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Wind Power Generation, a Review of the Doubly Fed Induction Generator

Abstract

In recent years, there's been a renewed interest in renewable energy sources due to environmental problems and the eventual shortage of fossil fuels. Wind energy made considerable strides especially in Europe, particularly Denmark and Germany [1, 2]. Wind is a source of energy which has gained popularity in the last few years, coupled with the fact that it is a non-polluting and renewable energy source with minimal costs involved in operating expenses. A lot of distribution systems use this energy source for their power supply. A lot of generators are in use with wind as a source of energy, however the most commonly used generator in modern times, and especially with units above 1 MW is the doubly fed induction generator (DFIG). This paper aims to look at the features of the doubly fed induction generator which has made it an enviable bride in wind power generation.

Keywords: Wind power generation, doubly fed induction generator

1. INTRODUCTION

Wind energy has gained a lot of global attention as an energy source in the production of electricity. This is basically because, unlike other conventional energy sources, wind is harmless to the environment and easily exploitable, hence it is very economical compared to other energy sources and can be said to be the most viable source of electrical power.

Induction machines coupled with gearboxes and a wind turbine using a fixed speed operation mode were designed to harness wind energy, this had its own drawbacks. They were relatively inefficient and a lot of power fluctuations occurred as a result of fluctuations from the wind speed. This anomaly was corrected by the introduction of variable speed power turbines whose control could reduce power fluctuations and maximally extract power from wind by operating at an optimal speed. One of the factors responsible for this improvement was the introduction of the doubly fed induction generator in the setup of these kinds of turbines [3].

2. WIND POWER GENERATION

The term wind power or energy is used in the description of the process by which wind is used in generating mechanical power or electricity. Kinetic energy in wind is converted into mechanical power by the use of wind turbines, this mechanical power is in turn converted into electricity by the use of generators. Wind turbines act like aircraft propellers, using the power of the wind to drive an electric generator. Wind passes over the rotating blades of the turbines which turn a shaft, going into a gearbox which in turn increases the rotational speed to a level appropriate for the generator, which then uses magnetic fields to convert the rotational energy into electrical energy [4]. The magnitude of energy generated from wind is dependent on the wind velocity and air density.

3. OPERATION OF THE DOUBLY FED INDUCTION GENERATOR

The doubly fed induction generator allows variable speed operation which is invariably makes it possible for optimal power extraction from wind. This is the basic advantage this configuration gives. They are variable three phase induction machines which have windings on both the stationary and rotating parts, where both windings transfer significant power between shaft and electrical system.

Rotor windings are connected to the grid via slip rings and back-to-back voltage source converters that control both the rotor and grid currents. Adjustment of the active and reactive power fed to the grid from the stator is made possible by control of the rotor currents using the converter and this is not dependent on the rotating speed of the generator.

The rotor side converter takes the variable frequency voltage and converts it into a dc voltage. The grid side converter has the ac voltage from the dc link as input and voltage at grid parameters as output. With the rotor-side converter it is possible to control the torque or the speed of the DFIG and also the power factor at the stator terminals, while the main objective for the grid-side converter is to keep the dc-link voltage constant regardless of the magnitude and direction of the rotor power. Between the two converters a dc-link capacitor is placed, as energy storage, in order to keep the voltage variations in the dc-link voltage small. The stator is connected directly to the grid. The rotor on the other hand needs a step down transformer in order to connect to the grid.

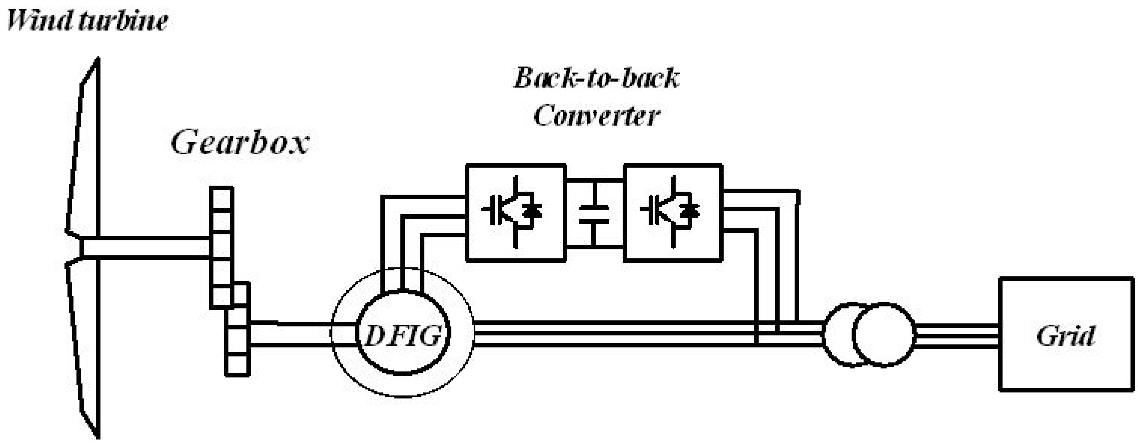

Fig. 1. Simple configuration of a doubly fed induction generator

4. BRAKING AND CONVERTER PROTECTION SYSTEMS

During the process of wind power generation, some abnormal scenarios such as over speed, maintenance or fault conditions may arise; this requires the braking systems for the wind turbine generation system to be able to reduce the speed of the aerodynamic rotor. Wind turbine design standards require two independent brakes which must be capable of reducing the wind turbine to a safe rotational speed in all anticipated wind speeds and fault conditions [5]. There are usually combined conventional mechanical shaft (disk) brakes and aerodynamic brakes for wind turbine brake.

The typical protection scheme used for a DFIG is the crowbar protection scheme where a set of resistor systems that are connected in parallel with the rotor winding on occurrence of an interruption, the crowbar circuit bypasses the rotor-side converter. The active crowbar control scheme connects the crowbar resistance when necessary and disables it to resume DFIG control

CONCLUSION

The DFIG system applied to wind power generation costs more than fixed-speed induction generators without converters. However, the performance and controllability are excellent in comparison with fixed speed induction generator systems; they allow the amplitude and frequency of their output voltages to be maintained at a constant value, no matter the speed of the wind blowing on the wind turbine rotor. As a result, DFIG can be connected directly to the ac power network and remain synchronized at all times with the ac power network.

References

1. Nayar C.V., Bundell J.H. "Modelling and Simulation of a Wind-Driven Wound Rotor Induction Generator with Tip-Speed Ratio Control", Electric Energy Conference 1987, Adelaide, 6–9 October 1987.

2. B. Connor, W.E. Leithead, "Performance Assessment of Variable-Speed Wind Turbines", Opportunities and Advances in Internnational Power Generation, 18–20th March 1996, Conference Publication No. 419, IEE, 1996

3. John Fletcher and Jin Yang (2010). Introduction to the Doubly-Fed Induction Generator for Wind Power Applications, University of Strathclyde, Glasgow, UK
4. Satish Choudhury, "Performance Analysis of Doubly-fed Induction Generator in Wind Energy Conversion System" M.tech thesis, NIT Rourkela (2011)
5. Craig, L.M.; Saad-Saoud, Z. & Jenkins, N. (1998). Electrodynamic braking of wind turbines, IEE Proc. – Electr. Power Appl., Vol. 145, No. 2, March 1998, 140–146, ISSN

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