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ANALYSIS OF STABILITY ISSUES IN DOUBLY FED INDUCTION GENERATOR WIND ENERGY SYSTEM

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Abstract-- Due to large power demand and environmental issues, electrical power generation from renewable energy sources is receiving more attention. Wind energy generation systems are being integrated to power networks worldwide in increasing numbers. The power system is therefore facing new challenges due to intermittent nature of input source. The stability becomes an issue when wind generators are connected to the grid, due to the interaction between the grid and the wind turbines. The main impact on the grid by the wind generators, regarding stability, is related to voltage sag, reactive power, harmonics, power peaks and flickers. The stability problem arises when the wind generators are equipped with the grid. Analysis done with real time system of grid interactive wind plant using Mat lab/Simulink power system block set.

***Index terms*-- Wind Energy, Stability, Grid and Turbines**

I. INTRODUCTION

Grid-connected wind capacity is undergoing the fastest rate of growth of any form of electricity generation, achieving global annual growth rates on the order of 20 - 30%. Capacity has been doubling every three years for the last decade. The World Energy Council has stated that it is doubtful whether any other energy technology is growing, or has grown, at such a rate.

Recently wind power generation has been experiencing a rapid development in a global scale. The size of wind turbines and wind farms are increasing quickly; a large amount of wind power is integrated into the power system. As the wind power penetration into the grid increases quickly, the influence of wind turbines on the power quality and voltage stability is becoming more and more important. It is well known that a huge penetration of wind energy in a power system may cause important problems due to the random nature of the wind and the characteristics of the wind generators.

In the case of smaller installations connected to weak electric grids such as medium voltage distribution networks, power quality problems may became a serious concern because of the proximity of the generators to the loads. The existence of voltage dips is one of the main disturbances related to power quality in distribution networks. In developed countries, it is known that from 75% up to 95% of the industrial sector claims to the electric distribution companies are related to problems originated by this disturbance type. These problems arise from the fact that many electrical loads are not designed to maintain their normal use behavior during a voltage dip.

II. STABILITY ISSUES IN WIND ENERGY SYSTEM

Power outages:

Power outages are total interruptions of electrical supply. Utilities have installed protection equipment that briefly interrupts power to allow time for a disturbance to dissipate.
Causes: Ice storms; lightning; wind; utility equipment failure.
Effects: Complete disruption of operation.

Voltage fluctuations:

Voltage fluctuations are changes or swings in the steady-state voltage above or below the designated input range for a piece of equipment. Fluctuations include both sags and swells.
Causes: Large equipment start-up or shut down; sudden change in load.
Effects: Data errors; memory loss; equipment shutdown; flickering lights; motors stalling/stopping.

Transients:

Transients, commonly called "surges," are sub-cycle disturbances of very short duration that vary greatly in magnitude. When transient occur, thousands of voltage can be generated into the electrical system, causing problems for equipment down the line.
Causes: Lighting; equipment start-up and shutdown; welding equipment.
Effects: Processing errors; computer lock-up; burned circuit boards; degradation of electrical insulation; equipment damage.

Harmonics: Harmonics are the periodic steady-state distortions of the sine wave due to equipment's generating frequency other than the standard 60 cycles per second.

Causes: Electronic ballasts; non-linear loads; variable frequency drives.

Effects: Overheating of electrical equipment; random breakers tripping.

III. STABILITY IMPROVEMENT IN WIND ENERGY SYSTEM

A. Frequency and power control

The real power generation of a wind turbine can be regulated down but it may be difficult to increase the power output since the input power is limited by the wind speed. However, some spinning reserve may be kept if the wind turbine is operated at a lower power level than the available power level which means a reduction in generation, and hence reduced revenues. Large scale energy storage system may present an answer, some fast response energy storage devices could be well technically suited for this purpose though more work is needed to make the solution an economic one. From the system operator's point view, a system level hot reserve allocation amount the generation units may be more cost effective to deal with the problem if possible.

B. Reactive power compensation

Many wind turbines are equipped with induction generators which consume reactive power. At no load (idling), the reactive power consumption is about 35-40% of the rated active power, and increases to around 60% at rated power. Reactive power is one of the major causes of voltage instability in the network due to the associated voltage drops in the transmission lines, reactive current also contributes to system losses. Locally installed capacitor banks may compensate the reactive power demand of the induction generators. For WT with self-commutated power electronic systems, the reactive power can be controlled to minimize losses and to increase voltage stability. Thus these WT can have a power factor of 1.00, as well as have the possibility to control voltage by controlling the reactive power. For a large scale wind farm, a central reactive power compensation device, such as SVC or STATCOM may be used to provide a smooth reactive power regulation.

