European Association for the Development of Renewable Energies, Environment and Power Quality (EA4EPQ)

International Conference on Renewable Energies and Power Quality (ICREPQ'10)
Granada (Spain), 23th to 25th March, 2010

Modelling and Simulation of a Wind Energy System with Fractional Controllers

R. Melício[1], V.M.F. Mendes[2] and J.P.S. Catalão[1]

[1] Department of Electromechanical Engineering
University of Beira Interior
R. Fonte do Lameiro, 6200-001 Covilhã (Portugal)
Phone: +351 275 329914, Fax: +351 275 329972, e-mail: **ruimelicio@gmail.com**, **catalao@ubi.pt**

[2] Department of Electrical Engineering and Automation
Instituto Superior de Engenharia de Lisboa
R. Conselheiro Emídio Navarro, 1950-062 Lisbon (Portugal)
Phone: +351 218 317 000, Fax: +351 218 317 001, e-mail: **vfmendes@isel.pt**

Abstract. This paper is on wind energy conversion systems with full-power converter and permanent magnet synchronous generator. Different topologies for the power-electronic converters are considered, namely two-level and multilevel converters. Also, a new fractional-order control strategy is proposed for the variable-speed operation of the wind turbines. Simulation studies are carried out in order to adequately assess the quality of the energy injected into the electrical grid. Conclusions are duly drawn.

Key words

Power converters, power quality, wind energy.

1. Introduction

The general consciousness of finite and limited sources of energy on earth, and international disputes over the environment, global safety, and the quality of life, have created an opportunity for new more efficient less polluting wind and hydro power plants with advanced technologies of control, robustness, and modularity [1]. Concerning renewable energies, wind power is a priority for Portugal's energy strategy. The wind power goal foreseen for 2010 was established by the government as 5100 MW. Hence, Portugal has one of the most ambitious goals in terms of wind power.

Power system stability describes the ability of a power system to maintain synchronism and maintain voltage when subjected to severe transient disturbances [2]. As wind energy is increasingly integrated into power systems, the stability of already existing power systems is becoming a concern of utmost importance [3]. Also, network operators have to ensure that consumer power quality is not deteriorated. Hence, the total harmonic distortion (THD) coefficient should be kept as low as possible, improving the quality of the energy injected into the electrical grid [4].

The development of power electronics and their applicability in wind energy extraction allowed for variable-speed operation of the wind turbine [5].

In this paper, a variable-speed wind turbine is considered with permanent magnet synchronous generator (PMSG) and different power-electronic converter topologies: two-level and multilevel. Additionally, a new fractional-order control strategy is proposed for the variable-speed operation of wind turbines with PMSG/full-power converter topology. Simulation studies are carried out in order to adequately assess the quality of the energy injected into the electrical grid. Hence, the harmonic behavior of the output current is computed by THD. A comparison with a classical integer-order control strategy is also presented, illustrating the improvements introduced by the proposed fractional-order control strategy.

References

[1] T. Ahmed et al., "Advanced control of PWM converter with variable-speed induction generator", IEEE Transactions on Industry Applications, Vol. 42, pp 934-945, 2006.

[2] Y. Coughlan et al., "Wind turbine modeling for power system stability analysis - A system operator perspective", IEEE Transactions on Power Systems, Vol. 22, pp 929-936, 2007.

[3 N.R. Ullah and T. Thiringer, "Variable speed wind turbines for power system stability enhancement", IEEE Transactions on Energy Conversion, Vol. 22, pp 52-60, 2007.

[4] J.M. Carrasco et al., "Power-electronic systems for the grid integration of renewable energy sources: A survey", IEEE Transactions on Industrial Electronics, Vol. 53, pp 1002-1016, 2006.

[5] J.A. Baroudi et al., "A review of power converter topologies for wind generators", Renewable Energy, Vol. 32, pp 2369-2385, 2007.