International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 04 | Apr 2020 www.irjet.net p-ISSN: 2395-0072

Issues of Power Quality in Wind Battery Grid Connected System

Divyansha Pandey[1], Astha Dixit[2]

[1]PG Student [Power System], Dept. of EEE, Maharishi University of Information Technology, Lucknow, U.P., India 1
[2]Assistant Professor, Dept. of EEE, Maharishi University of Information Technology, Lucknow, U.P., India 1

Abstract - *This paper includes a organized control strategy for large-scale energy storage in wind power system. The proposed strategy is based on five control constraints: storage power compensation, storage capacity, power conversion system (PCS) conditions, state of charge (SOC) control, grid power fluctuation. The method of power distribution encounters all the control constraints in storage system. STATCOM (Static Compensator) is a member of FACTS devices, is introduced here to rectify the power quality issues, & STATCOM is connected at the PCC (Point of Common Coupling) to support the reactive power demand with the BESS (Battery Energy Storage System) which is integrated in the system to provide the constant DC voltage to the STATCOM.*

In this work, STATCOM has been modeled with the wind energy conversion system with the energy storage system and simulated in MATLAB/SIMULINK.

Key Words: *Control Strategy, Power Distribution, Energy Storage, Wind Power, battery energy storage system, wind power generation, state of charge, smoothing of output, etc.*

1. INTRODUCTION

In last few years, generation of electrical energy using wind power has established considerable attention worldwide. When a large number of renewable energy generation access to power grid, the following issues requires further consideration and analysis in order to maintain the power quality of utility- and micro-grid power system:[1]

I. Stabilize power quality of islanding/interconnected system

II. Smooth output fluctuation of Photo Voltaic (PV) and Wind Power (WP) generation

III. Quantify the economics of new energy generation

IV. Effectively integrate intelligentized multiuser power system

V. Determine optimal energy generation/storage capacity, etc.

1.1 Wind Energy Conversion System (WECS)

Due to the limited availability of conventional resources, the non-conventional sources of energy having quick growth in generating the electric energy. Among all the renewable sources of energy Wind energy is one of the most popular non-conventional sources of energy. The Wind Turbine having the capability of 2-5 MW were in use from past few years , Moreover the cost of generation of electricity from wind mills is reduced to 4.5 %/KWh and is very cost-effective as comparison to other non-renewable fuels. However, the nature of wind is inconstant and the flow of wind is uncontrollable. Therefore, the integration of wind energy into the existing power system includes various technical challenges such as Voltage Regulation, Stability, and Power quality.

"The perfect power quality means the voltage is sinusoidal having constant amplitude and constant frequency "

For the rectification of such issues, Battery Energy Storage System (BESS) with STATCOM is used.

1.2 STATCOM system to the Grid

Power electronics devices have the capability to improve the alternating system controllability, reliability and stability and it also increases the power transfer capability.

The FACTS devices involves the very high speed Thyristor switches for switching the components of transmission line such as reactors, capacitors, or phase shifting transformer for appropriate performance of the system.

By the Power Transfer Equation of transmission lines, it is observed that power flow can be controlled by the voltages of the two systems, voltage angles at both the ends and the reactance of the tie line and FACTS can be used to control one or more parameters. In today's power system FACTS devices are appropriately used for reactive power compensation and voltage control in the non-conventional energy conversion system.

The STATCOM system consists of a shunt capacitor and a power convertor (DC/AC). The grid integration of STATCOM based on power convertors are used in grid integration renewable energy (non-conventional) conversion system.[2]

1.3 Technical challenges in the integration of WECS and STATCOM

Inborn characteristics of wind energy cause the technical challenges that are not present with conventional (non-renewable) sources of energy i.e. thermal, or nuclear power.

