A INNOVATIVE WIND SYSTEM BASED RENEWABLE ENERGY SYSTEM WITH POWER QUALITY IMPROVEMENT FEATURES

Vishvaneeta Patel[1] , Nitesh Tatwal[2]

[1]*Electrical & Electronics Department, Oriental University, Indore*

[2]*Electrical & Electronics Department, Oriental University, Indore*

[1]*M-TECH (EPS) 4th Sem* , [2] *Asst.Prof.(EX)*

[1] Vishvaneeta@gmail.com,

[2] Niteshtatwal@oriental.ac.in

Abstract — **The generated power from renewable energy source is always fluctuating due to environmental conditions. 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. This paper focuses on the power quality improvement features of wind energy system. The inverter can thus be utilized as a power converter injecting power generated from renewable energy source to the grid and as a shunt active power filter to compensate for power quality disturbances and load reactive power demand**

Keywords — **Wind power, Wind Turbine Generator (WTG), Power quality, Power fluctuation, Energy Storage System (ESS), Wind Energy Conversion System (WECS), STATCOM**

I. INTRODUCTION

Wind-power technology is experiencing significant growth in developing countries like India. As a result of scientific assessments of wind resources throughout India, wind power has emerged as a viable and cost-effective option for power generation. Also studies shows that small-scale WECS are more efficient and cost effective. Therefore targeted technology development for power quality improvements of small-scale WECSs can make a significant overall contribution toward the national energy supply. Although India has made considerable progress in implementing technologies based on large scale renewable sources of energy, the dispersed energy technology applications are still few [1]. PMG based power generation is one of the most favorable and reliable methods of power generation for small scale wind energy conversion systems since it has higher efficiency and smaller wind turbine blade diameter. To meet the amplitude and frequency requirements of conventional loads, the amplitude and frequency outputs of PMG require additional conditioning. This paper focuses on a small scale Wind Energy Conversion System (WECS) based on PMGs and power electronic converters.

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 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 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.

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

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

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

iii) 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) 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.

B. Grid coordination rule:

The American Wind Energy Association (AWEA) led the effort in the United States for adoption of the grid code for the interconnection of the wind plants to the utility system.. The rules for realization of grid operation of wind generating system at the distribution network are defined as-per IEC-61400- 21. The grid quality characteristics and limits are given for references that the customer and the utility grid may expect. According to Energy-Economic Law, the operator of transmission grid is responsible for the organization and operation of interconnected system.[5]

III. TOPOLOGY FOR POWER QUALITY IMPROVEMENT

The STATCOM based current control voltage source inverter injects the current into the grid in such a way that the source current are harmonic free and their phase-angle with respect to source voltage has a desired value. The injected current will cancel out the reactive part and harmonic part of the load and induction generator current, thus it improves the power factor and the power quality. The proposed grid connected system is implemented for power quality improvement at point of common coupling (PCC), as shown in Fig. 1. The grid connected system in Fig. 1, consists of wind energy generation system and battery energy storage system with STATCOM.

A. Wind energy generating system

The induction generator is used in the proposed scheme because of its simplicity, it does not require a separate field circuit, it can accept constant and variable loads, and has natural protection against short circuit. The available power of wind energy system is presented as under in Eq.

$$P=\frac{1}{2}\rho A V^3$$

Where (kg/m) is the air density and A (m) is the area swept out by turbine blade, V is the wind speed in mtr/s. It is not possible to extract all kinetic energy of wind, thus it extract a fraction of power in wind, called power coefficient.

IV. STATIC 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. A STATCOM is a controlled reactive power source. It provides the desired reactive power generation and absorption entirely by means of electronic processing of the voltage and current waveforms in a voltage source converter (VSC). A single line STATCOM power circuit is shown in Fig.1, where, a VSC is connected to a utility bus through a magnetic coupling. In the STATCOM is seen as an adjustable voltage source behind reactance. This means that capacitor banks and shunt reactors are not needed for reactive power generation and absorption, thereby giving STATCOM a compact design [7].

A STATCOM can improve power system performance as follows: The dynamic voltage control in transmission and distribution systems. The power oscillation damping in power transmission systems. The transient stability, voltage flicker control, and The control of not only reactive power but also (if needed) active power in the connected line, requiring a dc energy source.

Principle of Operation:

The exchange of reactive power is done by regulating the output voltage of the inverter VSTATCOM , which is in phase with the mains voltage V_k. The operation can be described as follows. If the voltage VSTATCOM is below V_k, the current through the inductor is phase shifted in relation to the voltage V_k which provides an Inductive current, then QS becomes positive and the STATCOM absorbs reactive power. If the voltage VSTATCOM exceeds V_k, the current through the inductor is phase shifted in relation to the voltage V_k which provides a capacitive current, then QS becomes negative and the STATCOM generates reactive power. If the voltage VSTATCOM is equal to V_k, the current through the inductor is zero and therefore there is no exchange of energy.

V. DSTATCOM

In order to study the dynamic performance of the DSTATCOM/FESS controller, a model of the combined system is proposed (see Fig. 1). This model consists mainly of the DSTATCOM controller, the Interface converter and the FESS device. The basic component of the DSTATCOM is the voltage-source inverter (VSI) with semiconductors devices having turn-off capabilities [6]. Other components are the coupling step-up transformers, the line connection filter and the DC bus capacitor. The Interface couples the DC bus of the DSTATCOM with the FESS device, which the basic component is a VSI. The FESS device is mainly made up of a motor/generator and a flywheel. The DSTATCOM and the Interface use two-level VSIs. The commutation valves used are Insulated Gate Bipolar Transistors (IGBT) with anti-parallel diodes. The VSIs are modelled with detailed blocks of the switches and diodes, incorporated into the simulation program. The technique of sinusoidal pulse width modulation (SPWM) is used to obtain a sinusoidal voltage waveform. The SPWM of the VSI in the interface works with a frequency higher than that of the DSTATCOM. The interface VSI needs a voltage with a higher frequency to operate the FESS machine at high speeds. In order to reduce the disturbance produced on the distribution system by the high-frequency switching harmonics generated by the SPWM control, a low pass sine wave filter is used. This filter is built with the leakage inductances of the step-up coupling transformer windings and a bank of capacitors.

VI CONCLUSION

There are different processes to be used for power quality analysis of wind energy conversion system. STATCOM and DSTATCOM are powerful tool to analyze power disturbances in wind energy system. These tool increase the system performance and efficiency of the system

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