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Modelling and Simulation of Wind Turbine Generator in MATLAB/SIMULINK

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Abstract: In this report, work done to develop generator model using MATLAB (Matrix laboratory) environment is explained. The main aim of the project was to develop an excellent Doubly fed induction generator model. The model can be used to understand, simulate and analyze transients load. The simulation of the model under different grid condition and articulation of the resonant excitation would be possible. This report also contains the technology of generator systems in wind energy conversion systems which are already in use and some of the new concepts and their technical features. The new generator technologies could generate invariable wind power and does not depends on the changes happen in the velocity of the wind. It has huge application across the globe and especially at the remote areas of the world.
Keywords: Variable speed, Wind Turbine Generator (WTG), Doubly-Fed Induction Generator (DFIG), Matrix Laboratory (MATLAB)/SIMULINK, Wound Rotor Induction Generator (WRIG), Fatigue Aerodynamics Structures, and Turbulence model (FAST).

I. INTRODUCTION

Hybrid is a consolidation of two or more energy sources which bring out decisive energy power because we are added more than one energy source. Scope of Hybrid Energy System is more in rural and remote areas because of lack benefit from the grid supply and because of increasement in demand, global warming, depletion of non-renewable energy sources is comple to go for renewable energy sources. The power which we get by tame of wind energy is called wind power. Solar and Wind energies give better results because these energies sources are adulatory in nature. Both energies are adulatory in nature when there is torrent of wind there is no sun about-face.

Recently, wind power infiltration into the power grid has been increasing globally at a momentous rate. The flexible speed generator wind turbine (ASGWT) has decisive advantages over the fixed-speed generator wind turbine (FSGWT) in premise of less mechanical stress, enhanced power quality, high system productivity and minimised acoustic noise. One imperative class of ASGWT is the Doubly-Fed Induction Generator (DFIG), which has attained important attention from the electric power industry due to its assets over the other class of ASGWT that is fully rated converter-based wind turbines.

During the recent years, with rising advancement of wind energy alteration technology, in the End of 2004 the total installed capacity has reached up to 39.234GW and will outstrip 110GW by 2012.In Nowadays Fixed speed or Variable speed Applications available in the market heed to ingenious concepts in technology.

II. DESCRIPTION

Using toolbox of MATLAB Simpowersystems, Doubly fed Induction Generator turbine model has been developed. The developed model is a phasor model where power system is treated as balanced three phase fixed frequency network. In balanced three phase fixed frequency, each phase voltage is equal in magnitude but phase difference between any two phases is 120 degrees. The differential equation representing the network with a of algebraic equations' set at a frequency which is fixed are replaced by phasor simulation.

Transient stabilities studies of systems with multiple machines is also possible with the help of phasor simulation. For studying the unbalanced events, phasor simulation cannot be used.

Phasor simulation is also known as positive sequence simulation. For the simulation of electromechanical oscillations of low frequency within seconds to minutes, this model is always adapted. For the simulation of generator in another way, there is a technique called three-phase representation can be used. In three phase representation, simulation of unbalanced condition is possible.

Grid unbalanced voltage (such as transients, faults or dips) or unbalanced grid impedance are the main cause of unbalanced conditions. The model developed till date does not cover all these factors.

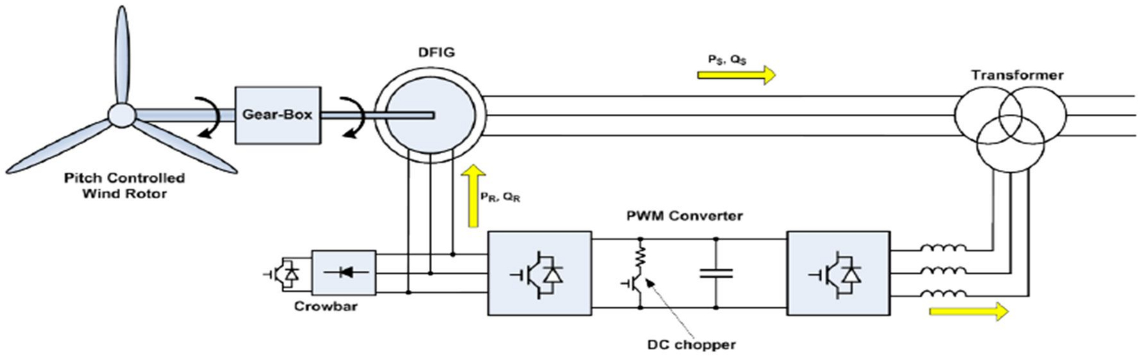

Fig.1 Wind turbine connection diagram

Wind turbine generators (shown in figure) are variable-speed wind turbines with DFIG. This type of turbine is the most popular type among other types that are available in market and it is being put in position in large numbers. Operation of DFIG is in variable speed mode in which power converter of partial size is connected to WRIG's rotor winding. Connection of WRIG's stator winding is to the grid at a required frequency. Normal operation of WTG is between 30 percent slip (sub synchronous speed) and -30 percent slip (super synchronous speed), converter is operated at 30 percent of the output power which is rated. The role of power converter is to perform back to back AC-DC-AC conversion with the help of two pulse width modulation-switched voltage-source inverters coupled with a DC link. For the protection purposes, crowbar circuit is deployed, allowing shorting rotor circuit, if necessary.