The number of problems arises in the integration of wind energy system to the grid, but among all the problems, one of the important issue is how to integrate this wind energy system into the grid. Although the traditional approach during the last decade has been used was power convertor

control of renewable energy system. Now, there is a critical need to develop new improved power converted control technologies for following reasons.

a) The performance of existing power convertor control technologies was not well.

b) Unbalance & very high harmonic distortion have been formed, which instabilize the grid system and affect the renewable energy source.

c) The power quality issues in not to be considered in the existing controller design for the power convertor control system. However, the power quality should be critical factor in power system & which has to be improved.

d) The existing power convertor control mechanism without BESS can cause malfunction of the system, for example, abnormal DC capacitor voltage, Active power and Reactive power.

2. General Structure for Grid Integration of Wind Energy Conversion & STATCOM system

2.1 Structure of Wind Energy System

In a wind energy conversion system, the wind turbine converts the kinetic energy of the wind into the rotational energy; and this rotational energy rotates the generator.

The wind nature either is constant speed or variable speed. The power fluctuation caused by the variable wind speed which can be reduced by using power electronic equipments such as converters with BESS, (Battery Energy Storage System). [3]

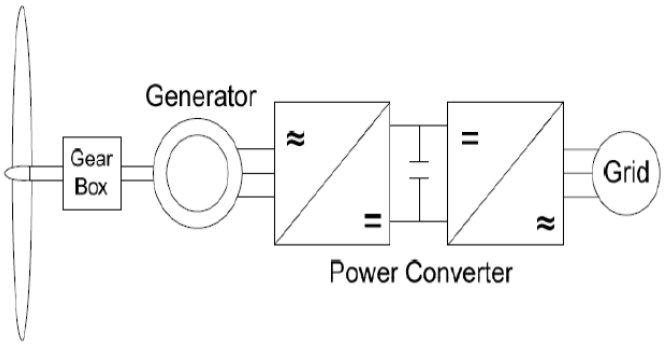

Figure 1: Wind Turbine with Induction Generator

Figure 1 show the constant speed wind turbine which consists of induction generator. In this, the wind turbine is connected to the induction generator through the gear box and here pitch control technique is used to maintain the maximum speed of the Generator.

Pitch control in wind turbine can change the incidence of the wind blades according to the speed of wind blowing and this leads to maximum speed for the wind turbine rotor at a particular velocity of the wind.

2.2 Structure of Energy Storage System

The energy storage system of a renewable energy can be used for the backup power supply. The battery energy storage system (BESS) is the solution for the challenges, since it can provide power to the grid whenever the wind output power is lower. Figure 2 shows the battery storage energy system in this application, shows the interface between the battery and the grid with the dc/ac power converters.

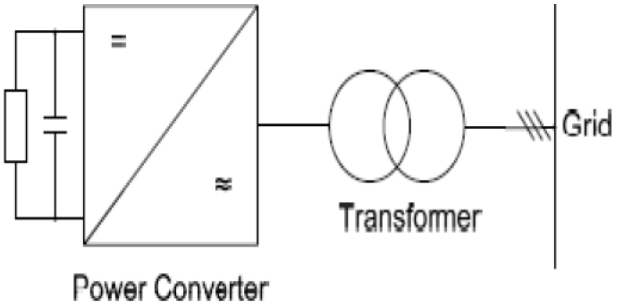

Figure 2: Energy Storage Systems

The controller of the power converter should have the ability to generate the real power to the grid when there is power output from wind generator is low.

The Battery Energy Storage System (BESS) is connected across the capacitor which keeps the fixed dc voltage across the capacitor that is perfect for the STATCOM, because STATCOM act as source or sink of reactive power according to the requirement for maintaining the stability of the power system. [4]

When there is power distribution across the Energy Storage system is used to control it by discharging and charging process.

