UPQC based Power Quality Control Technique in Grid Connected Wind Energy System

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Abstract— *now a day's generation and utilization of Renewable energy increases. In renewable wind power connected to the electrical grid is the one of the configration used in nature. Due to uncertinity in wind speeds It Injection of the wind power into an electric grid affects the power quality. The performance of the wind turbine and there by power quality are determined based on the measurements and the norms followed according to the guideline specified in International Electro-Technical Commission standard, IEC-61400. This paper demonstrates the power quality problem due to installation of wind turbine with the grid. In this proposed scheme, Unified Power Quality Conditioner (UPQC)is connected at a point of common coupling with a battery energy storage system (BESS) to mitigate the power quality issues. The battery energy storage is integrated to sustain the real power source under fluctuating wind power. The effectiveness of proposed scheme relives the main supply source from the reactive power demand of the load and the induction generator. The development of the grid co-ordination rule and the scheme for improvement in power quality norms as the grid has been presented. The UPQC control scheme for the grid connected wind energy generation system is simulated using MATLAB/SIMULINK enviournment.*

Keywords— International Electro-Technical Commission (IEC), Power Quality, Wind Generating System (WGS), UPQC Unified Power Quality Control Introduction

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 and thermal-generation etc. In sustainable energy system, energy conservation and the use of renewable source are the key source. They need to integrate the renewable energy like wind energy into power system is to make it is possible to minimize the environmental impact on conventional plant. The integration of wind energy into existing power system presents a technical challenge and that requires consideration of voltage regulation, stability, power quality problems. The power quality is an essential customer-focused measures 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 there has been an extensive growth and quick development in the exploitation of wind energy in recent years.

This paper represents the UPQC control scheme for the grid connected wind energy generation system for power quality improvement. Today, more than 28000 wind generating turbines is 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 and also fractional problems occurring in power distribution system.

During the normal operation, wind turbine produces a continuous variable output power. These power variations are mainly caused by the effect of turbulence, wind shear, and tower-shadow and of control system in the power system. Thus, the network needs to manage for such 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. And the causes of power quality problems are generally complex and difficult to detect when we integrate a wind turbine to the grid. Technically speaking, the ideal AC line supply by the utility system should be a pure sine wave of fundamental frequency (50/60Hz). We can conclude that the lack of power quality can cause loss of production, damage of equipment or appliances or can even be damage to human health. It is therefore imperative that a high standard of power quality is maintained. This project demonstrates that the power electronic based power conditioning using custom power devices like P-STATCOM can be effectively utilized to improve the quality of power supplied to the customers.

II. PROPOSED SYSTEM DESCRIPTION

This proposed system having both BESS-STATCOM and UPQC(unified power quality conditioner). The battery energy storage system (BESS) is used as an energy storage element for the purpose of voltage regulation and The Unified Power Quality Conditioner is a custom power device that is employed in the distribution system to mitigate the disturbances that affect the performance of sensitive and/or critical load. It is a type of hybrid APF and is Power Quality Improvement in Grid Connected Wind energy systems.

A. Wind energy unit

In this configuration, wind generations are based on constant speed topologies with pitch control turbine. The induction generators 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 asunder the equation,

$$P_{wind} = \frac{1}{2}\rho A V_{wind}^3 \quad (1)$$

It is not possible to extract all kinetic energy of wind, thus it extract a fraction of power in wind, called power coefficient Cp of the wind turbine, and is given in equation,

$$P_{mesh} = C_p P_{wind} \quad (2)$$

B. Bess-Statcom

The battery energy storage system (BESS) is used as an energy storage element for the purpose of voltage regulation. The BESS will naturally maintain dc capacitor voltage constant and is best suited in STATCOM since it rapidly injects or absorbed reactive power to stabilize the grid system. It also control the distribution and transmission system in a very fast rate. When power fluctuation occurs in the system, the BESS can be used to level the power fluctuation by charging and discharging operation. The battery is connected in parallel to the dc capacitor of STATCOM.

The STATCOM is a three-phase voltage source inverter having the capacitance on its DC link and connected at the point of common coupling. The STATCOM injects a compensating current of variable magnitude and frequency component at the bus of common coupling.

C. Proposed Model Operation

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. To accomplish these goals, the grid voltages are sensed and are synchronized in generating the current command for the inverter. The proposed grid connected system is implemented for power quality improvement at point of common coupling (PCC).