The nature of torque characteristics of WTG is the function (quadratic) of the rotational speed. There is possibility of maximum extraction of wind power in WTG system because output power of WTG system could be electronically controlled following optimal power curve. The optimal power curve is in form of function (Cube) of the rotational speed. Pitch Controller plays a major role in limiting the rotational speed of the rotor. Pitch controller is always put in position to control the rotational speed to the rated speed, if the speed of rotor exceeds its rated value. WTG experiences runaway event, when pitch controller is unable to control wind turbine's aerodynamic power.

Simpowersystems toolbox of MATLAB/Simulink gives an example phasor model of a Doubly fed Induction generator Turbine which has most straightforward mechanics. This model has been modified, basic mechanical and aerodynamics aspects have been replaced with the FAST Simulink block.

The torque input was provided to the Doubly fed Induction Generator block (light blue in colour) model, but various calculations for two mass (generator and turbine) shaft model is handled by FAST. This is the reason speed input can be directly provided to the generator. Two-mass shaft sub-model was by passed within the generator. Crowbar or DC chopper is not included in this generator model. In the original model, pitch control subsystem was not present. So, it is added in this model.

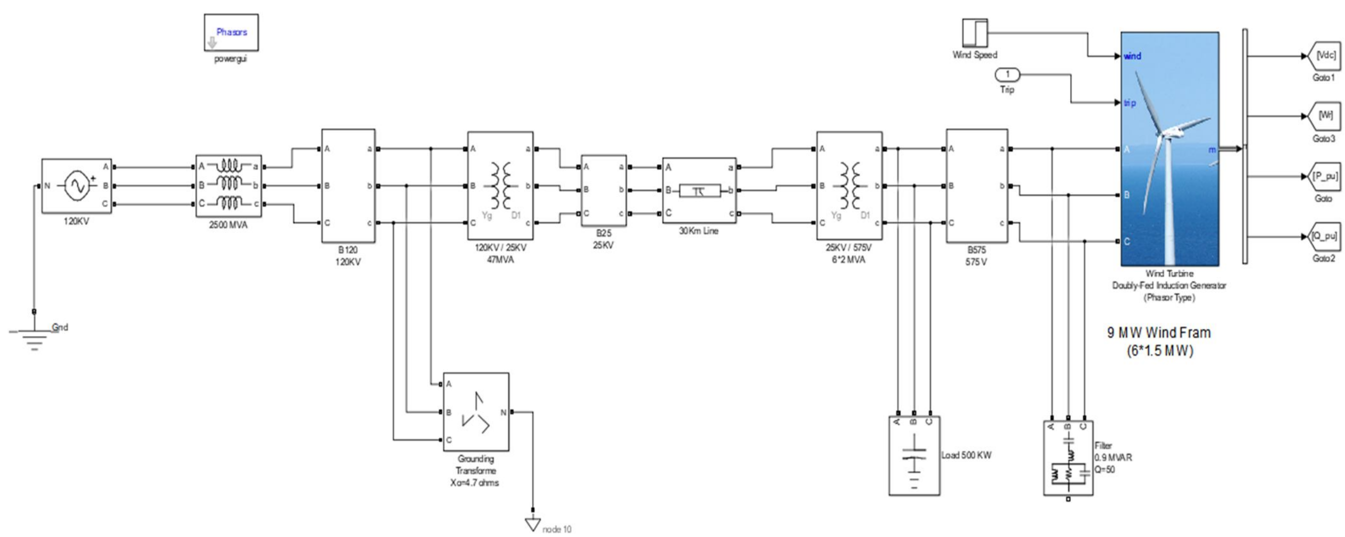

Fig.2 Wind turbine model using Sim Power Systems

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III. RESULT

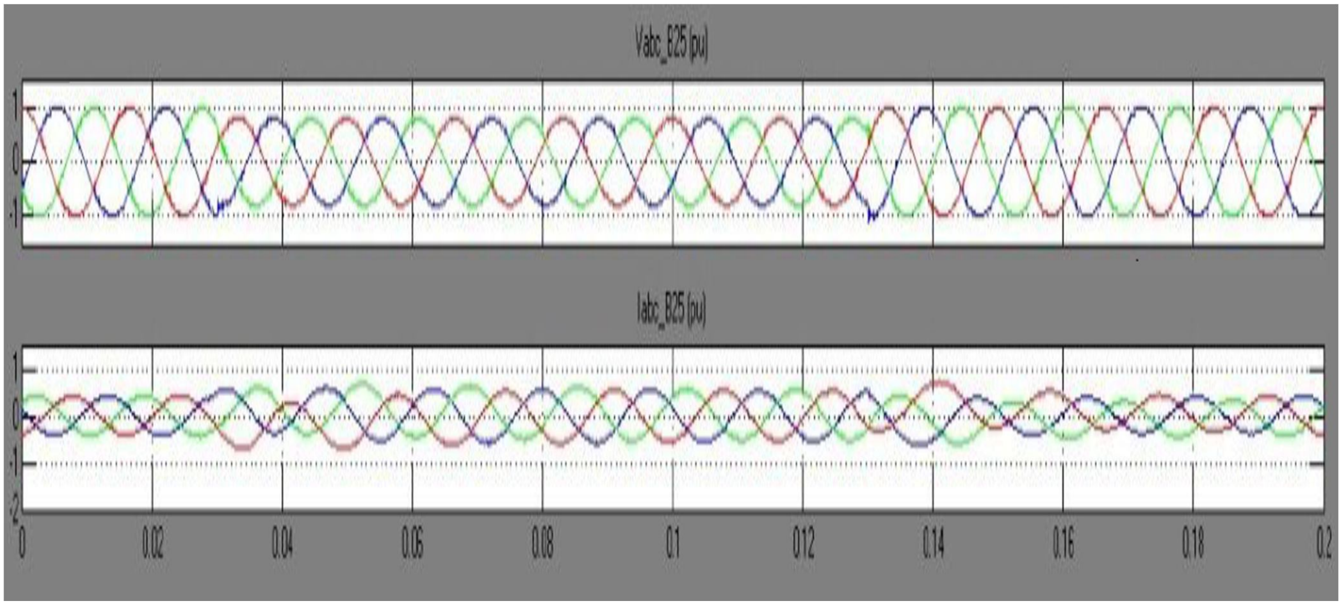

Fig.3 Voltage and Current Waveform

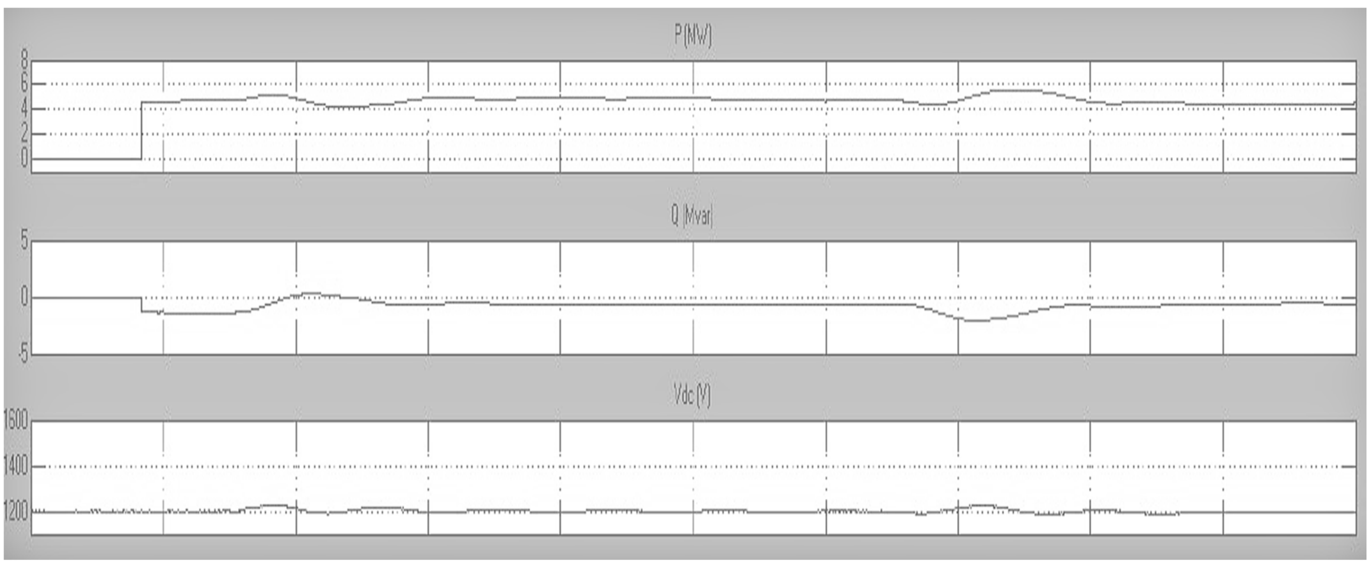

Fig.4 Power and Voltage Waveform

IV. CONCLUSION

The role of wind power generation in the age of early power generation was considered to be minor. As the technology grows and expands, there has been a lot of progresses in the field of wind power generation that will lead to better generators with excellent interfaces of grid. Wind power generation is considered as crucial type of generation by the utility industry. The demand and requirement of WTGs are increasing day by day. As the demand