3. Control Scheme of Grid Side Convertor

In traditional control scheme technique PID controller are used. But in this paper work control technique based of fuzzy logic are used, the main advantage of fuzzy logic controller is the possibility to implement a human experience, intuition and heuristics in to the controller.

a. Conventional PI Control Technique

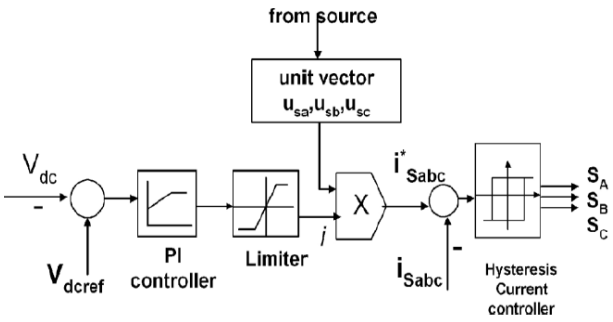

Figure 3: control circuit for inverter switching

The control technique which depend upon injecting the current into the main power system is the hysteresis band current controller; this hysteresis controller hold the

variables within the limits of hysteresis regions, so as to provide actual switching signals for proper functioning of inverter.

In figure 3 shows control schemes to generate the switching signals for the inverter. The control mechanism measures the source current i_{sabc} of each phase. V_{dc} dc bus voltage and i_{iabc} inverter current.

The control unit compares two inputs, one is reference current,„i_s *$_{abc}$„and actual current $i_{s\,abc}$ of each phase to operate the inverter in current control mode.

b. Novel Fuzzy Logic Control techniques

Fuzzy logic control expertise in real time system, which implements a portion of human operator's or process engineer's experts which cannot be easily expressed through PID control parameters or differential equation instead in situation or action rules. In fuzzy logic control technique the controller action is determine from simple linguistic rules.

"Linguistic variables are the variables whose value is words or sentences in a natural or artificial language. For example, age, height, speed temperature, error, etc are the linguistic variable. If its values are linguistic instead of digital, i.e. quite tall, very tall, tall, not tall, not very tall, not short, short, very short, quite short etc instead of 190, 170, 150...centimeters.

The objective of the system is to reject any variations in the input supply of utility, wind generation system and in load transients. When the developed rules are not viscerally appropriate then Experts knowledge is required.

In this Fuzzy control is used for switching the firing angle of the switches for the IGBTs of STATCOM. There are two inputs for the fuzzy control based STATCOM;

I. Change in voltage (ΔV) and change in current (ΔI) and

II. One control output (ΔU).

"Fuzzification"is" the process in which input variable will convert to fuzzy variable called fuzzification. After fuzzification the fuzzy inputs send to interface engine (rule base) and the output from this enters to defuzzification to obtain the final outputs.

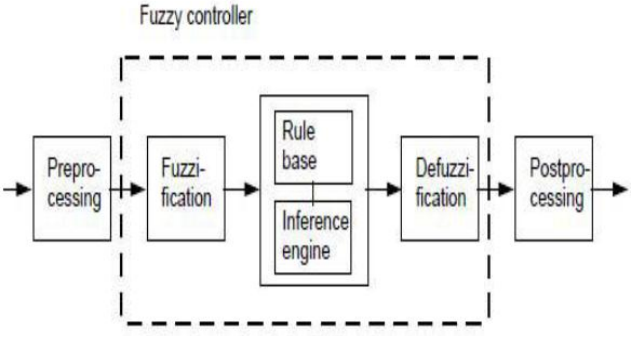

Figure 4: fuzzy control block diagram

Now consider seven fuzzy subsets for two inputs such as

PB (POSITIVE BIG)
PM (POSITIVE MEDIUM)
PS (POSITIVE SMALL)
ZE (ZERO)
NS (NEGATIVE SMALL)
NM (NEGATIVE MEDIUM)
NB (NEGATIVE BIG)

Decision making: The fuzzy logic control rules that are responsible for fuzzy outputs from the fuzzy inputs obtained from general intuitive behaviour of the system. However these rule uses „trial and error" method with its intuitive for the process control. Table 1 shows the rules for fuzzy logic control for the STATCOM results to understand STATCOM behaviour and experiment test for VSIs performance.