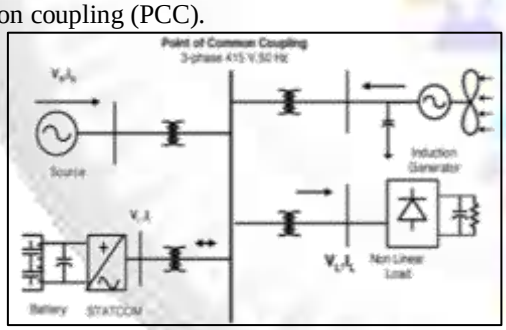

Fig. 1: Grid Connected System for Power Quality Improvement of Proposed System

D. UPQC

The best protection for sensitive loads from sources with inadequate quality, is shunt-series connection i.e. unified power quality conditioner (UPQC) .Recent research efforts have been made towards utilizing unified power quality conditioner (UPQC) to solve almost all power quality problems for example voltage sag, voltage swell, voltage outage and over correction of power factor and unacceptable levels of harmonics in the current and voltage The basic configuration of UPQC is shown in figure2. The main purpose of a UPQC is to compensate for supply voltage flicker/imbalance, reactive power, negative sequence current, and harmonics [14]. In other words, the UPQC has the capability of improving power quality at the point of installation on power distribution systems or industrial power systems. The UPQC, therefore, is expected as one of the most powerful solutions to large capacity sensitive loads to voltage flicker/imbalance.

Unified Power Quality Conditioner (UPQC) for non-linear and a voltage sensitive load has following facilities:

- It eliminates the harmonics in the supply current, thus improves utility current quality for nonlinear loads.
- UPQC provides the VAR requirement of the load so, that supply voltage and current are always in phase, therefore, no additional power factor correction equipment is necessary.
- UPQC maintains load end voltage at the rated value even in the presence of supply voltage sag.
- The voltage injected by UPQC to maintain the load end voltage at the desired value is taken from the same dc link, thus no additional dc link voltage support is required for the series compensator.

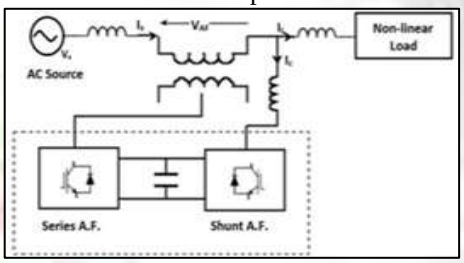

Fig. 2: Unified Power Quality Conditioner (UPQC)

E. Control Scheme

The STATCOM is a three-phase voltage source inverter having the capacitance on its DC link and connected at the point of common coupling. The STATCOM injects a compensating current of variable magnitude and frequency component at the bus of common coupling.

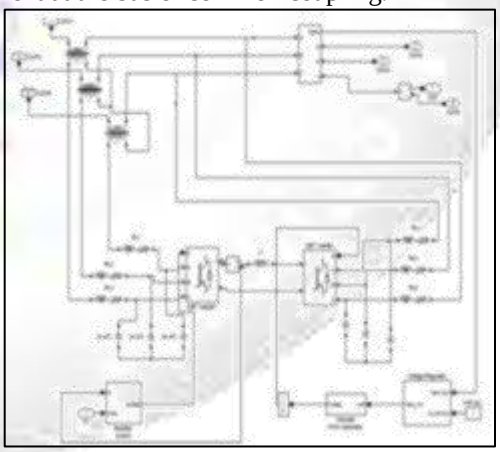

Fig. 3: Control scheme in STATCOM

The shunt connected STATCOM with battery energy storage is connected with the interface of the induction generator and non-linear load at the PCC in the grid system. The STATCOM compensator output strategy, so as to maintain the power quality norms in the grid system. The current control strategy is included in the control scheme that defines the functional operation of the STATCOM compensator in the power system. A single STATCOM using insulated gate bipolar transistor is

proposed to have a reactive power support, to the induction generator and to the nonlinear load in the grid system.

Wind generation using wind turbine, pitch control, Induction Generator. Here we are using the induction generator as generating machine due to its advantages over other machines for its simplicity and economic factors. The pitch angle controller makes the angle of the turbine blade to adjust in such a way that the speed of rotation at every velocity of the wind is maintained constant. And the parallel capacitive bank is to supply the reactive power to the IM running as the generator. Here we considered the per unit values in the closed loop that can be seen from the Figure 5.

The rms values of the current and voltage generated is taken and the power is being calculated at every sampling time interval and the wave form is being traced in the scope. A timer is used in figure for assigning the wind velocity at 3 different states which will be linearize after some loop operations.

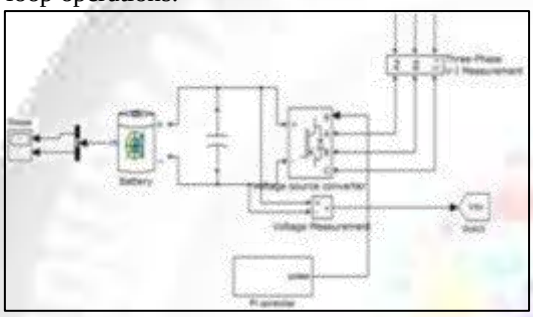

Fig. 5: Voltage Source Inverter with Battery and Controller

1) Parameters

- Grid voltage 415 V.
- Operating frequency 60 HZ.
- Induction generator 3.35KVA, 415V, 60 Hz.
- Speed 1440rpm,
- Rr 0.01 Ω,
- Rs 0.015 Ω,
- Ls=Lr 0.06H.
- Inverter - DC Link Voltage 800V,
- DC Link Capacitance 100μF,
- Switching Frequency 2 kHz.
- Non linear load 25 KW.

III. Simulation Results

The proposed model is simulated in MATLAB/ SIMUNLINK environment. The proposed unified power quality conditioner and proposed system are modeled in SIMULINK shown in Fig.7 (a). and Fig.7 (b).

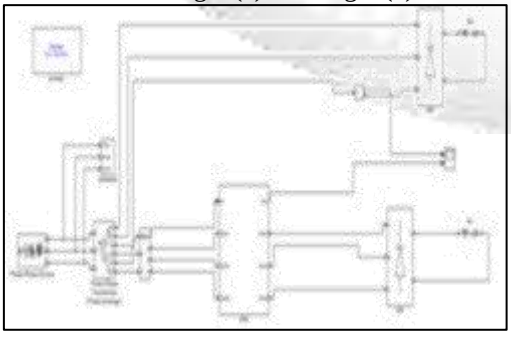

Fig. 6: Over all Circuit Diagram in Simulink with UPQC

A. Results

1) Line current

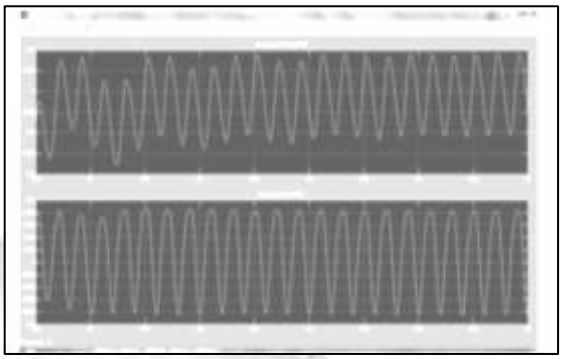

Fig. 7: Line Current

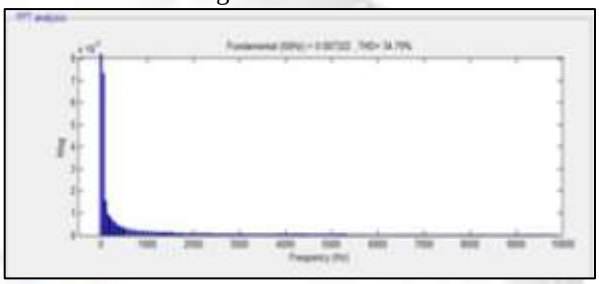

Fig. 8: THD details Without UPQC

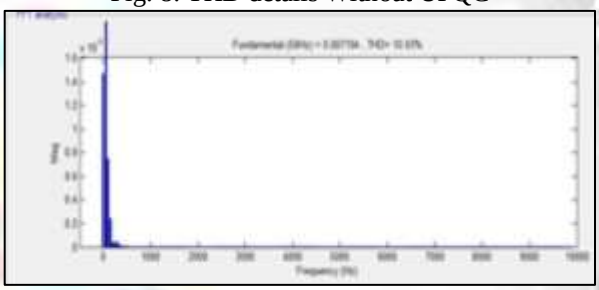

Fig. 9: THD Details With UPQC

IV. Conclusions

In this paper we present the FACTS device (UPQC) -based control scheme for power quality improvement in grid connected wind generating system and with nonlinear load. The power quality issues and its consequences on the consumer and electric utility are presented. The operation of the control system developed for the UPQC in MATLAB/SIMULINK for maintaining the power quality is to be simulated. It has a capability to cancel out the harmonic parts of the load current. It maintains the source voltage and current in-phase and support the reactive power demand for the wind generator and load at PCC in the grid system, thus it gives an opportunity to enhance the utilization factor of transmission line. Thus the integrated wind generation and FACTS device with BESS have shown the outstanding performance in maintaining the voltage profile as per requirement. Thus the proposed scheme in the grid connected system fulfils the power quality requirements and maintains the grid voltage free from distortion and harmonics.

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