C. Stability support

An important issue when integrating large scale wind farms is the impacts on the system stability and transient behavior. System stability is largely associated with power system faults in a network such as tripping of transmission lines, loss of production capacity (generator unit failure) and short circuits. These failures disrupt the balance of power (active and reactive) and change the power flow. Though the capacity of the operating generators may be adequate, large voltage drops may occur suddenly. The unbalance and re-distribution of real and reactive power in the network may force the voltage to vary beyond the boundary of stability. A period of low voltage may occur and possibly be followed by a complete loss of power (blackout). Many of power system faults are cleared by the relay protection of the transmission system either by disconnection or by disconnection and fast reclosure. In all the situations the result is a short period with low or no voltage followed by a period when the voltage returns. A wind farm nearby will see this event. In early days of the development of wind energy, only a few wind turbines were connected to the grid. In this situation, when a fault somewhere in the lines caused the voltage at the wind turbine to drop, the wind turbine was simply disconnected from the grid and was reconnected when the fault was cleared and the voltage returned to normal. Because the penetration of wind power in the early days was low, the sudden disconnection of a wind turbine or even a wind farm from the grid did not cause a significant impact on the stability of the power system. With the increasing penetration of wind energy, the contribution of power generated by a wind farm can be significant. Therefore, the new generation of wind turbines is required to be able to “ride through” during disturbances and faults to avoid total disconnection from the grid. In order to keep system stability, it is necessary to ensure that the wind turbine restores normal operation in an appropriate way and within appropriate time. This could have different focuses in different types of wind turbine technologies, and may include supporting the system voltage with reactive power compensation devices, such as interface power electronics, SVC, STATCOM and keeping the generator at appropriate speed by regulating the power etc.

IV. CASE STUDY

PLANT DETAILS

Capacity	17x1.5MW
Make	GE
Rating	1500kW, 690V
Type	DFIG

Wind Turbine (WT) Details

Rated power	1.5 MW
Nominal apparent power	1.666 MVA
Rated voltage(V)	690
Rated current(A)	1340
Power factor	0.9-1-0.9
Type of generator	DFIG
Number of poles	4
Nominal speed(rpm)	1800
Power(kW)	1500

Pf cosØ	⩾ 0.92
Efficiency	96%
Ventilation	Forced cooling
Direction of rotation	Right
Useful life hour	>100000

V. MATLAB/SIMULINK MODEL OF DFIG WIND ENERGY SYSTEM

For the above Plant Data the model is considered for analysis of stability issues in DFIG wind energy system. Analysis done with real time system of grid interactive wind plant using Mat lab/Simulink power system block set.