ΔI/ ΔV	NB	NM	NS	ZE	PS	PM	PB
NB	NB	NB	NB	NB	NM	NS	ZE
NM	NB	NB	NM	NM	NS	ZE	PS
NS	NB	NM	NS	NS	ZE	PS	PM
ZE	NM	NM	NS	ZE	PS	PM	PB
PS	NM	NS	ZE	PS	PS	PM	PB
PM	NS	ZE	PS	PM	PM	PB	PB
PB	ZE	PS	PM	PB	PB	PB	PB

Table I- Control Rules

Now, the table shows the 49 control rules are developed using Gaussian Membership functions. This process is used to represents the inputs as suitable linguistic variable which converts the every piece of input data to a degree of membership function called fuzzification. In Fuzzification input data match with condition of rules to specify how well the input data relates the condition of each rule.

The number fuzzy levels are not fixed. It may vary according to the input settlement required for a process to operate. If number of fuzzy levels are larger than no. of input settlements. Here the implemented fuzzy logic control uses sinusoidal value fuzzy sets.

c. Simulation Study & Performance

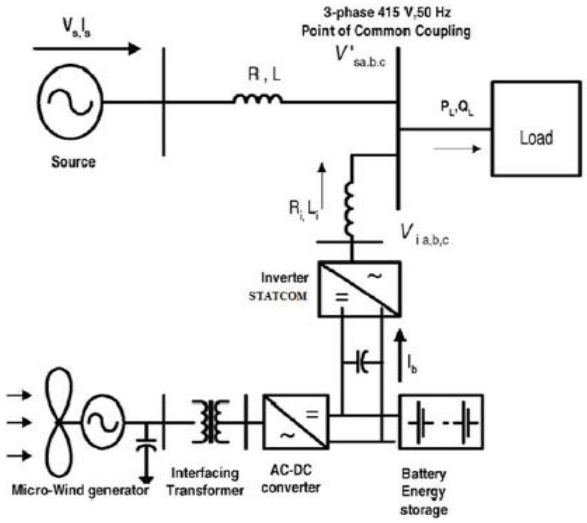

Figure 5: Scheme for wind generation with battery energy storage

In this the micro wind generator produces the electric power which is injected in to the grid at point of common coupling (PCC) through the Battery Storage System (BESS) and the STATCOM. The power from wind generator charges the battery and when the battery voltage is more the grid voltage then the STATCOM injects the reactive power into the grid or it consumes reactive power when the battery voltage is less than the grid voltage, hence maintaining the stability of the system and reducing the power quality issues. [5]

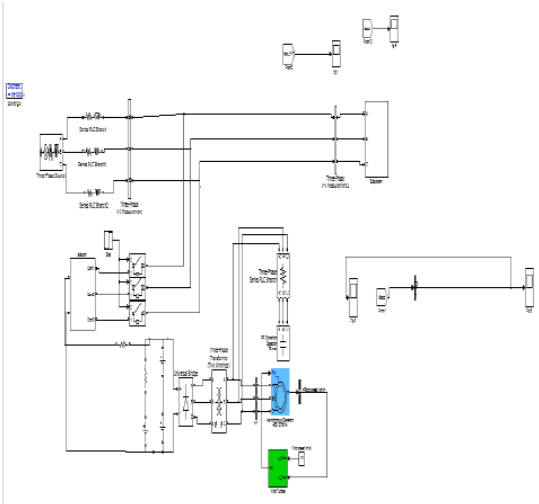

Figure 6: Simulation model of wind generator with battery storage system

4.1 RESULTS OF SIMULATION:

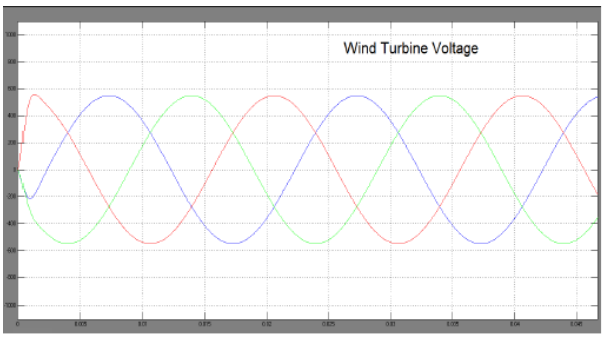

Figure 7: Wind turbine voltage

Figure 7 shows the wind turbine voltage which is sinusoidal and having fixed amplitude and frequency.

