A REVIEW OF QUALITY AND STABILITY ASSESSMENT OF POWER SYSTEM OF WIND ENERGY IN DISTRIBUTION NETWORK

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Abstract: This paper presents control methods to improve power system stability direct drive variable speed wind turbine connected to distribution system. Induction generator absorbs reactive power from the power system, which affects the active and reactive power resulting a bus voltage instability and low power factor. FACTs devices are used to improve power system stability and to enhance the system performance during loss of generation, voltage sag, voltage swell, load changes and faults. FACTs devices are used to improve power system stability and to enhance the system performance during loss of generation, voltage sag, voltage swell, load changes and faults. The IEEE 34 node radial distribution test feeder used as main system and simulation perform in MATLAB software and results are carried out.

Keywords: Wind turbine, Power system stability, Reactive Power, FACTS devices, MATLAB

I. INTRODUCTION

India's power sector is one of the most diverse in the world. Sources of energy era extend from ordinary sources, for example, coal, lignite, bio gas, oil, hydro and atomic energy to renewable sources, for example, wind, solar energy, and agricultural & domestic waste. Power request in the nation has expanded quickly and is required to rise assist in the years to come. To take care of the expanding demand for power in the nation, massive expansion to the installed generating capacity is required. This large scale penetration of wind energy in the electrical network systems is consistently imposing challenges to the engineers due to the corresponding advancement of technology and provides an increasing evidence of the influence between wind farms and distribution system.

The main objective of this paper is to provide control methods to improve power system stability of direct drive variable speed wind turbine connected to distribution network. Using different techniques to provide reactive power supports for the improvement in the bus voltage and to enhance the system performance under different contingencies.

II. EXISTING SYSTEM

Wind turbines can work with either settled speed or variable speed. For fixed speed wind turbines, the generator (induction generator) is directly connected to grid. Since the speed is practically settled to the grid, and unquestionably not controllable, the turbulence of the wind will bring about power varieties and thus affect the power quality of the grid. This is standard IEEE 34 bus in which two regulators are connected. This research paper find the solution without regulators and without them system is stable.

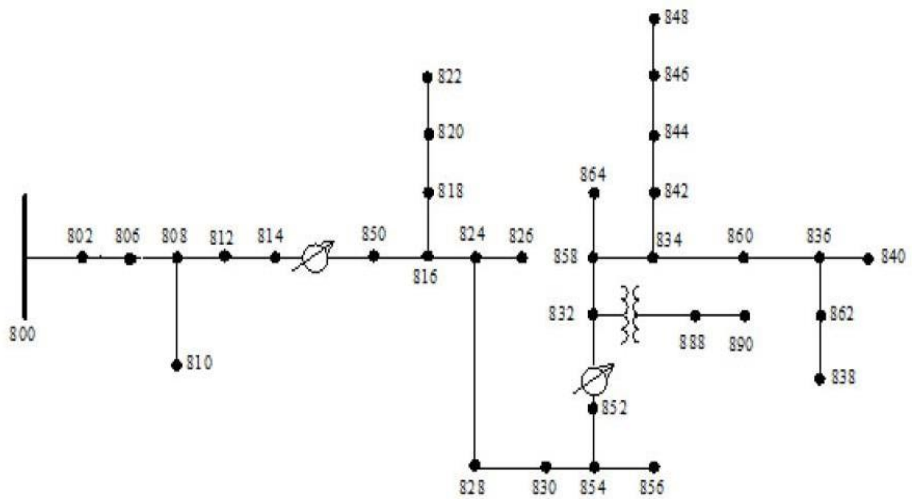

Figure 1: Single line diagram of IEEE 34 Bus Radial Distribution Feeder

Limitation of existing system:
The voltages at PCC (point of common coupling) between the wind turbine and the power grid experiences issues, for example, voltage spikes/surge, noise, swell, commotion, and power blackout. Numerous specialized difficulties influence the power quality which incorporates voltage instability, voltage and frequency fluctuation harmonics, reactive power compensation. Wind turbines induction generator ingests reactive power from the power system, which influences the grid active and reactive power coming about a bus voltage instability and low power factor.

III. PROPOSED SOLUTION

A. Simulate IEEE-34 Radial distribution network and compute load flow analysis.
B. Find out optimum location to install wind energy sources and improve the bus voltage profile.
C. FACTS device used to improve power system stability.
D. Current high-power wind turbine like doubly fed induction generator (DFIGs)are broadly embraced in current wind power industry because of its expanding of maximizing the energy capture during variable wind condition.

IV. LITERATURE SURVEY

(1) S. Miller, M. Deicke & RIK W. De Doncker, "Doubly-fed Induction Generator Systems for Wind Turbine," IEEE INDUSTRY APPLICA- TIONS MAGAZINE, MAY—JUNE 2002.
This paper represents basic construction of DFIG and dynamic modelling of DFIG. It also provide vector controller block diagram for DFIG and describe power flow in DFIG for Over-synchronous and Under-synchronous operation. Above synchronous speed, the four-quadrant converter works as a generator of active power conveying energy to the grid parallel to DFIG. Beneath synchronous speed, the four quadrant converter circles active power from the grid into rotor circuit. Dynamic model of DFIG has been proposed in the literature. To develop decoupled control of active and reactive power, a DFIG dynamic model is needed. The construction of a DFIG is similar to wound rotor induction machine and comprise a three phase stator winding and three phase rotor winding.

(2) Khaled Saleh Banawair & Jagadeesh Pasupuleti, "DFIG Wind-Turbine Modeling with Reactive Power Control Integrated to Large Distribution Network" IEEE International Conference Power & Energy (PECON), IEEE 2014.
This paper presents detailed model for DFIG wind turbine. It is also simulated including the reactive power control strategy. Two types of control strategy: Rotor-Side Converter (RSC) Control & Grid-Side Converter (GSC) Control. In this paper, Back-to-Back power converter system is modelled for the reactive power compensation. Reactive power is used for giving the suitable measure of volt-ampere responsive (VAR). Accurate reactive power pay with appropriate channel and controller can dispose of voltage fall, harmonic distortion and power system instability.

(3) Yi Wang and Lie Xu, "Coordinated Control of DFIG and FSIG-Based Wind Farms Under Unbalanced Grid Conditions," IEEE TRANSAC- TIONS ON POWER DELIVERY, VOL. 25, NO. 1, JANUARY 2010.
This paper investigates the control and operation of doubly-fed induction generator (DFIG) and fixed-speed induction generator (FSIG) based wind farms under unbalanced grid conditions. The point of this paper is to examine DFIG control and operation amid system unbalance, to upgrade the operation of FSIG based wind farms which are situated at generally short separations from wind farms using DFIGs. Uneven voltage at DFIG and FSIG terminals can bring about unequal warming on the stator windings, additional mechanical stresses and output power changes. To improve the stability of a wind energy system containing both DFIG and FSIG based wind farms during network unbalance, a control strategy of unbalanced volt- age compensation by the DFIG systems is proposed.

(4) LABIDI sabrine and HASNAOUI Othman, "Wind Generator Stability by Using STATCOM," The fifth International Renewable Energy Congress, IREC-2014, March 25-27, Hammamet, TUNISIA.
This paper examines the utilizing of the STATCOM which is one of the FACTS's family to support the fixed speed wind power plant keeping in mind the end goal to satisfaction the required voltage-dip ride-through ability. FACTs device used to expand transmission line limit, consistent state voltage regulation, give transient voltage support to anticipate system fall and damp power oscillations. FACTs devices can be utilized as a part of wind power system to enhance the transient stability and also improve the dynamic stability of the power system. The power flow control is realized by using appropriately design controllers to force the line currents to track their respective reference values.

