Romero, A. Junyent-Ferré, Indirect vector control of a squirrel Cage induction generator wind turbine, Computers and Mathematics with Applications 64 (2012) 102-114.

[12]. G. Hima Bindu, Dr. P. Nagaraju Mandadi Design and Modelling of Induction Generator Wind power Systems by using MATLAB/SIMULINK International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering(An ISO 3297: 2007 Certified Organization)Vol. 3, Issue 8 2014.

[13].Yu-Jen Lin Comparison of Speed and Voltage based Critical Clearing Time of Squirrel Cage Induction Generator Department of

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