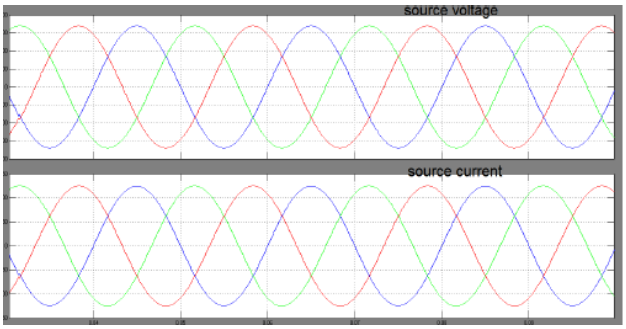

Figure 8: source voltage and source current

Figure 8 shows the source voltage and source current both having constant amplitude and frequency.

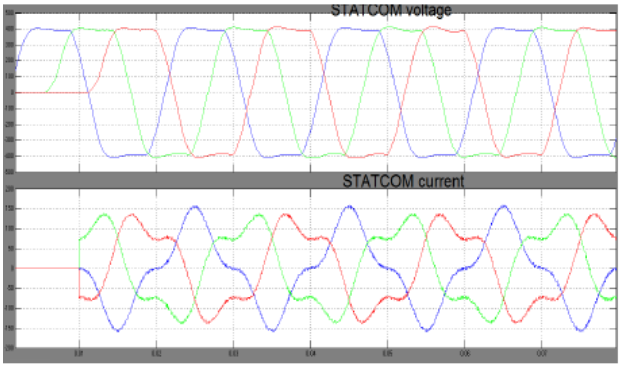

Figure 9: Injected STATCOM voltage and STATCOM current

Figure 9 shows the injected STATCOM voltage and STATCOM current, the injected voltage having constant amplitude and frequency but is not pure sinusoidal, whereas the amplitude and frequency of the injected current is not constant and it is also not sinusoidal, because STATCOM supplies or absorbs the reactive power, therefore the current varies and doesn't have constant amplitude and frequency to maintain the stability of the system. [6]

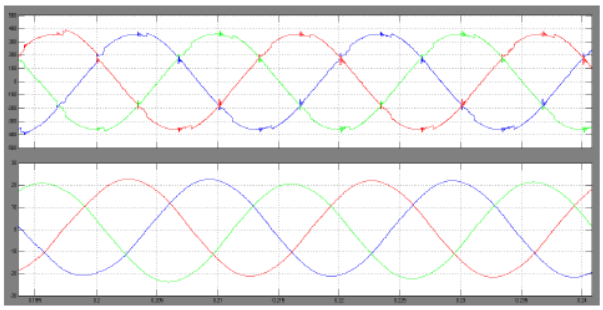

Figure 10: Load voltage and load current

Figure 10 shows the load voltage and load current, load voltage as we can observe from the load voltage and the current waveform that both the waveform have the same frequency and the load voltage becomes sinusoidal with constant amplitude and frequency so, it can be say that the power quality of the system is improved by using STATCOM and BESS system. [10]

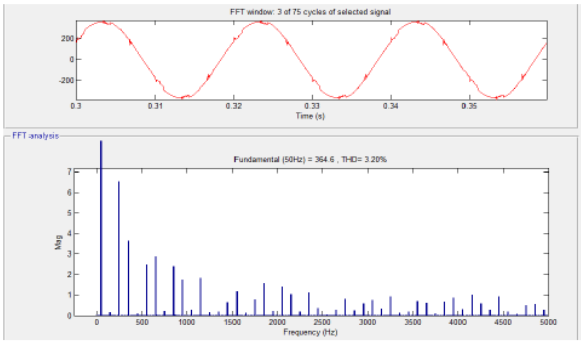

Figure 11: FFT analysis STATCOM control system

Figure 11 shows the total harmonic distortion THD is 3.20, which is in the permissible limit hence the system is stable and the power quality issues are reduced.

