Power Quality Analysis in Grid Connected Wind Energy Conversion System

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***Abstract*— Wind Energy Conversion Systems (WECS) show variability in their output power as a result of changing their main engines (wind speed). This introduces a new grid uncertainty factor and poses many challenges to electricity system designers and utilities in terms of grid network integrity, ie power system security, power system stability and power quality. This paper discusses the various challenges of wind energy when integrated into the grid and identifies different mitigation strategies for its smooth integration.**

Keywords:- Wind Energy Conversion Systems; Total Harmonic Distortion.

I. INTRODUCTION

As a result of environmental concerns and the energy security effort, efforts are being made to integrate renewable energy sources into the grid. Wind energy stands out among renewable energy sources due to its technological maturity, solid infrastructure and relative cost competitiveness. Wind energy is expanding at a rate of 20% per year at the moment and is projected to increase at a rate of 12% per year in the future.

Due to the unpredictable nature of wind resources as a result of constant fluctuations in weather conditions, the output power of WECS varies. The intermittent and diffuse nature of wind energy adds a new level of uncertainty to the grid, possibly affecting grid integrity, such as power quality, system security and power system stability.

Wind energy is controlled by nature and this can affect the electrical system. To effectively replace wind turbines with conventional conventional generators, they must be able to provide small ancillary services, control key voltages, ensure the load that follows, maintain the grid frequency and contribute to the fault current. all services performed by conventional power stations. Wind energy penetration is still low (maximum 20% in Denmark). Auxiliary services are largely supported by conventional power stations. When the level of penetration increases, the technical implications for network integrity may arise, this must be understood. This therefore implies the need for certain technologies that will allow the smooth and correct integration of WECS into the network. Therefore, the necessary specifications for such technologies must be understood and appropriate.

This study discusses the many issues WECS faces when integrating directly into the network and defining the parameters and variables required for smooth integration using various mitigation problems.

II. LITERATURE SURVEY

A technical overview of energy issues related to renewable energy-based distributed generation systems, and how custom power devices (CPDs) such as STATCOM, DVR, and UPQC can help improve energy quality. One of the most important factors for the custom selection of power devices is the IEEE and IEC standards for grid-connected renewable energy systems. The issues of integration with photovoltaic and wind systems are examined, as well as related PQ issues. The relevance of CPDs to improving the integration of renewable energy sources and to providing high quality energy through custom power parks is discussed[1].

The wind energy conversion system (WECS) is interconnected with the utility system through electronic power converters, which plays an important role in the integration of wind energy into the electricity grid. The main power quality disturbances due to the integration of WECS in the network are the power fluctuations and harmonics[2][3]. In order to maintain the network synchronization and to maintain the total harmonic distortion (THD) within operating limits, suitable control circuits for the side-grid converter are required. The main objective of the controller from the network side is to control the power provided to the network, the synchronization of the network, the provision of high quality power to the network and the observance of the compliance with the network code. In this document, the control schemes used in the grid-connected wind energy conversion system to control the inverter on the generator side and on the grid side are thoroughly reviewed[4].

The paper presents a comparative study of rotor flow oriented and direct torque control (DTC) control techniques applied to the Permanent Magnet Generator Side Frequency Converter (PMSG) for application of wind turbines. For the peripheral converter, various control schemes are developed mainly based on voltage oriented control (VOC) or direct power control (DPC). The performance of the VOC-based control system depends essentially on the method used for the current control.

The requirements for the integration of the wind turbine in the network, the network synchronization and the requirements of the monitoring unit are also discussed.

The high cost of fossil fuels, together with environmental concerns, require a significant increase in the use of renewable energy sources. One of these wind projects has earned a significant amount of money. Due to the speed behavior of wind turbines, it is difficult to achieve good power quality. The voltage and power of the components connected to the

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wind turbine are affected. A new technique and control must be designed to handle fluctuations and increase wind energy production. Potential excitation induction generators are also used for safety reasons[5].
In addition, many energy storage technologies are used to compensate for changes in wind energy. A static compensator is used for harmonic current injection and correction of reactive power. Fault tolerance is also increased, in addition to improving the power quality of wind turbines. The wind turbine's reactive power correction handles a dynamic voltage rectifier[6].
Wind Energy Conversion Systems (WECS) show variability in their output power as a result of changing their main engines (wind speed). This introduces a replacement factor of grid uncertainty and poses many challenges to electricity system designers and therefore utility operators in terms of grid network integrity, ie grid security, grid stability and power quality[7].