and requirement of wind power increases, wind power plants must have capabilities of have fault ride-through to make sure that wind power generation remains connected to the grid in the situation of minor disturbances. Manufacturers of wind turbine are required to analyse the consequences of the disturbances occur in the grid and new requirements which will impact on the design of wind turbine generators in order to support power system reliability. Similarly, to provide adherent services to support the grid, a planner of the power system is required to analyse the limitation of wind turbine generators. Various requirements consisting of inertial response, spinning reserves capability and governor response capability are being enforces by transmission system operators. Inspiration of this project was to conduct a better approach for designing and analysing the wind turbines in both ways i.e., impact of turbine on grid and impact of grid on turbine.

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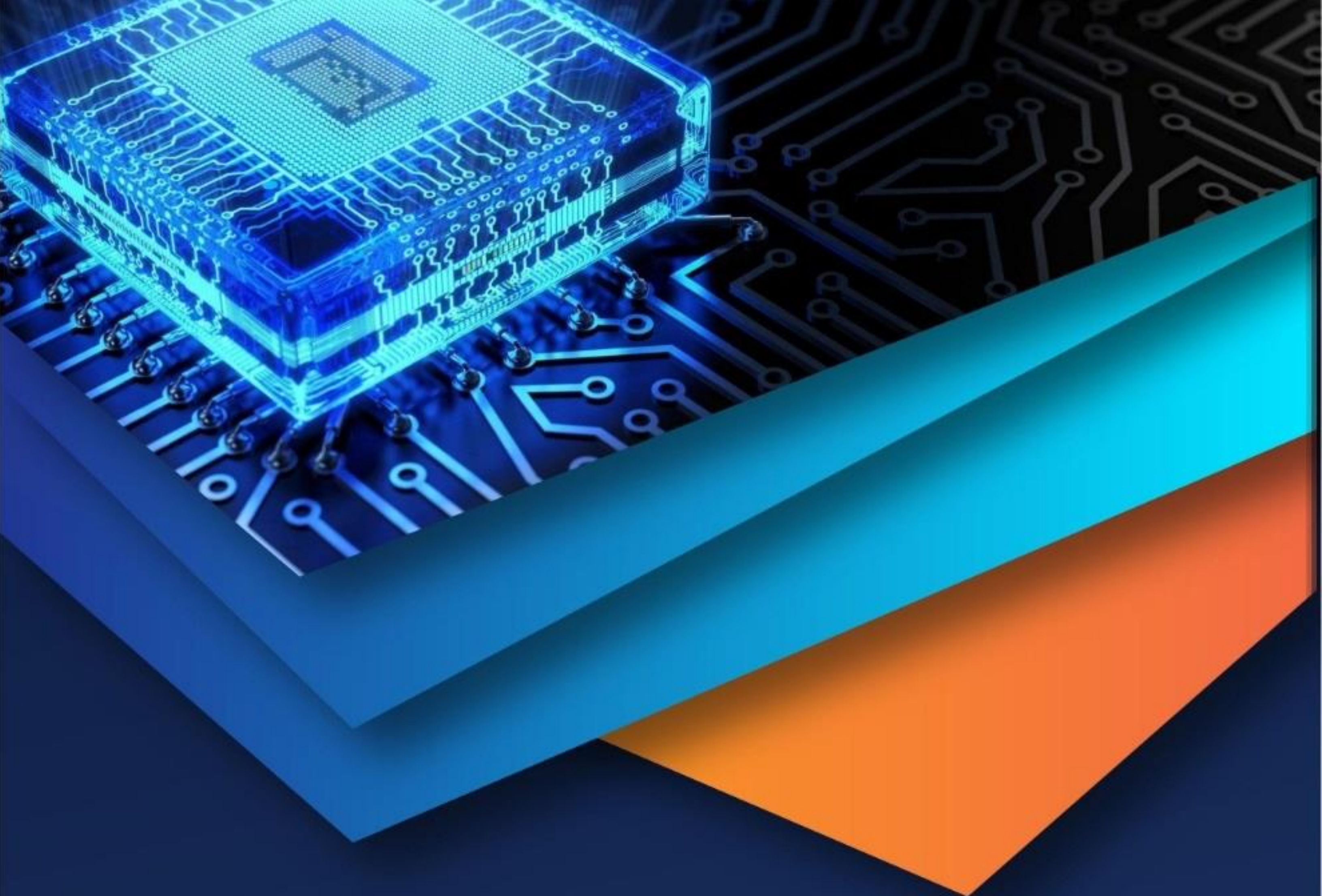

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