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Analysis of Efficient Control Strategy for Wind Farm Using Converters

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Abstract-- *Wind energy has been one of the most important and promising green energy options in recent years and demands that greater grids reliability during and after grid disruptions be sustained. This project deals with improving the efficient control strategy of a wind farm using converters both during fault and removal of fault conditions. By the use of converters and crowbar, the whole system is protected even during fault conditions. By using better means of converters the reactive power is improved in overall system. Using variable speed wind turbine turbines, the main benefit of speed control is usually configured that gives optimum power. The goal of this project is to achieve an effective control strategy for improving the low voltage drive (LVRT), which uses converters based on its merits in the Doubly Fed Induction Generator (DFIG).*

KEYWORDS: *Wind Energy Conversion system (WEC), Doubly Fed Induction Generator (DFIG), Low-Voltage Ride-Through (LVRT), Converter, Matlab.*

I INTRODUCTION

According to the rising need for power and environmental concerns, there is a major push to produce electricity from renewable energy sources. There are plenty of benefits of the use of sustainability. Wind is one of nature's most abundant renewable energy sources. The wind energy system consists of a wind turbine, an electric motor, a compressor and control systems for power electronics.

Back-to - back converters are used to connect the DFIG rotor to the infrastructure while the grid-based DFIG is usually applied. The magnetizing and torque rotor currents are controlled by the rotor side converter. The grid side converter monitors the voltage on the back-to - back converter's dc bus. Thyristors are widely used in the shaft generator network for switching purposes, as they are more robust, powerful and simple to achieve high ratings.

Because of the unexpected variations in the frequency and voltage of the DFIG wind turbine, the DFIG 's ac electricity produced is converted once in the dc power by means of the thyristor rectifier, and the dc power is transformed again with the inverter into ac power with a constant frequency and constant voltage. The advantages of using this converter are

1. Better reliability
2. High efficiency
3. Uses simple control techniques

Wind turbines may be used as an autonomous technology or attached to a power grid network. A significant number of wind turbines are typically built in near tandem with the design of a wind turbine with energy sources.

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II WIND ENERGY CONVERSION SYSTEM

A. Overview

Wind is very appealing as a power source because it is strong, unquenchable, sustainable and non-polluting. Scarce services are not lost. Wind flows for 320 days a year in a wide part of the world and this gives them a advantage of direct sunlight conversion systems, and the expense of running a wind mill is negligible. In fact, the ecosystem is not subject to any undue pressure.

Optimal efficiency is 59%, but aerodynamic and other mechanical losses may cause a total efficiency of 30%. With a wind speed of 10 m/s, this gives a power of around 0.3 kW / m2. Power from wind is derived from the transformation of wind power into power. A wind turbine is identical to the windmill, its precursor. Aerodynamic power is converted into electricity in wind turbines. Two conversion cycles are carried out in a wind turbine. Initially, the wind power (aerodynamic power) is transformed to mechanical power, and a dually fed induction turbine transforms the mechanical power into electricity. Wind turbines can be either constant speed or variable speed generator.

B. Practical Arrangement of a Wind Power Plant

A wind turbine, to which an alternator is connected, may be powered with the wind power. On a tower are hollow blades with a diameter of around 25 m. The air from the high chimney passes to the hollow blade and the blade rotates because of the centrifuge force. When the air hits the tower, the wind turbine powers and produces electricity**.**

C. Operation of a Wind Power Plant

Figure 1 displays the design structure of a wind turbine. The Aero Turbines transform the energy into spinning mechanical energy in flowing air. For proper action, they need pitch control and yaw control. A mechanical interface includes a set-up equipment and an effective link that transmits the spinning mechanical energy into the electric generator. The generator's output is related to the grid.

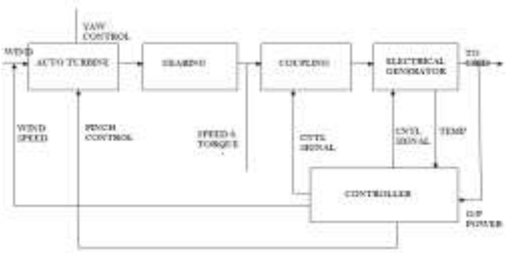

Fig.1 Schematic Diagram of Wind Power Plant

Controller is used to sense wind speed, wind direction, shaft velocity and torques, power output and generator temperature, and to regulate the electrical output along with the wind inpu

D. Capacity Factor

As the wind rate is not constant, the annual energy production of the wind farm is never as high as the total of hours in the year of the generator name plate rating. The present output ratio is considered the capability factor in one year from this theoretical limit. Typical ability factors are between 20 and 40 per cent and especially preferred values at the upper end of the spectrum. A 1 MW turbine with a power factor of 35 percent would, for instance, not generate 8,760 MW • hours a year (1 alternatively 24 • 365), but just 1 alternatively 0.35 • 24 alternatively 365 MWh (to 0.35 MWh) by default.

III. DOUBLY FED INDUCTION GENERATOR

A. DFIG Modelling

On the following conditions and assumptions the general machine model is developed:

(a) The generator follows a constructive direction with the stator and rotor currents.

(b) The equations are constructed by means of a parallel (d) and square (q) axis in a synchronous reference frame.

(c) Each unit of device parameters and variables is known as the stator side of the DFIG.

The stator, rotor and d – q reference frame voltages and streams moving at an angular speed of ω are defined by,

$$V_{sdq} = R_s i_{sdq} + j\omega\psi_{sdq} + \frac{1}{\omega b}\frac{d\psi sdq}{dt}$$

$$V_{rdq} = R_r i_{rdq} + j\omega_2\psi_{rdq} + + \frac{1}{\omega b}\frac{d\psi rdq}{dt}\psi_{sdq} = L_s i_{sdq} + L_m i_{rdq} \text{and } \psi_{rdq} = L_m i_{sdq} + L_r i_{rdq}$$

Wherever the surge, voltage and current are expressed by V and I. Stator and rotor quantities are indicated in subscripts s and r. Ls and Lr are inductive stator and rotor itself, Lm is the mutual inductance, § 2 is the frequency of rotor slip, § b is the frequency of the base angle, and v is the velocity of the referee d – q. The stator and rotor resistances are also Rs and Rr.

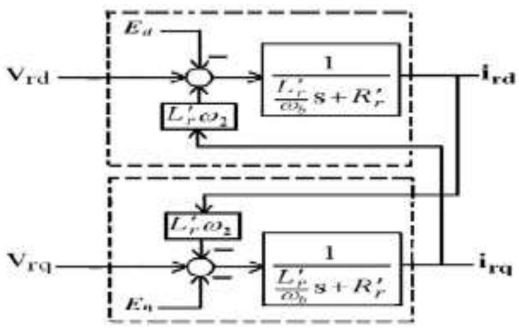

Fig. 2 d-q Axis Dynamics of Rotor Currents

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The term Edq reflects the effects of stator dynamics on the d-q rotor back-EMF voltage induced by the rotary winding.

IV. LVRT CONTROL DESIGN

The major issue with the achievement of LVRT is the peak rotor loss which can surpass the RSC.

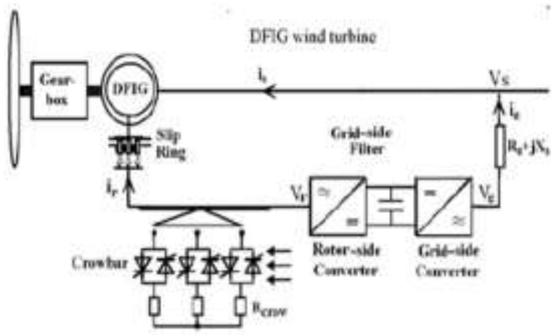

Fig. 3 Schematic diagram of the conventional Crowbar protection

A mixture of passive and active LVRT trims is the LVRT management technique. In the voltage drop and a few milliseconds after resolving the loss to avoid large transients, this LVRT technique is used.

V. WIND TURBINE MODELLING

The Wind Energy Conversion System block diagram is shown in figure 4. This requires a DFIG containing voltage-back-to-back converters linking a rotor to the power grid. The RSC controls the reaction speed and power of the generator whereas the GSC is connected to the Grid via a grid side filter and controls the reactive power and dc-link voltage with the grid. The RSC controls.

