Chapter 9
Double Fed Induction Generator Control for Wind Power Generation

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ABSTRACT

Doubly-fed induction generator wind turbines are largely developed due to their variable speed feature. The response of wind turbines to grid disturbance is an important issue, especially since the rated power of the wind turbine is increased; therefore, it is important to study the effect of grid disturbances on the wind turbine. In the chapter, the characteristics of the doubly-fed induction generator during wind speed fluctuation are studied. MATLAB/Simulink software has been used to observe the characteristics of wind turbines during wind speed fluctuation. Simulation results of the doubly-fed induction generator wind turbine system show improved system stability during wind speed variation. Power electronics converters used in the DFIG system are the most sensitive parts of the variable speed wind turbines with regards to system disturbances. To protect from excessive current, the DFIG system is equipped with an over-current and DC voltage overload protection system that trips the system under abnormal conditions.

INTRODUCTION

Out of all renewable energy sources, wind energy is the most promising due to its cost-effectiveness and environmentally friendly nature. No other renewable energy-based electricity-producing technology has attained the same level of maturity as wind power. There are no significant technical barriers to significant scale penetration of wind power. During the last decade, wind energy is developed and extended to industrial use in some European countries, including Germany, Denmark, and Spain. Their success in wind energy generation has encouraged other countries to consider wind energy also in their electricity generation systems. Its clean, economic, practical and renewable interaction with the environment soon draws attention from political, business circles and individuals.

DOI: 10.4018/978-1-7998-2718-4.ch009

The power in the wind can be computed by using the concept of kinetics. The windmill works on the principle of converting the kinetic energy of wind to mechanical energy. The power is equal to energy per unit time. The energy available is the kinetic energy of the wind. The kinetic energy of any particle is equal to one half it's mass times the square of its velocity, or $\left[\frac{1}{2}mV^2\right]$. The amount of air passing in unit time, through an area A, with velocity V, is $A \times V$, and its mass m is

$$m = \rho AV \tag{1}$$

Where, ρ = density of air (kg/m^3)
m = mass of air transferring the area A in unit time (in kg)
Substituting the value of the mass in the expression for the kinetic energy, we obtain

$$\text{Kinetic energy (in unit time)} = \frac{1}{2}\rho AV^3 \text{ Watt} \tag{2}$$

For the circular area of diameter D (m) in horizontal axis aero turbine the area

$$A = \frac{\pi}{4}D^2 \tag{3}$$

$$\text{Therefore available wind power } P = \frac{1}{2}\rho\frac{\pi}{4}D^2V^3 \text{ watts} \tag{4}$$

In practice, the actual output will be smaller than that represented by equation (4) due to the inability of the rotor to convert the entire kinetic energy available in the wind. This is represented by C_p (power coefficient), which varies as a function of velocity having the maximum value at the design wind speed. The power coefficient C_p gives the fraction of kinetic energy that is converted into mechanical energy by wind turbines.

Wind Energy Conversion Systems (WECS) convert the energy in moving air (the wind) to electrical energy. The basic idea is quite simple and has been around for centuries. The wind strikes some sort of set of blades mounted on a shaft that is free to rotate. The wind hitting the blades generates a force that turns the shaft, and this rotational kinetic energy may then be used for any of a number of purposes (historically, things like pumping water, moving a saw, or turning grain-grinding stones, to name a few).

The significant advantage of the DFIG system, which has made it famous, is that the power electronic equipment only has to handle a fraction of the total system power. This means that the losses in the power electronic equipment can be reduced in comparison to power electronic equipment that has to handle total system power as for a direct – driven synchronous generator, hence saving in cost of the converter. Other advantages of variable-speed operation of wind turbines are the possibility to reduce stresses of mechanical structure, acoustic noise reduction and the possibility to control active and reactive power.