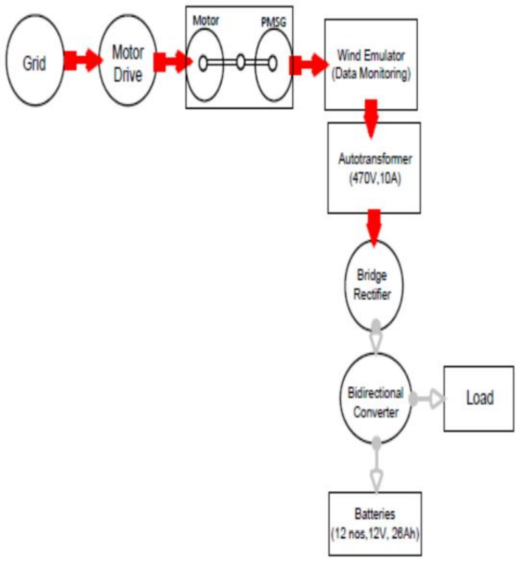

Fig.1: Block diagram of WECS

III. DESIGN AND IMPLEMENTATION

Power Analysis with a Function of Wind Speed and the speed at which air rushes rapidly to a point above the Earth's surface is referred to as wind speed. Due to this relationship, small differences in wind speed result in large power inequalities. The power generated by the wind is related to the velocity cube and depends to a large extent on the wind speed.

The following equation determines how much power is available in the wind.

$P = 1/2\ \rho A v3$

where

P= power

ρ = density

A= rotor area

v = wind speed.

The density of the air changes with altitude, temperature, and weather fronts.

Table 1: Power Analysis with a Function of Wind Speed

Wind Speed	Turbine Power	Generator Power
3.0	31.9	3.0
5.0	147.5	14.5
7.0	404.8	42.3
9.0	880.3	68.8
11.0	1570.8	123.8
11.0	1570.0	157.7

Table 1 shows the power analysis with a function of wind speed. It shows the result of turbine power and generated power with respect to wind speed. The corresponding graph and practical view is shown in the Figure 2 and Figure 3.