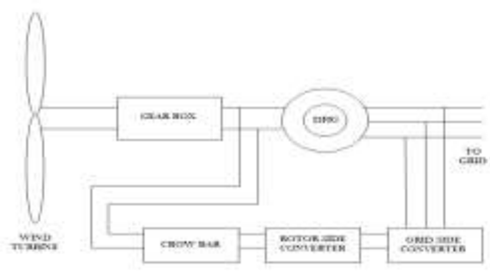

Fig. 4: Block Diagram of Wind Energy Conversion System

VI. CONVERTER METHODOLOGY

The standard converter configuration is shown in Figure 5. It consists of a generator side rectifying system and a grid side inverter, which can be a VSC capacitor or a CSC inductor, via a dc-link item.

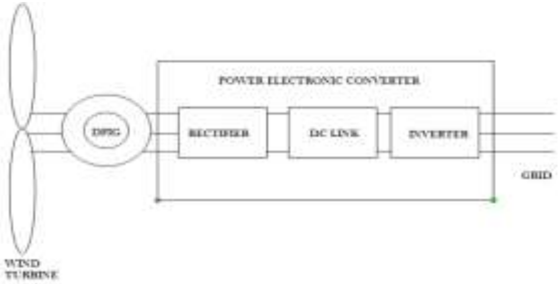

Fig. 5: Converter Topology

Because the DFIG's output frequency and tension are altered due to unexpected wind variations, the DFIG ac power produced once with the thyristor rectifier is converted to dc. The dc power is then converted again into the ac current, with the inverter supplied to the charges (or electrical power supplies), at a constant frequency and constant voltage.

VII. RESULTS AND DISCUSSIONS

Simulation is achieved with the MATLAB / SIMULINK software kit via the Sim Power device component before it is implemented. Below are the results. The simulation results of wind turbine embedded power system with and without fault and crowbar are shown.

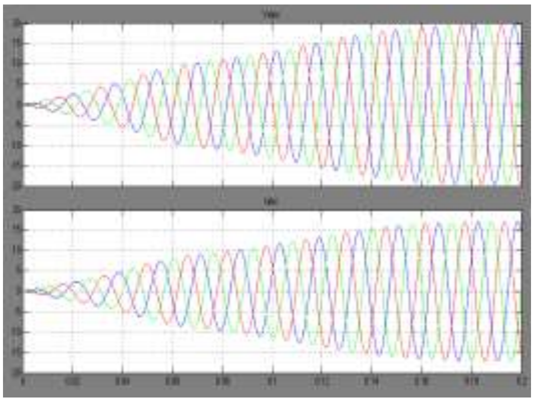

Figure 6: Output Voltage and Current Waveform of a Wind Farm

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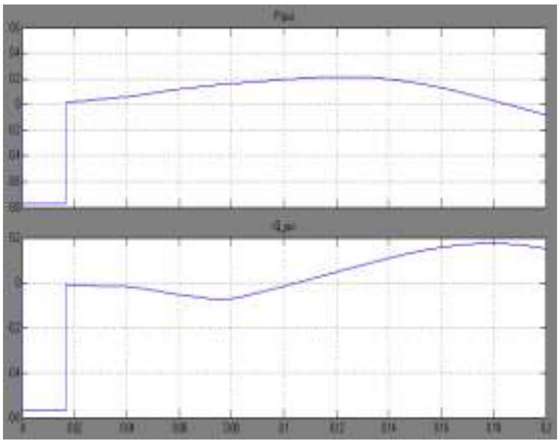

