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Direct Power Control for Grid-Connected Doubly Fed Induction Generator Using Disturbance Observer Based Control

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Abstract

A disturbance observer based control method for a grid-connected doubly fed induction generator is presented in this study. The proposed control method consists of a state-feedback controller and a disturbance observer (DO). The DO is used to compensate for model uncertainties with the aim of removing the steady-state error. The control objective consists of regulating the stator currents instead of the rotor currents in order to achieve direct control of the stator active and reactive powers. Such a control scheme removes the need for an exact knowledge of the machine parameters to achieve accurate control of the stator active and reactive powers. The main advantage of this control method is ensuring a good transient performance as per the controller design specifications, while guaranteeing zero steady-state error. Moreover, the proposed control method was experimentally validated on a small scale DFIG setup.

keywords: WECS, DFIG, disturbance observer based control (DOBC)

MSC: RENE-D-17-02808

1. Introduction

The global power consumption over the past years increased significantly due to the industrial and population growth. Natural fossil resources such as oil, coal, natural gas, etc. have many drawbacks, environmental issues for instance. Renewable energies like solar and wind are environmental friendly. Among many renewable energy sources, wind energy is one of the fastest growing source nowadays. According to the wind global energy council, the global total wind energy installation in 2015 was close to 433 GW, and the expected cumulative installed capacity by 2020 is 791.9 GW [1]. Doubly-fed induction generator is an electric machine that is fed with AC currents in both their stator and rotor windings. Nowadays, the majority of doubly-fed induction generators are three-phase wound-rotor induction machines. They have many advantages such as speed operation range between $\pm 30\%$ of the synchronous speed, complete independent control of power exchange to and from the grid when controlled with power converters, and reduced power losses and cost due to the use of small scale power converters which is about only 30% of the generator rating [2, 3]. The common techniques of controlling electric machines are the vector control or field oriented control, direct power, and direct torque control [4, 5]. Many control methods such as proportional integral, sliding mode, model predictive, disturbance observer based, intelligent control, and H-infinity were applied to the DFIG system. The conventional proportional integral control is the most basic control method used to control DFIG based wind energy conversion system (WECS). It is easy to design and implement. In addition, this control can use direct power control [6, 7], vector control [8], or even a combination of the two control schemes [4]. Moreover, different DFIG models including dq - synchronous reference frame [4] and $\alpha\beta$ -reference frame [8] models are used. In [7], the experimental validation of small scale DFIG using proportional integral control is conducted. The inability to operate under different operating points and control parameter tuning are the main drawbacks of this control method. Sliding mode control is a robust control method which has very high tracking accuracy and robustness to system parameters variations [9, 10]. This method can be

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