

A Peer Reviewed Open Access International Journal

A Novel Hybrid Control Strategy of a STATCOM for Power Quality Improvement in a Grid Connected Wind Driven Induction Generator

A.Raviteja PG Student (EPS), JB Institute of Engineering & Technology, Hyderabad, Telangana.

Mr.M.Vinod Kumar, M.Tech
Assistant Professor,
Department of EEE,
JB Institute of Engineering &Dr.S.Siva Prasad, M.Tech, Ph.D
HOD,
Department of EEE,
JB Institute of Engineering &JB Institute of Engineering &
Technology, Hyderabad, Telangana.JB Institute of Engineering &
Technology, Hyderabad, Telangana.

ABSTRACT:

Now a days Power electronic converters, ever more widely used in industrial, commercial, and domestic applications, suffer from the problem of drawing non-sinusoidal current and reactive power from the source. Like conventional power plants, wind power plants must provide the power quality required to ensure the stability & reliability of the power system. While connecting wind turbine to grid it is important to understand source of disturbance that affect the power quality. In general voltage & frequency must be kept as stable as possible.

This stability can be obtained by using FACTS devices. Recently voltage-source or current-source inverter based various FACTS devices have been used for flexible power flow control, secure loading and damping of power system oscillation. Some of those are used also to improve transient & dynamic stability of wind power generation system (WPGS). The power arising out of the wind turbine when connected to a grid system concerning the power quality measurements, are: active power, reactive power, voltage sag, voltage swell, flicker, harmonics, and electrical behavior of switching operation. Proposed concept simulated and verified by using Matlab/simulink software.

Keywords:

wind power, distribution network, induction generator, STATCOM, reactive power, harmonics and Power quality

I.INTRODUCTION:

To have sustainable growth and social progress, it is necessary to meet the energy need by utilizing the renewable energy resources like wind, biomass, hydro, cogeneration, etc. In sustainable energy system, energy conservation and the use of renewable source are the key paradigm. The need to integrate the renewable energy like wind energy into power system is to make it possible to minimize the environmental impact on conventional plant. The integration of wind energy [1] into existing power system presents technical challenges and that requires consideration of voltage regulation, stability, power quality problems. The power quality is an essential customer focused measure and is greatly affected by the operation of a distribution and transmission network. The issue of power quality is of great importance to the wind turbine [2]. There has been an extensive growth and quick development in the exploitation of wind energy in recent years.

The individual units can be of large capacity up to 2MW, feeding into distribution network, particularly with customers connected in close proximity. Today, more than 28000 wind generating turbines are successfully operating all over the world. In the fixed-speed wind turbine operation, all the fluctuation in the wind speed are transmitted as fluctuations in the mechanical torque, electrical power on the grid and leads to large voltage fluctuations. The power quality issues can be viewed with respect to the wind generation, transmission and distribution network, such as voltage sag, swells, flickers, harmonics etc. However the wind generator introduces disturbances into the distribution network.

One of the simple methods of running a wind generating system is to use the induction generator connected directly to the grid system. The induction generator [3] has inherent advantages of cost effectiveness and robustness. However; induction generators require reactive power for magnetization. When the generated active power of an induction generator is varied due to wind, absorbed reactive power and terminal voltage of an induction generator can be significantly affected [4].

Volume No: 3 (2016), Issue No: 1 (January) www.ijmetmr.com



A Peer Reviewed Open Access International Journal



Fig.1. Grid connected system for power quality improvement.

A proper control scheme in wind energy generation system is required under normal operating condition to allow the proper control over the active power production. In the event of increasing grid disturbance, a battery energy storage system for wind energy generating system is generally required to compensate the fluctuation generated by wind turbine[6]. A non-linear load on a power system is typically a rectifier (such as used in a power supply), or some kind of arc discharge device such as a fluorescent lamp, electric welding machine, or arc furnace. Because current in these systems is interrupted by a switching action, the current contains frequency components that are multiples of the power system frequency. It changes the shape of the current waveform from a sine wave to some other form and also create harmonic currents in addition to the original (fundamental frequency) AC current. The most used unit to compensate for reactive power in the power systems are either synchronous condensers or shunt capacitors, the latter either with mechanical switches or with thyristor switch, as in Static VAR Compensator (SVC). The disadvantage of using shunt Capacitor is that the reactive power supplied is proportional to the square of the voltage. Consequently, the reactive power supplied from the capacitors decreases rapidly [9] when the voltage decreases [3]. To overcomes the above disadvantages; STATCOM is best suited for reactive power compensation and harmonic reduction. It is based on a controllable voltage source converter (VSC).

Static Synchronous Compensator (Statcom):

The STATCOM is a shunt-connected reactive-power compensation device that is capable of generating and/ or absorbing reactive power and in which the output can be varied to control the specific parameters of an electric power system.

It is in general a solid-state switching converter capable of generating or absorbing independently controllable real and reactive power at its output terminals when it is fed from an energy source or energy-storage device at its input terminals. Specifically, the STATCOM, which is a voltage-source converter which when fed from a given input of dc voltage, produces a set of 3-phase ac-output voltages, each in phase with and coupled to the corresponding ac system voltage through a relatively small reactance (which is provided by either an interface reactor or the leakage inductance of a coupling transformer). The dc voltage is provided by an energy storage capacitor. A STATCOM based control technology has been proposed for improving the power quality which can technically manages the power level associates with the commercial wind turbines.

A STATCOM can improve power-system Performance like:

1. The dynamic voltage control in transmission and distribution systems,

2. The power-oscillation damping in power- transmission systems,

- 3. The transient stability;
- 4. The voltage flicker control; and

5. The control of not only reactive power but also (if needed) active power in the connected line, requiring a dc energy source.

A STATCOM is analogous to an ideal synchronous machine, which generates a balanced set of three sinusoidal voltages at the fundamental frequency with controllable amplitude and phase angle. This ideal machine has no inertia, is practically instantaneous, does not significantly alter the existing system impedance, and can internally generate reactive (both Capacitive and inductive) power.

II. WIND DRIVEN INDUCTION GENERA-TOR WITH STATCOM

The STATCOM is a three-phase voltage source inverter having a capacitor connected to its DC link. Fig 2 shows aneutral clamped topology of VSI for STATCOM application.

Volume No: 3 (2016), Issue No: 1 (January) www.ijmetmr.com



A Peer Reviewed Open Access International Journal



Fig 2.Six Pulse VSI STATCOM

But in the proposed system with STATCOM, reactive power requirement of induction generator and load is supplied by the STATCOM instead of grid. The STATCOM injects a compensating current of variable magnitude and frequency component at the PCC [8]-[10]. The shunt connected ST A TCOM is connected to the PCC through interfacing inductors.

The induction generator and load is also connected to the PCC [10]. The STATCOM compensator output is controlled, so as to maintain the power quality norms in the grid system. Reference current for the ST ATCOM is generated based on instantaneous reactive power theory [7]-[10]. A STATCOM injects the compensation current which is a sum of reactive component current of IG, nonlinear load and harmonic component current of non-linear load.

III.HYSTERESIS CONTROLLER FOR STATCOM:

The current control scheme for ST A TCOM is using a "hysteresis current controller." Using this technique, thecontroller keeps the ST A TCOM current between boundaries of hysteresis area and gives correct switching signals for STATCOM operation [11]-[12]. It is a feedback current control method where the actual current tracks the reference current within a hysteresis band. The current controller generates the fIring pulses to the VSI by comparing the reference and actual current.

The hysteresis current control scheme for generating the switching signals to the STATCOM is shown in Fig.3. If the current exceeds the upper limit of the hysteresis band, upper switch of the inverter arm is turned off and the lower switch is turned on. As a result, the current starts to decay. If the current crosses the lower limit of the hysteresis band, the lower switch of the inverter arm is turned off and the upper switch is turned on.