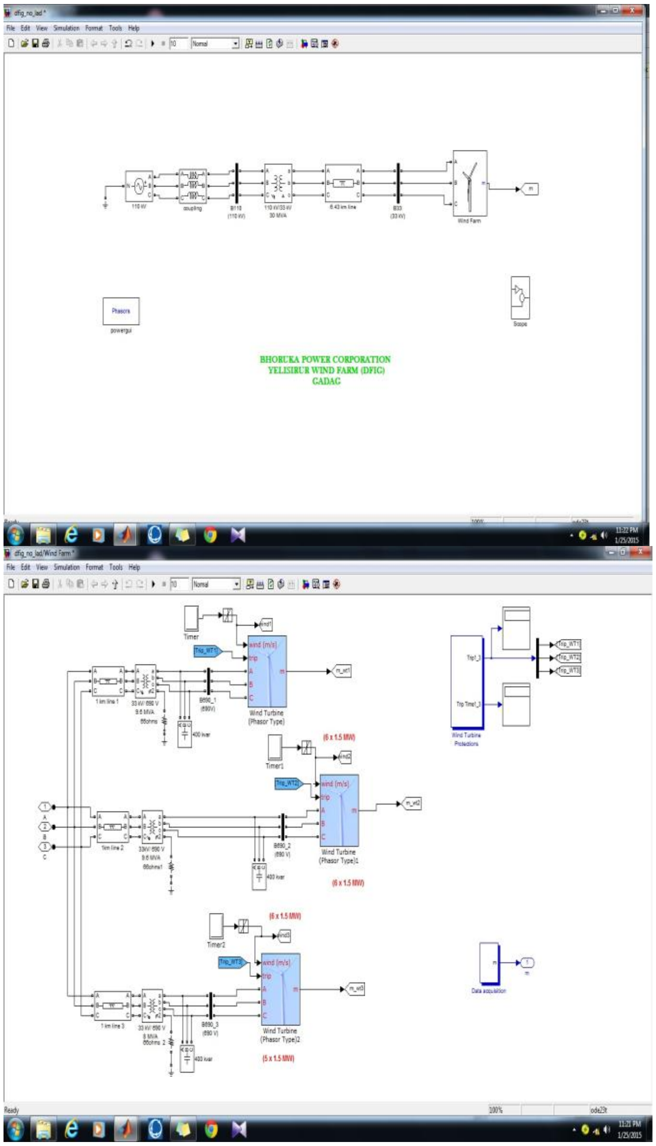


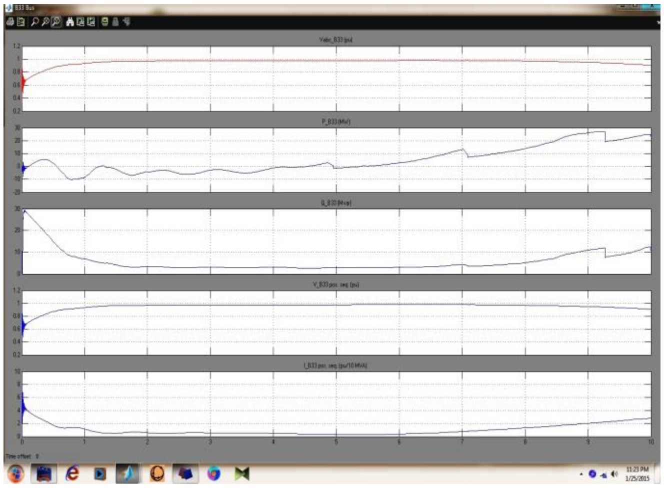
Figure 1: Simulink model of DFIG Wind System

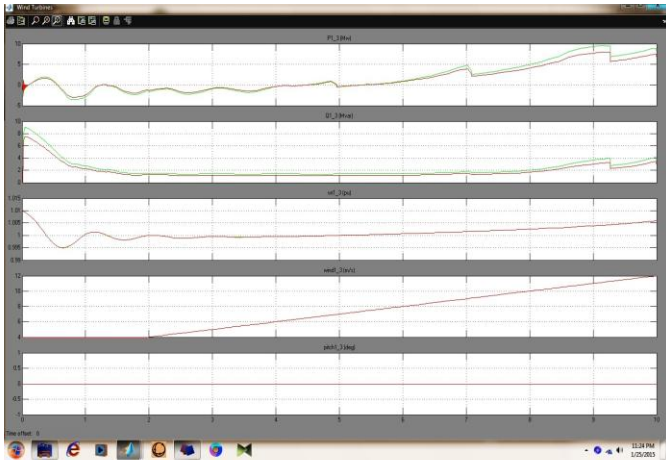
VI. RESULTS OBTAINED AT DIFFERENT CASES

CASE1: NO LOAD CONDITION

CASE 1	TIME (SEC)	BUS VALUES 33 KV				
		V(PU)	P(MW)	Q(Mvar)	Vpseq (PU)	Ipseq (PU)
NO LOAD CONDITION	5	0.97	-1	3.3	0.97	0.44
	10	0.91	24	10	1.0093	0.1227

WIND TURBINE VALUES				
P(MW)	Q(Mvar)	ROTOR SPEED(PU)	WIND SPEED(m/s)	PITCH ANGLE(deg)
-0.3	1.68	1	7	0
8.4	3.6	1	12	0



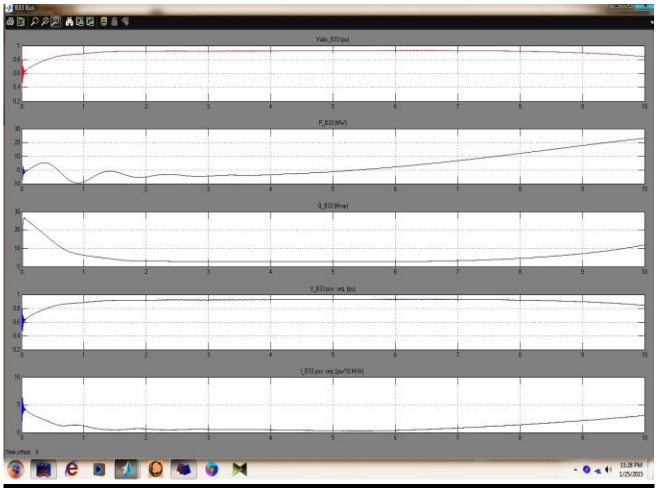


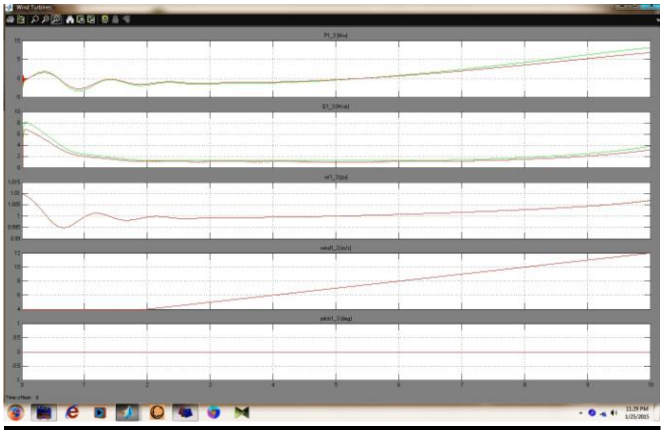
Graph 1: Waveforms of Bus Voltages and Wind Turbine

CASE2: LOAD AT 110KV BUS- LOAD VALUE 6MW

CASE 2	TIME (SEC)	BUS VALUES 33 KV				
		V(PU)	P(MW)	Q(Mvar)	Vpseq(PU)	Ipseq (PU)
LOAD AT 110KV BUS LOAD 6MW	5	0.92	-1.3	3.0	0.92	0.32
	10	0.85	23.2	11.5	0.84	3.075