(5) D. Das, M. E. Haque, A. Gargoom and M. Negnevitsky, "Control Strategy for Combined Operation of Fixed Speed and Variable Speed Wind Turbines Connected to Grid," Australasian Universities Power Engineering Conference, AUPEC 2013, Hobart, TAS, Australia, 29 September - 3 October 2013.
Control strategies for combined operation of FSIG and DFIG wind turbines is investigated in this paper. Control strategies for the rotor side converter(RSC), grid side converter(GSC) and STATCOM are implemented in software.
A static synchronous compensator (STATCOM) is utilized to upgrade the system performance like loss of generations, voltage sag, voltage swell, load change and fault analysis. The STATCOM is put at PCC for steady state voltage control and transient voltage support.

(6)Authors James O. Owuor, Josiah L. Munda, Adisa A. Jimoh, "THE IEEE 34 NODE RADIAL TEST FEEDER AS A SIMULATION TEST- BENCH FOR DISTRIBUTED GENERATION," IEEE African 2011, The Falls Resort and Conference Centre, Livingstone, Zambia, 13 - 15 September 2011.
This paper expects to present outcomes acquired in the usage of the IEEE 34 node system and compare them with IEEE Distribution Subcommittee load flow results. Different distribution generation (DG) are connects to the IEEE 34 established networks and carried out the different analysis and simulated different results. Various types of load models are connected to the distribution grid like constant PQ, constant currents and constant Z. This paper shows the modelling of the IEEE 34 Node Test Feeder and the steady state results are compared with the results for the IEEE benchmark system.

V. LOAD FLOW ANALYSIS FOR DIFFERENT CASES

Case I : Wind Generation of 1 MW connected at Bus-890 & Bus-848 which supplies only reactive power and active power is zero(P=0).
Case II : STATCOM of 1.5 MVA connected at Bus-890 & Bus-848.
Case III: Wind Generation of 1 MW connected at Bus-890 & STATCOM of 1.5 MVA connected at Bus-848.
Case IV: Wind Generation of 1 MW connected at Bus-890 & Bus-848 which supplies both reactive power and active power.

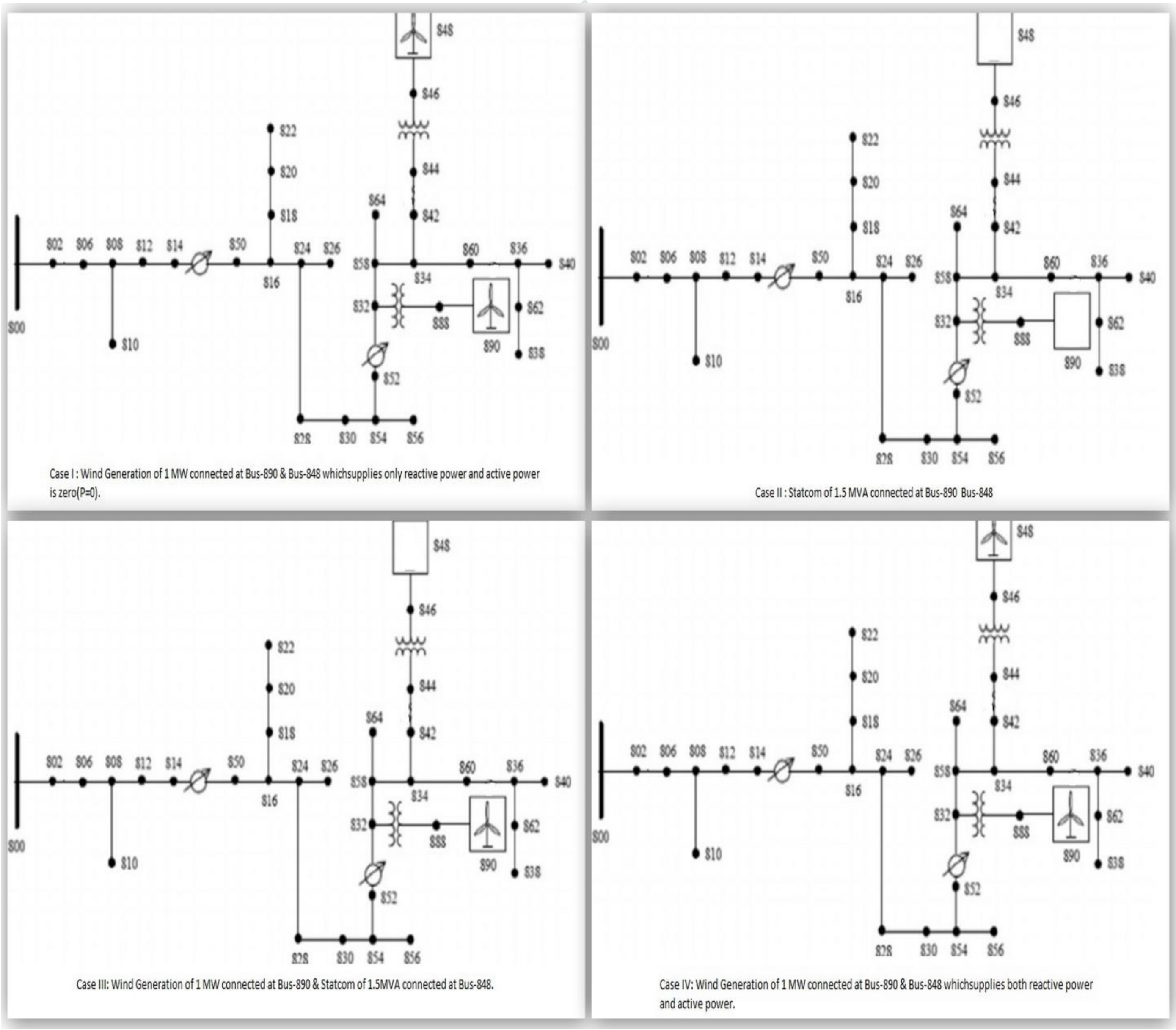

Figure 2: Load-flow analysis for different cases

Table 1: Active Power and Reactive Power Analysis

		P (MW)	Q(Mvar)
Case:1	Swing bus	2.303	-1.294
	Wind at 890	-0.004	0.4183
	Wind at 848	-0.007	0.383
Case: 2	Swing bus	2.381	-0.691
	STATCOM at 890	-0.7572	0.1375
	STATCOM at 848	-0.0073	0.945
Case: 3	Swing bus	1.739	-1.349
	Wind at 890	0.9759	-0.1404
	STATCOM at 848	-0.0106	1.504
Case: 4	Swing bus	0.0734	1.202
	Wind at 890	0.9752	0.081
	Wind at 848	0.9756	-0.3302

Table 2: Bus voltage in PU for different cases

Bus No	Phase	Case: 1	Case: 2	Case: 3	Case: 4
816	A	0.9815	0.9609	0.9599	0.9894
	B	1.0222	1.0086	1.0043	1.0234
	C	1.0126	1.0063	1.003	1.0135
832	A	0.9497	0.912	0.9387	0.9596
	B	0.9852	0.9628	0.9722	0.987
	C	0.9721	0.9607	0.9895	0.9738
848	A	0.9502	0.9073	0.9353	0.9512
	B	0.9836	0.9579	0.9799	0.9892
	C	0.9707	0.9563	0.9851	0.973
890	A	1.0766	0.9643	0.9667	1.0103
	B	1.1266	1.0518	1.009	1.058
	C	1.11	1.0295	0.9848	1.045

VI.THREE PHASE FAULT ANALYSIS ON DIFFERENT LOCATION:

Here, Voltage stability analysis & Fault analysis have been carried out for different case. Wind generation and FACTs devices are connected to different location of IEEE-34 radial distribution system.

5.1 Only swing generator connected to distribution system (Steady-state condition): In this case, Existing IEEE-34 bus system connected to only one swing generator at bus-800.