Figure 7: Active and Reactive Power of a Wind Farm

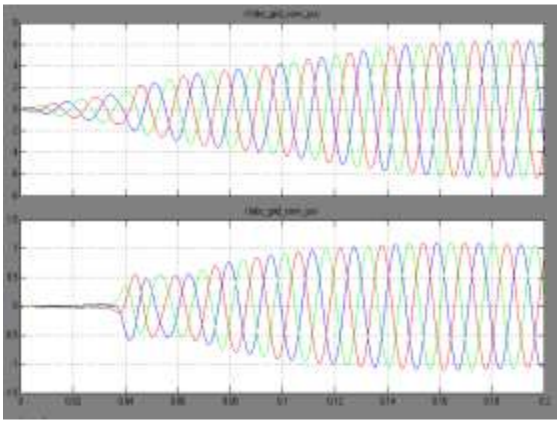

Figure 8: Output Voltage and Current Waveform on Grid Converter Side

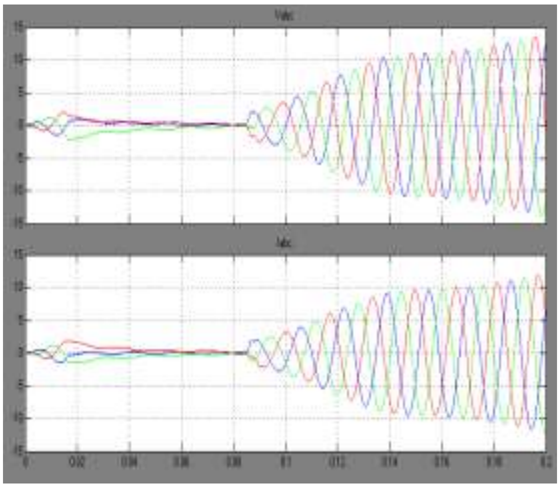

Figure 9: Voltage and Current Waveforms of a Wind Farm Embedded Power System with a 3-Phase Fault

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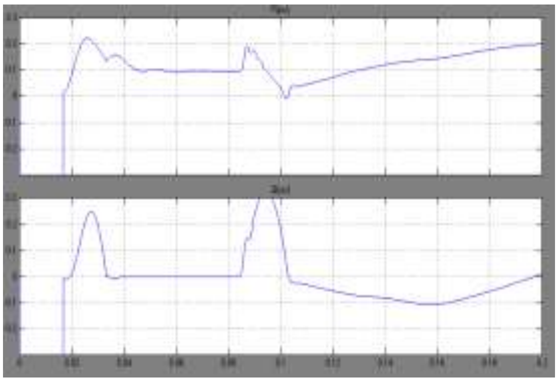

Figure 10: Output Waveform of Active and Reactive Power of a Wind Farm with 3-Phase Fault

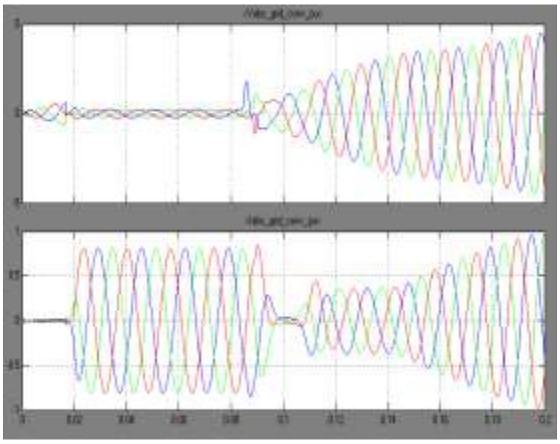

Figure 11: Voltage and Current Waveforms of Grid Side Converters of a Wind Farm with 3-Phase Fault

A significant number of harmonics are represented by the waveforms of a three-phase wind farm. It will take several years and will slowly decrease due to the crowbar safety scheme that defends the entire system against high defects. Within the wind speed region of about half to full value, the converters are used to properly control the generators for varied speed operation. The rotor side converters that turn ac into dc control both the speed of the generator and the reactive power are used. The grid-side transformer that converts the dc into ac regulates the dc-like voltage and the grid reactive power exchange.

III CONCLUSION

With the rectifier and the inverter the wind farm is built. The attributes are low cost , low power loss and high reliability. The results of the simulation show that the rectifier can properly monitor the generators to achieve variable speed activity from about half to full value in the wind speed area. Even With the use of a crowbar, side converters and grid converters, system protection shall be designed under a fault condition. The use of converters and crowbars that provide an efficient reactive power production for the wind farm and the maximum power output for consumers. This efficient wind farm control strategy.

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