WIND TURBINE VALUES				
P(MW)	Q(Mvar)	ROTOR SPEED(PU)	WIND SPEED(m/s)	PITCH ANGLE(deg)
-0.5	-6.5	1.0	7	0
0	0	1.15	12	0



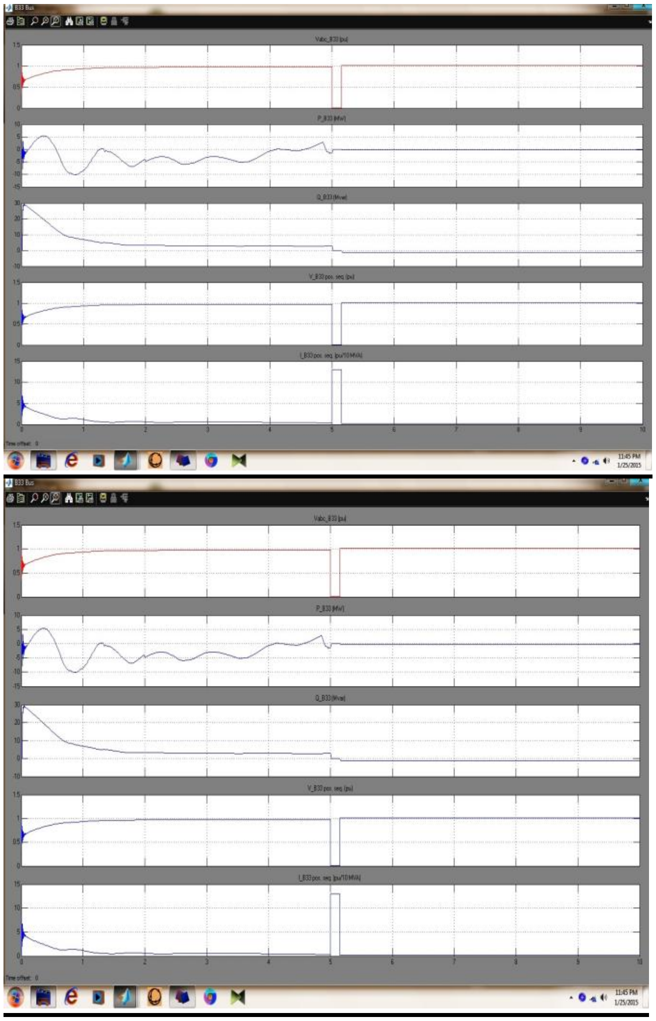


Graph 2: Waveforms of Bus Voltages and Wind Turbine

CASE3: FAULT AT 690V BUS – NO LOAD

CASE 3	TIME (SEC)	BUS VALUES 33 KV				
		V(PU)	P(MW)	Q(Mvar)	Vpseq(PU)	Ipseq(PU)
FAULT AT 690V BUS NO LOAD	5	0.97-0	-1.4	0	1.16	12.93
	10	1	0	-1.2	1.0092	0.1237

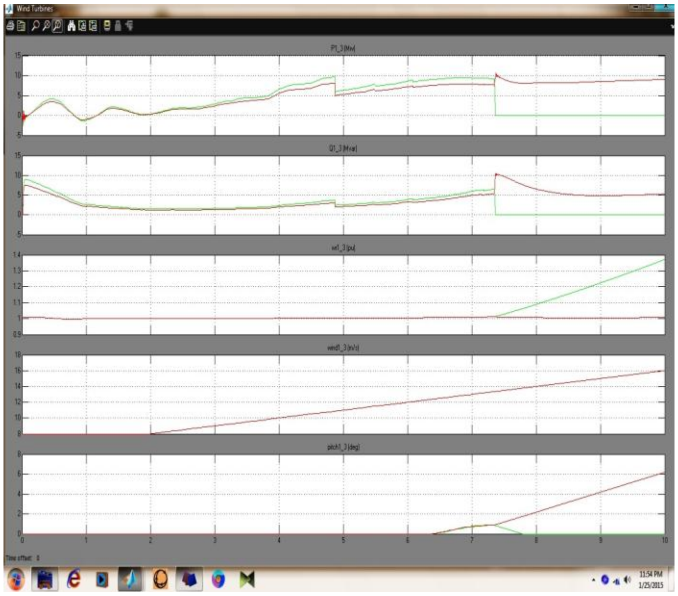
WIND TURBINE VALUES				
P(MW)	Q(Mvar)	ROTOR SPEED(PU)	WIND SPEED(m/s)	PITCH ANGLE(deg)
0	1.5	1	7	0
8.1	1.0	1.007	12	0



Graph 3: Waveforms of Bus Voltages and Wind Turbine

CASE 4: CHANGE OF SPEED AT NO LOAD CONDITION

SPEED (m/s)	P (MW)	Q (Mvar)	ROTOR SPEED (PU)	PITCH ANGLE (deg)
8	1	1.7	1	0
9	3.2	1.8	1.0015	0
10	5	2	1.0025	0
11	6.5	2.5	1.004	0
12	8.5	3.8	1.006	0
18	10.45	5.2	1.66	9.6
20	11.6	6.5	2.0	13.6
22	12.6	8.5	2.4	17.6
24	0	0	2.72	21.8



Graph 4: Waveform of Wind Turbine at change of speed

VII. RESULT ANALYSIS

The above results shows the Stability issues of Grid interactive DFIG Wind Energy system. The Voltage variations with respect to different turbines in a plant causes voltage instability. The power outages at the Buses causes instability in the DFIG wind Energy system.

In Case 1 at no load condition the model is simulated using Matlab/Simulink power system block set. No load condition Voltage fluctuation at the Bus values and Power outages at the wind turbine values we can see.

In case 2 Load at 110KV bus the load value will be given as 6MW. In that also we can observe Voltage fluctuation and Power outages compared to Case 1 of No load condition.

In case 3 Fault at 690V bus that should fault value without load at that situation we can the Voltages and Power outages with greater instability of the wind plant.

Finally Case 4 Change of Wind Speed, if change in wind speed obviously changes in the Power, Reactive power, Rotor speed and pitch angle. Here we can observe the Stability of wind depends also with change in wind speed.

VIII. CONCLUSION

Here on top of results and discussion relating to the DFIG turbine Plant solely of Stability problems and the way the instability happens within the Wind energy system shown with simulation model. All on top of cases shows instability within the system. Currently we are able to improve the stability of the system by using reliable FACTS controllers or the other solution and improve the stability of the Wind Energy System.

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