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Sliding Mode Controls of Active and Reactive Power of a DFIG with MPPT for Variable Speed Wind Energy Conversion

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Abstract: This paper presents the study of a variable speed wind energy conversion system based on a Doubly Fed Induction Generator (DFIG) based on a sliding mode control applied to achieve control of active and reactive powers exchanged between the stator of the DFIG and the grid to ensure a Maximum Power Point Tracking (MPPT) of a wind energy conversion system. The proposed control algorithm is applied to a DFIG whose stator is directly connected to the grid and the rotor is connected to the PWM converter. To extract a maximum of power, the rotor side converter is controlled by using a stator flux-oriented strategy. The created decoupling control between active and reactive stator power allows keeping the power factor close to unity. Simulation results show that the wind turbine can operate at its optimum energy for a wide range of wind speed.

Key words: Doubly Fed Induction Generator, Wind Energy, Wind Turbine, Sliding Mode Control, Maximum Power Point Tracking (MPPT).

INTRODUCTION

Recently, the doubly fed induction generator (DFIG) is becoming the main configuration of wind power generation because of its unique advantages. Vector control technology is used to control the generator, and the rotor of DFIG is connected to an AC excitation of which the frequency, phase, and magnitude can be adjusted. Therefore, constant operating frequency can be achieved at variable wind speeds (Guo-qing, W.U., 2010).

A doubly fed induction generator is most commonly used in wind power generation. It is a wound rotor induction machine with slip rings attached at the rotor and fed by power converter. With DFIG, generation can be accomplished in variable speed ranging from sub-synchronous speed to super-synchronous speed (Jeong-Ik Jang, 2006).

The variable speed constant frequency (VSCF) wind power generation is mainly based on the research of optimal power-speed curve, namely the most mechanical power of turbine can be achieved by regulating the speed of generator, where the wind speed may be detected or not (Guo-qing, W.U., 2010).

Through studying the characteristics of wind turbine, the paper proposed the maximum power point tracking (MPPT) control method. Firstly, according to the DFIG character, the paper adopts the vector transformation control method of stator oriented magnetic field to realize the decoupling control for the active power and reactive power using sliding mode control (SMC).

Sliding mode theory, stemmed from the variable structure control family, has been used for the induction motor drive for a long time. It has for long been known for its capabilities in accounting for modelling imprecision and bounded disturbances. It achieves robust control by adding a discontinuous control signal across the sliding surface, satisfying the sliding condition. Nevertheless, this type of control has an essential drawback, which is the chattering phenomenon caused from the discontinuous control action. To alleviate the chattering phenomenon, the idea of boundary layer is used to improve it. It is called a modified controller. In this method, the control action was smoothed such that the chattering phenomenon can be decreased (Hazzab, A., 2005).

In this paper, we apply the SMC method to the wind energy conversion systems to design a novel MPPT control algorithm.

2. Model of Turbine:

The wind turbine input power usually is (Xuemei Zheng, 2009):

$$P_v = \frac{1}{2}\rho S_w v^3 \qquad (1)$$

where ρ is air density; S_w is wind turbine blades swept area in the wind; v is wind speed.

The output mechanical power of wind turbine is:

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