Table 3: Analysis of Active power(MW), Reactive power(Mvar) & Bus voltage (pu)

		Steady State	Fault at Bus-828	Fault at Bus-848	Fault at Bus-890
Bus-800 (Swing Bus)	V(pu)	1.05	1.05	1.05	1.05
	P(MW)	2.016	17.82	10.24	2.027
	Q(Mvar)	0.7217	12.55	6.184	2.24
Bus-828	V(pu)	0.9554	0.0031	0.4703	0.888
	P(MW)	-	-	-	-
	Q(Mvar)	-	-	-	-
Bus-848	V(pu)	0.893	0.002	0.001	0.8068
	P(MW)	-	-	-	-
	Q(Mvar)	-	-	-	-
Bus-890	V(pu)	0.7953	0.0014	0.08	0.009
	P(MW)	-	-	-	-

	Q(Mvar)	-	-	-	-

Following table shows analysis of bus voltage, active power& reactive power for different fault location in the distribution system. During t=15 sec to t=15.5 sec, Three phase fault (LLL-G) analysis carried out for different location like Bus-828, Bus-890 & Bus-848.

5.2 DFIG wind turbines & swing generator connected to distribution system: In this case, Existing IEEE-34 bus system connected to only one swing generator at bus-800 & Two DFIG wind turbines of 1 MW at bus-848 & bus-890. Following table shows analysis of bus voltage, active power & reactive power for different fault location in the distribution system. During t=15 sec to t=15.5 sec, Three phase fault (LLL-G) analysis carried out for different location like Bus-828, Bus-890 & Bus-848.

Table 4: Analysis of Active power (MW), Reactive power (Mvar) & Bus voltage (pu)

		Steady State	Fault at Bus-828	Fault at Bus-848	Fault at Bus-890
Bus-800 (Swing Bus)	V(pu)	1.05	1.05	1.05	1.05
	P(MW)	0.5512	17.82	10.24	2.186
	Q(Mvar)	-0.1401	12.55	6.184	2.003
Bus-828	V(pu)	1.018	0.01	0.4744	0.936
	P(MW)	-	-	-	-
	Q(Mvar)	-	-	-	-
Bus-848	V(pu)	1.026	0.304	0.02	0.8975
	P(MW)	0.9694	0.08	0.09	0.016
	Q(Mvar)	-0.245	0.1913	0.786	0.1062
Bus-890	V(pu)	0.9913	0.4744	0.2291	0.032
	P(MW)	0.9759	0.2829	0.238	0.02
	Q(Mvar)	-0.2045	0.3756	0.396	0.056

VII. RESULTS

- The load flow simulation of IEEE 34 bus distribution system with regulator, without regulator, with wind generation at bus 848 and with wind generation at bus 848 & 890 is simulated in MATLAB software.
- Various parameters at different buses are obtained after the load flow simulation for this distribution system with regulator, without regulator, with wind generation at bus 848 and with wind generation at bus 848 & 890. The comparison and analysis of these parameters for different cases to be done in this section.
- Voltage stability analysis & Fault analysis have been carried out for different case. Wind generation and FACTs devices are connected to different location of IEEE-34 radial distribution system.

VIII. CONCLUSION

The fixed speed wind turbines are dominated by variable speed wind turbines due to their operation over a wide range of speed. Due to the availability of power electronics and better controllability, DFIG and Full-converter based wind turbines are the most popular variable speed wind turbines. Wind tur- bines induction generator absorbs reactive power from the power system, which affects the grid active and reactive power resulting a bus voltage instability. The IEEE 34 node radial test feeder for distribution generation used as main system and simulation perform in MATLAB software. A direct drive variable speed wind turbine are connected to IEEE 34 node radial test feeders and control methods are provide for the improvement of power system stability. FACTS devices are used to improve power system stability and to enhance the system performance during different contingencies. A static synchronous compensator (STATCOM) is utilized to upgrade the system performance like loss of generations, voltage sag, voltage swell, load change and fault analysis.

IX. FUTURE SCOPE

Superconducting Magnetic Energy Storage (SMES) used for voltage suppression in distribution system. Fuzzy logic controller (FLC) used for DC-DC chopper to control in power transfer between the grid and SMES coil. The FLC is designed so that the SMES can absorb/deliver active power from/to the distribution system.

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