5. CONCLUSIONS

STATCOM (Static Compensator) is a member of the FACTS devices, for maintaining the stability and voltage of the power system under the integration of wind energy generation, the STATCOM plays a main role for providing the reactive power support. The STATCOM is proposed for the improvement in power quality. Such as

i. STATCOM helps is reducing the harmonic parts of the load current, hence the THD of the load current is reduced to permissible level.
ii. Source voltage and the source current both are maintained in the same phase.
iii. STATCOM is useful for providing the reactive power demand for the wind energy generation and for a nonlinear load at PCC (point of common coupling) in the grid system.

So, STATCOM helps in many ways for improving the power quality and maintaining stability of the system, STATCOM acts as a current controlled voltage source (CCVS) inverter, consists of six IGBTs which are the triggered by the control strategy i.e. fuzzy logic control.

In summary this control system introduced capability of handling the normal and abnormal operating conditions with the integration of wind energy generation into the grid with STATCOM and BESS. The advantage of using proposed system includes stability, power quality and protection of system devices.

6. REFERENCES

[1] S. W. Mohod and M. V. Aware, "A STATCOM-Control scheme for Grid connected Wind Energy System for Power Quality Improvement", in IEEE Systems Journal, Volume 4, no.3, September 2010.

[2] Jalilzadeh, Saeid; Kazemi, Ahad and Farhang, Peyman. "Analysis and Assessment of Power System Including Wind Farm by Using SVC and STATCOM", International Review of Electrical Engineering, 2012.

[3] C. Han, A. Q. Huang, M. Baran, S. Bhattacharya, and W. Litzenberger, "STATCOM impact study on the integration of a large wind farm into a weak loop power system" IEEE Transactions on Energy Conversion, vol. 23, no. 1, pp. 226232, March 2008.

[4] C. Han, A. Q. Huang, M. Baran, S. Bhattacharya, and W. Litzenberger,"STATCOM impact study on the integration of a large wind farm into a weak loop power system," IEEE Trans. Energy Conv., vol. 23, no. 1,pp. 226–232,Mar. 2008.

[5] S. Sabna, D. Prasad, R. Shivakumar, "Power System Stability Enhancement by Neuro Fuzzy Logic Based SVC for Multi Machine System" IJEAT, ISSN: 2249 – 8958, Volume-1, Issue-4, April 2012.

[6] S. W. Mohod and M. V. Aware, "Power quality issues &it's mitigation technique in wind energy conversion," in Proc. of IEEE Int. Conf. Quality Power & Harmonic, Wollongong, Australia, 2008.

[7] R. Billinton and Y. Gao, "Energy conversion system models for adequacy assessment of generating systems incorporating wind energy", IEEE Transaction on Energy Conversion, volume. 23, no. 1, pp. 163169, December 2008.

[8] Aodsup, K., Boonchiam, P.N., Sode-Yome, A., Kongsuk, P. and Mithulananthan, N.

[9] "Response of DSTATCOM under Voltage Flicker in Farm Wind", 7th InternationalConference on Power Electronics and Drive Systems, 2007. PEDS '07, 27-30 Nov. 2007.

[10] Saravana Murthy, P., P. Devaki, and J. Devishree. "A Static Compensation Method Based Scheme for Improvement of Power Quality in Wind Generation", 2011 International Conference on Process Automation Control and Computing, 2011.

[11] Chen, Zhong, M. Ding, and J. Su. "Modeling and control for large capacity battery energy storage system." Electric Utility Deregulation and Restructuring and Power Technologies (DRPT), 2011 4th International Conference on IEEE, 2011, pp. 1429 – 1436.

[12] Li, Q., et al. "On the Determination of Battery Energy Storage Capacity and Short-Term Power Dispatch of a Wind Farm." IEEE Transactions on Sustainable Energy 2.2, 2011, pp. 148 - 158.