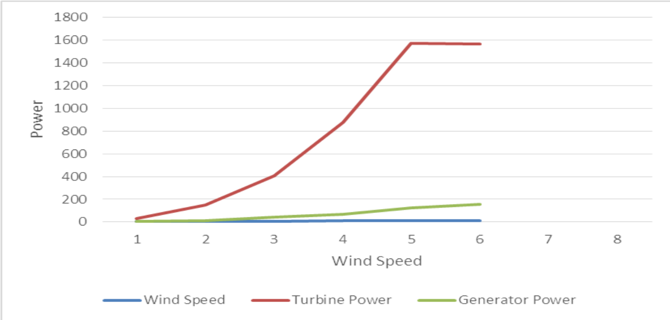

Fig. 2: Power Analysis Function of Wind Speed

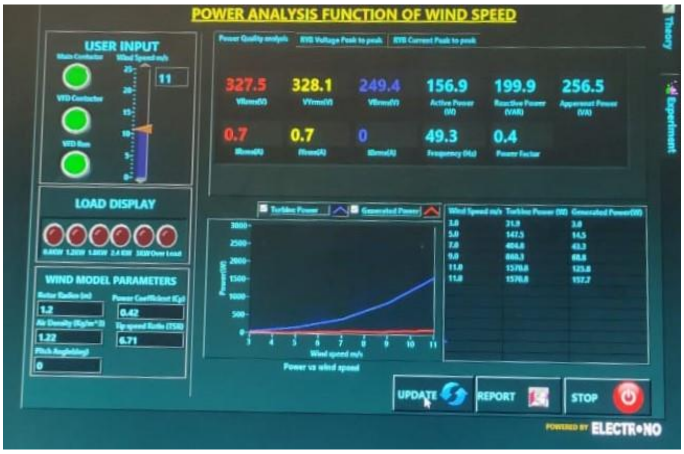

Fig 3: Result of Power Analysis Function of Wind Speed

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IV. ELECTRICAL CHARACTERIZATION TO IMPROVE POWER QUALITY

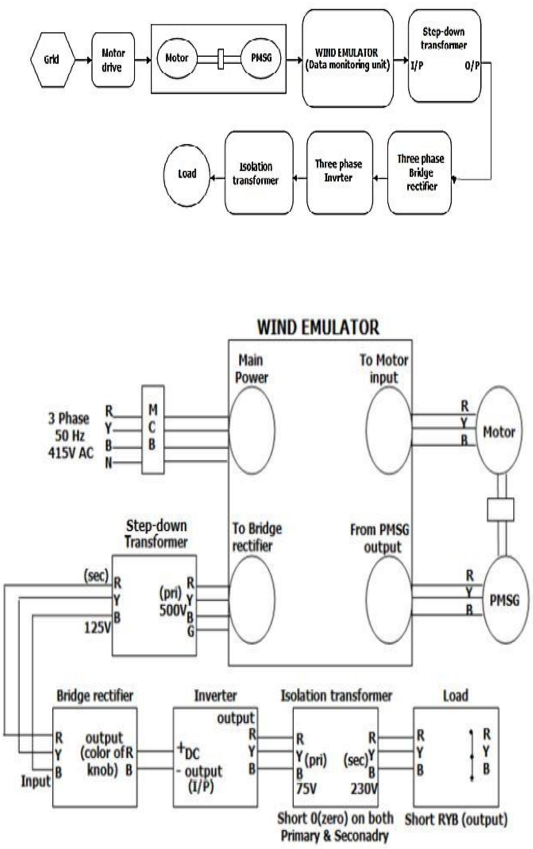

Fig. 4: Block Diagram and Connection Diagram for Electrical Characterization to Improve Power Quality

AC and DC integration technologies can be used to connect renewable energy sources to utility networks. Due to its structure, AC integration is a practical and cost-effective solution. However, the quality protection of its power is insufficient. Due to the additional AC / DC voltage conversion, the DC integration approach provides good power quality to the wind simulator, but its power efficiency is lower than the AC integration method. The advantages of both AC and DC integration methods are combined in this project to provide a controlled AC / DC integration system. AC integration is enabled in the proposed approach to provide high integration efficiency when the utility power quality is sufficient. When the power quality of the utility network is insufficient, DC integration is activated to improve the power quality of the wind simulator.

Voltage relaxation and current harmonic distortion were used as detrimental effects on the utility electricity in the model. In terms of voltage and current standards, the results show that the transitions between AC and DC integration modes are reliable.
The design of the block diagram and the connection diagram for the electrical characterization to achieve power quality is shown in Figure 4 and the results are shown in Table 2.

Table 2: Electrical Characterization to Improve Power Quality

Speed	Input frequency	Inverter output voltage	Inverter output current	Frequency
486	4.825	106	0.73	36.20
486	10.307	106	0.727	36.84
489	15.132	106.8	0.733	38.10
644	19.956	142	0.568	36.28
814	25.219	179.7	1.228	36.14
962	29.825	213.3	1.453	36.45
1133	35.087	250.9	1.719	36.29

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V. CONCLUSION AND FUTURE SCOPE

Interface of inverter incurrent regulated mode of real and reactive power is included in the proposed study on wind energy conversion system employing battery energy storage for nonlinear load. Battery energy storage improves system stability by providing rapid response and enhancing performance when wind turbine production fluctuates. A passive filter used to minimize harmonics produced by the load is simulated in earlier chapter. It is preferable to replace the induction generator with a doubly fed induction generator for better performance Off-shore wind turbines will be used in the future due to their advantages of providing high power

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