Figure 3 Hysteresis current modulation

As a result, the current gets back into the hysteresis band. Hence, the actual current is forced to track the reference current within the hysteresis band. The choice of the current band depends on the value of compensation current and the interfacing inductance.

IV POWER QUALITY ISSUES: A.Voltage Variation:

The voltage variation issue results from the wind velocity and generator torque. The voltage variation is directly related to real and reactive power variations. The voltage variation is commonly classified as under:

- Voltage Sag/Voltage Dips.
- Voltage Swells.
- Short Interruptions.
- Long duration voltage variation.

The voltage flicker issue describes dynamic variations in the network caused by wind turbine or by varying loads. Thus the power fluctuation from wind turbine occurs during continuous operation. The amplitude of voltage fluctuation depends on grid strength, network impedance, and phase-angle and power factor of the wind turbines. It is defined as a fluctuation of voltage in a frequency 10–35 Hz.

B.Harmonics:

The harmonic results due to the operation of power electronic converters. The harmonic voltage and current should be limited to the acceptable level at the point of wind turbine connection to the network. To ensure the harmonic voltage within limit, each source of harmonic current can allow only a limited contribution. The rapid switching gives a large reduction in lower order

Volume No: 3 (2016), Issue No: 1 (January) www.ijmetmr.com

January 2016 Page 184



A Peer Reviewed Open Access International Journal

harmonic current com- pared to the line commutated converter, but the output current will have high frequency current and can be easily filter out. The harmonic distortion is assessed for variable speed turbine with a electronic power converter at the point of common connection [9]. The total harmonic voltage distortion of voltage is given as in (8)

$$V_{\rm THD} = \sqrt{\sum_{h=2}^{40} \frac{V_n^2}{V_1} 100}$$

Where Vn is the nth harmonic voltage and V1 is the fundamental frequency (50) Hz. The THD limit for 132 KV is < 3 %.THD of current ITHD is given as in (9)

$$I_{\text{THD}} = \sqrt{\sum \frac{I_n}{I_1}} 100$$

Where In is the nth harmonic current and I1 is the fundamental frequency (50) Hz. The THD of current and limit for 132 KV is <2.5%.

C.Reactive Power:

Traditional wind turbine is equipped with induction generator. Induction Generator is preferred because they are inexpensive, rugged and requires little maintenance. Unfortunately induction generators require reactive power from the grid to operate. The interactions between wind turbine and power system network are important aspect of wind generation system.

When wind turbine is equipped with an induction generator and fixed capacitor are used for reactive compensation then the risk of self excitation may occur during off grid operation. Thus the sensitive equipments may be subjected to over/under voltage, over/under frequency operation and other disadvantage of safety aspect.

The effective control of reactive power can improve the power quality and stabilize the grid. The suggested control technique is capable of controlling reactive power to zero value at point of common connection (PCC).

D.Wind Turbine Location in Power System:

The way of connecting the wind generating system into the power system highly influences the power quality. Thus the operation and its influence on power system depend on the structure of the adjoining power network.

V.MATLAB MODELEING AND SIMULA-TIONRESULTS



Figure 4. Simulink Circuit of Grid connected Wind Energy Systems







Fig.5.1 Three Phase Source Voltage and Source Current at PCC

100	lla
100	lib
100-	llo

Fig.5.1 Three Phase Source Voltage and Source Current at PCC

50			lca
0	 5	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	5
50.			lcb
50			
50			loc
0			

Fig.5.2 Three Phase Load Currents at PCC



A Peer Reviewed Open Access International Journal



Fig.5.3 STATCOM Currents at PCC (Point of Common Coupling)



Fig.5.4 Three Phase Source Voltage and Source Current at Induction Generator



Fig.5.5 Load Currents and STATCOM Compensation Currents at Induction Generator



Fig.5.6 Simulated Results for Load Current



Fig.5.7 Simulated Results for STATCOM Current



Fig.5.8 Three Phase Grid, Load and STATCOM Currents Before the PC



Fig.5.9 THD Analysis for IRP Technique STATCOM



Fig.5.10 THD Analysis for Id-Iq Technique STAT-COM VI CONCLUSION:

This project presents the STATCOM-based control scheme for reactive power compensation and harmonic reduction in grid connected wind generating system feeding non linear load. The control system for the STATCOM is simulated using MATLAB/SIMULINK. The Simulation results shows the grid voltage and current are in-phase, making the power factor unity, which implies that the reactive power demand of Induction generator and load is no longer, fed by the grid rather it is supplied by the STATCOM. Also the shape of the grid current is almost sinusoidal and the % THD has been improved from 1.02 % to 0.11 % after compensation. The proposed control scheme has improved the power quality requirement of a low voltage grid connected wind driven IG system feeding a non-linear load.

VII REFERENCES:

[I] 1. 0 .Q. Tande 'Applying Power Quality Characteristics of wind turbinefor Assessing impact on Voltage Quality', Wind Energy, pp 52, 2002.

[2] Z. Chen, E. Spooner, 'Grid Power Quality with Variable Speed WindTurbines', IEEE Trans on Energy Conversion, Vol. 16, No .2, pp 148-154, June 200 I.

[3] L. H. Hansen, L. Helle, F. Blaabjerg, E. Ritchie, S. Munk-Nielsen, H.Binder, P. S0rensen and B. Bak - Jensen "Conceptual Survey of Generators and Power Electronics for Wind Turbines ", Ris0 NationalLaboratory, Roskilde, Denmark, December 2001.

[4] A.Arulampalam, M.Bames&NJenkins, Power quality and stabilityimprovement of a wind farm using ST A TCOM, Proc. TEE Generation, Transmission & Distribution, Vol. 153, No.6, 2006, 701-710.

[5] Z.Saad-Saoud, M.1.Lisboa, 1.B.Ekanayake, N. Jenkins &G.Strbac, Application of ST A TCOMs to wind farms, Proc. TEE Generation, Transmission & Distribution, Vol.I45, No. 5, 1998, 511-516.

Volume No: 3 (2016), Issue No: 1 (January) www.ijmetmr.com



A Peer Reviewed Open Access International Journal

[6] A.Arulampalam, 1.B.Ekanayake &NJenkins, Application study of aST A TCOM with energy storage, Proc. IEE Generation, Transmission &Distribution, Vol. 150, No. 3, 2003, 373-384.

[7] Fang Zheng Peng, Jih-Sheng Lai, 'Generalized Instantaneous ReactivePower Theory for Three-phase Power Systems', IEEE on instrumentationand measurement, vol. 45, no. I, Feb,1996.

[8] Joao Afonso, Carlos Couto, Julio Martins, 'Active Filters with ControlBased on the p-q Theory', IEEE industrial electronic societynewsletter.vol. 47, n° 3, Sept. 2000, ISSN: 0746-1240, pp. 5-10.

[9] Fang Zheng Peng, , George W. Ott, Jr., and Donald J. Adams, 'Harmonic and Reactive Power Compensation Based on the GeneralizedInstantaneous Reactive Power Theory for Three-Phase Four-WireSystems' IEEE Trans on power electronics, vol. 13, no. 6, nov 1998.

[10] Leszek S. Czamecki:Instantaneous Reactive Power p-q Theory andPower Properties of Three-Phase Systems' IEEE Trans on powerdelivery', vol. 21, no. I, Jan 2006.

[I I] K. DerradjiBelloum, and A. Moussi, 'A Fixed Band Hysteresis CurrentController for Voltage Source AC Chopper' World Academy ofScience, Engineering and Technology 45 2008.

[12] 1. Dalessandro, U. Drofenik, S. D. Round and 1. W. Kolar, 'A NovelHysteresis Current Control for Three-Phase Three-Level PWMRectifiers', Swiss Federal Institute of Technology (ETH) Zurich, PowerElectronic Systems Laboratory.