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Towards a Practical Identification of a DFIG Based Wind Generator Model for Grid Assessment

Salma EL AIMANI

Ibn Zohr University, Ploydisciplinary Faculty of Ouarzazate
BP 638, 45000 Ouarzazate, Morroco
phone: +212524885798, fax: +212524885801
e-mail: elaimani_salma@ yahoo.fr

Abstract

The main impacts on electrical systems, for transmission operators, are variations of the voltage and changes of the power flows. In this paper we detail how we have identified the main characteristics of a DFIG based wind generator. Simulation results of this model will be compared with experimental results measured on the real 1.5 MW wind generator. Thanks to the use of power electronic converters this variable speed wind generator is controlled according to four operating modes. A modeling of power electronic converters has been developed to highlight the impact of the switching phenomena and the power quality of the generated quantities.

Keywerds : Doubly Fed Induction Generator, turbine modeling, control design, variable speed wind generator, grid integration.

1. Introduction

Actually, the market for variable speed wind turbines is oriented to the design of high power wind generation systems (2 MW and more) [1], [2], [3]. The most specific generators are doubly fed induction generators (DFIG), they have great interests since they are able to generate Controllable high power thanks to reduced rated power converters in comparison with other same power technologies [4]. As wind power penetration continues to increase, more widely applicable methodologies have to be developed for evaluating the actual benefits and technical constraints of adding wind turbines to conventional generating systems.

In this paper a wind doubly fed generator system whose wound rotor is connected to the grid via two back-to-back voltage source inverters is considered. An adequate dynamic model of the global system taking into account the switching nature of the power converters is developed and identified with the help of experimental measurements. In results, two ideal voltage sources, one controlling the rotor current and one controlling grid currents are used [5]. In order to take into account the switching nature of the converters, the proposed model allows observing the harmonic content of the different state variables. Thus, a model of power converters taking into account a large frequency spectrum (1kHz–10kHz) is developed. The complexity of this model results from a compromise between

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the global computing time and the desired accuracy. The control strategy is operating in four domains and concerns the control of the reactive power, the power quality and the control of the intermediary DC bus. The proposed global model is simulated with the help of Matlab-Simulink.

The wind energy conversion system (WECS) is presented and quantities easy to measure are highlighted. Recorded data, which will be useful for the design of a model, are shown. Then a simple mathematical model of the turbine and of the mechanical parts is considered. Main parameters are retrieved from recorded data. Hence the modeling of the DFIG and the power electronic cascade is presented. The control strategy of this system is described. The proposed global model is simulated with the help of Matlab-Simulink. Then, by considering experimental measurements during ten hours on a real 1.5 MW doubly fed induction generator (DFIG), simulation results are compared with the equivalent measured data for a measured wind profile. Finally, the utility of this model is shown by evaluating impacts on power quality (voltage fluctuations and harmonics) of this wind generator into an electrical network, which is simulated with the help of the Sim Power System toolbox.

2. System Configuration

Figure 1 shows the overall wind generation system. Stator windings are directly connected to the grid and the wound rotor is connected to the grid via two back-to-back voltage source inverters. The grid side converter is connected via three chokes to filter the current harmonics. Hence rotor currents can be controlled with a wished frequency and power quality of grid currents can be guaranteed.

In order to identify main parameters of a turbine model and main time constants of the control system, the time evolution of mechanical and electrical quantities have been measured onto a 1.5 MW DFIG wind generator every 10 seconds during 10 hours. The main interest of these sensed data is that they cover all operating domains of the wind turbine because of the large variation of the recorded wind speed (fig. 2).

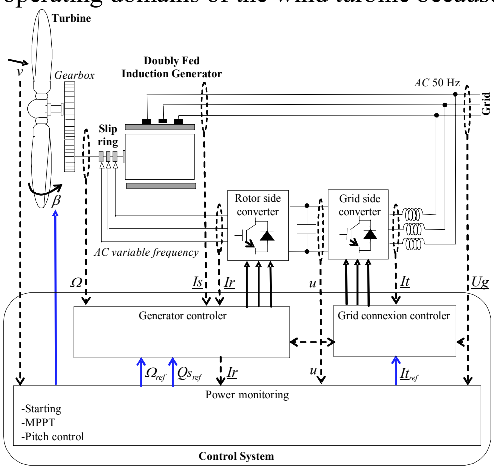

Fig. 1. A DFIG based WECS

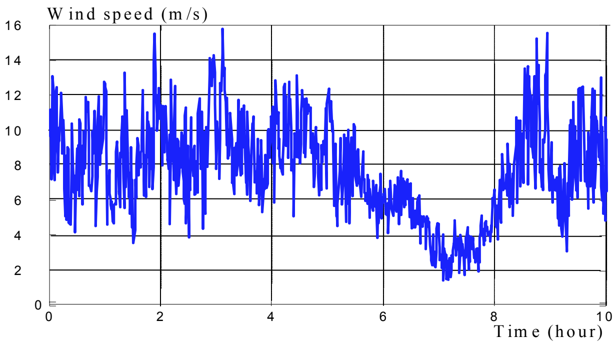

Fig. 2. Measured wind speed

3. Modelling of the turbine and mechanical parts

3.1 Turbine modelling

A wind turbine is characterized by its aero dynamical torque, which is given by: