Power Quality Improvement for Grid Connected Wind Energy System using FACTS device

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***Abstract*— The Renewable energy sources, which have been expected to be a promising alternative energy source, can bring new challenges when it is connected to the power grid. However, the generated power from renewable energy source is always fluctuating due to environmental condition. In the same way Wind power injection into an electric grid affects the power quality due to the fluctuation nature of the wind and the comparatively new types of its generators. On the basis of measurements and norms followed according to the guidelines specified in IEC-61400 (International Electro-technical Commission) standard, the performance of the wind turbine and thereby power quality are determined. The power arising out of the wind turbine when it connected to grid system concerning the power quality measurements are-the active power, reactive power, voltage sag, voltage swell, flicker, harmonics, and electrical behaviour of switching operation and these are measured according to national/international guidelines. The paper clearly shows the existence of power quality problem due to installation of wind turbine with the grid. In this proposed scheme a FACTS device {STATIC COMPENSATOR (STATCOM)} is connected at a point of common coupling with a battery energy storage system (BESS) to reduce the power quality problems. The battery energy storage system is integrated to support the real power source under fluctuating wind power. The FACTS Device (STATCOM) control scheme for the grid connected wind energy generation system to improve the power quality is simulated using MATLAB/SIMULINK in power system block set. The intended result of the proposed scheme relives the main supply source from the reactive power demand of the load and the induction generator. From the obtained results, we have consolidated the feasibility and practicability of the approach for the applications considered.**

***Keywords*— Power Quality, Wind Generating System (WGS), STATCOM, BESS, IEC standard.**

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, co-generation, 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 [1]. The integration of wind energy 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 2 MW, feeding into distribution network, particularly with customers connected in close proximity [3]. Today, more than 28 000 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 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. 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. 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. The proposed STATCOM control scheme for grid connected wind energy generation for power quality improvement has following objectives.

- Unity power factor at the source side.
- Reactive power support only from STATCOM to wind Generator and Load.
- Simple PI controller for STATCOM to achieve fast dynamic response.

The paper is organized as fallows. The Section II introduces the power quality standards, issues and its consequences of wind turbine and the grid coordination rule for grid quality limits. The Section III describes the topology for power quality improvement. The Sections IV, V, VI describes the control scheme, system performance and conclusion respectively.

II. POWER QUALITY IMPROVEMENT

A. *Power Quality Standards, Issues And Its Consequences*

1) *International Electro Technical Commission Guidelines:* The guidelines are provided for measurement of power quality of wind turbine. The International standards are developed by the working group of Technical Committee-88 of the International Electro-technical Commission (IEC), IEC standard 61400-21, describes the procedure for determining the power quality characteristics of the wind turbine.[4]

The standard norms are specified.

1) IEC 61400-21: Wind turbine generating system, part-21. Measurement and Assessment of power quality characteristic of grid connected wind turbine.

2) IEC 61400-13: Wind Turbine—measuring procedure in determining the power behavior.

3) IEC 61400-3-7: Assessment of emission limits for fluctuating load IEC 61400-12: Wind Turbine performance. The data sheet with electrical characteristic of wind turbine provides the base for the utility assessment regarding a grid connection.

2) *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. The IEC 61400-4-15 specifies a flicker meter that can be used to measure flicker directly.

3) *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, as per the IEC-61400-36 guideline. The rapid switching gives a large reduction in lower order harmonic current compared to the line commutated converter, but the output current will have high frequency current and can be easily filter-out.

4) 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.

5) *Self-Excitation of Wind Turbine Generating System:* The self-excitation of wind turbine generating system (WTGS) with an asynchronous generator takes place after disconnection of wind turbine generating system (WTGS) with local load. The risk of self-excitation arises especially when WTGS is equipped with compensating capacitor. The capacitor connected to induction generator provides reactive power compensation. However the voltage