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PERFORMANCE ANALYSIS OF GRID-CONNECTED WIND FARM

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ABSTRACT:

The worldwide consumption of electrical energy is increasing and there is gradually increased demand for power generation. The wind turbine power generation unit is more economical and competitive than all the existing environmentally clean and safe renewable energy sources. However, wind electrical generation systems provide intermittent energy depending upon the wind regimes in the region. Therefore, any transient disturbance can result in changes in the voltage, current, and power at various points of the integrated system. Various simulation results are obtained through transient analysis using a generic wind turbine generation model. In this wind farm, a doubly fed induction generator (DFIG) model is used. For showing the simulation of DFIG, *MATLAB/SIMULINK* software is used.

KEYWORDS:

DOUBLY FED INDUCTION GENERATOR (DFIG), POINT OF COMMON COUPLING (PCC), WIND ENERGY CONVERSION SYSTEM (WECS).

1. INTRODUCTION

The worldwide consumption of electrical energy is increasing and there is gradually increased of demand on power generation. Thus in accumulation to conventional power generation sources a various number of renewable energy sources are being connected to the power system. Wind is most desirable source surrounded by all other renewable energy because it is non-polluting, available in abundance and reasonable cost for both small and large order systems. The most satisfying resource this whole need for wind in a natural source energy source. The wind turbine power generation unit is more economical and competitive than all the existing environmentally clean and safe renewable energy sources in the world. In wind turbine generation technology variable speed double-fed induction and constant-speed squirrel-cage induction generators are used. However, wind electrical generation systems provide intermittent energy depending upon the wind regimes in the region. Therefore, any transient disturbance can result in changes in the voltage, current and power at various points of the integrated system. A study of such effects is useful to the power system energy planner.

1.1 WIND ENERGY CONVERSION SYSTEM

Wind energy conversion system (WECS) is applied to change wind energy into useful mechanical energy. The terms "wind power" or "wind energy" relate the operation by which the wind is used for develop electric energy or mechanical energy. In rural and remote areas, wind turbine system is most generally installed. These areas generally have weak grids and which generally have under voltage conditions and voltage unbalances. The torque generated by the electrical machine (induction generator) is fluting in nature when the stator phase voltage supplied by the grid is unbalanced in nature. The developed torque is pulsations in nature with double the grid frequency and resulted in acoustic noise at low levels and at high levels and it can damage the blade assembly, gearbox or rotor shaft. The induction generator will take the unbalanced current when the grid is unbalanced. These unbalanced current causes over current problems as well as increase the grid voltage unbalance. The most important components of a typical WECS are wind turbine, interconnection apparatus, turbine generator and control systems. The wind turbine is used as the prime-mover to supply mechanical power to an electrical generator (DFIG). The WECS has basically consists of two considerable components:

(i) Turbine system and associated control box (including the gearbox)

(ii) Electrical system consists the rotor converter system and the associated control

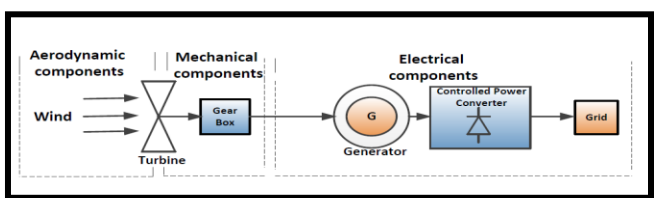

FIG. 1 BLOCK DIAGRAM OF THE COMPONENTS OF WECS CONNECTED TO THE GRID

2. POWER GRID MODEL

The single line diagram of the test system used for the *MATLAB simulation* is shown in figure 3. *MATLAB/SIMULINK* is used for the analysis. The grid model [American system] consists of a 120kV, 60Hz grid supply point, feeding the supply to 25 kV distribution system through a step down transformer of 120-25kV, 47MVA, another 25kV-575V, 12MVA step-down transformer connected between grid and bus B4 to again step down the voltage at the level 575 volt.

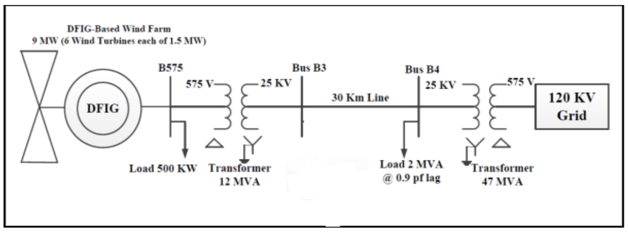

FIG.3 SINGLE LINE DIAGRAM OF THE TEST SYSTEM

There are two loads in the system one load is (a) 2MVA and 0.9 p.f. (lag) at 30 km from the transmission line, and (b) a static load of 500-kW at 575V bus. The 25kV, 30-kmlong line is represented as nominal-Π line. A DFIG-based wind farm consists of six DFIG-based wind turbines connected at 575V bus, each with 1.5MW (for a total of 9MW) which have a protection system monitoring current, voltage, speed and

SimPower System toolbox used for the simulation of wind farm of 9 MW wind farm. Six DFIG-based wind turbines are connected together and represented by a single equivalent wind turbine mode of 9 MW. Each individual DFIG wind turbine system has a capacity of 1.5MW, which results a total of 9MW DFIG-based Wind farm. The simulation analysis is discussed using *MATLAB/SIMULINK* platform for various transient disturbance cases.

grid, a grounding Transformer is applied with capacity of 47MVA and leakage impedance (Xo=4).

3. RESULTS AND DISCUSSION

4.1 SYSTEM RESPONSE WITH CHANGE IN WIND SPEED

DFIG-based wind farm was initially run under normal operation to calculate the steady state output conditions of the system. Wind speed given as input to a step block that shows the sudden variation in wind speed. At starting the wind speed fixed at 8m/s and at a time of t=5s the wind speed is suddenly increased to 14m/s through a step signal. The control mode is fixed at voltage regulation mode with the help of control block of the DFIG-linked wind farm. In this mode reference voltage is set 1 p.u. on the basis of generator rating which 9 MVA and 575volt at the point of common coupling (PCC)at bus B-575. At time t = 5s, the generated active power begins increase gradually with the turbine speed and Approximately 18sec and also reach to its maximum power generation capacity of 9 MW. Within same time the speed of turbine is rise from 0.8 to 1.2 p.u. of the synchronous speed. At PCC (Bus B575 in this model) voltage should be maintain at 1 p.u .so that it is necessary that reactive power should be under controlled. The equivalent DC link voltage should be approximately 1200 volt and increase pitch angle from 0 to 0.78 deg to restrict the mechanical power. At rated power, the wind turbine absorbs 0.682 Mvar reactive power (Q=-0.68 Mvar) to maintain the voltage 1 p.u. equivalent to reference voltage

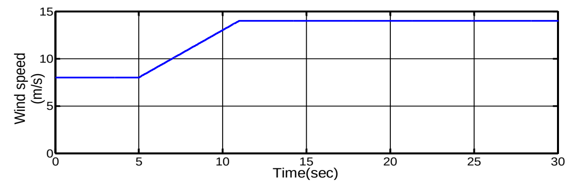

FIG. 4: WIND SPEED PROFILE

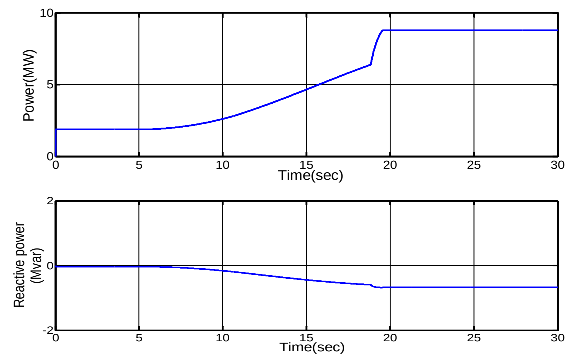

FIG. 5: DFIG GENERATED ACTIVE AND REACTIVE POWER

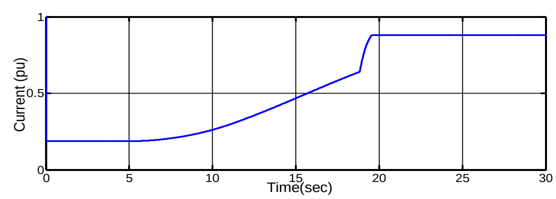

FIG.6: CURRENT AT PCC (BUS B575)

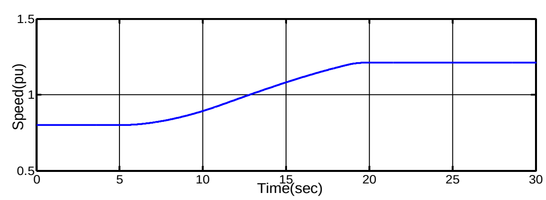

FIG. 7: TURBINE SPEED AT PCC (BUS 575)

4. CONCLUSION

On the basis of Simulation results it can be concluded that the dynamic behavior of DFIG turbine varies with the variation in the base wind speed. Fluctuations in the wind speed will produce a prominent influence on the stability of the system.

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