Renewable Energy and Power Quality Journal (RE&PQJ), ISSN 2172-038 X, No.9, 12th May 2011, Reference Paper: 415

Time Domain Variable Speed Wind Energy Conversion Systems Modelling Using ATP Platform

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Abstract. This paper presents a comprehensive computational representation of a variable speed Wind Energy Conversion Systems (WECS) and its connection to typical AC grid systems. The arrangement chosen for modelling purposes consists of a multipole synchronous generators unit. This type of arrangement appears as a modern tendency to WECS composition. The paper content comprises basic information about the overall scheme structure, time domain modelling and computational implementation in the well known ATP platform. Using this approach studies involving transients, dynamic and steady state analysis can be then performed. Although these facilities are available, the case studies here considered are focused on the investigation of the relationship between specific wind and PCC voltage conditions and the final voltage and current forms produced at the AC busbar. Wind energy with distinct ramp and gust conditions are utilized so as to highlight the control action in limiting and optimizing the energy transference to the generators. In addition to this, the occurrence of non-ideal conditions to the PCC voltage and the overall interaction with WECS and AC system can be fully taken into account for power quality studies.

Key words

Modelling, power quality, variable speed topology, wind energy.

1. Introduction

The energy produced by the wind is winning larger prominence because of the great and inexhaustible wind potential available in the world. Having in mind the electrical energy generation possibilities one may consider the use of synchronous and asynchronous generators. Constant speed turbines are usually coupled to induction generators with squirrel cage or wound rotor type. On the other hand, variable speed turbines can be linked to both wound rotor induction generators as well as synchronous generators [1]. The later is the chosen technology here selected to be described, modeled and simulated.

Using the mentioned arrangement, this paper is directed to the description of the physical components of the overall wind generation unit, their modeling using time domain techniques, the implementation in the traditional ATP simulator and, finally, the investigation of the voltage and current waveforms and power quality indexes at the PCC. By performing such studies with a general wind condition and distinct AC voltage supply conditions, relevant information concerning harmonic distortion, voltage unbalance and voltage profile are obtained and compared to the power quality standards requirements.

2. Wind Energy Conversion System

The model of the proposed wind turbine is formed by several sub-systems (or representative components), as illustrated in Figure 1.

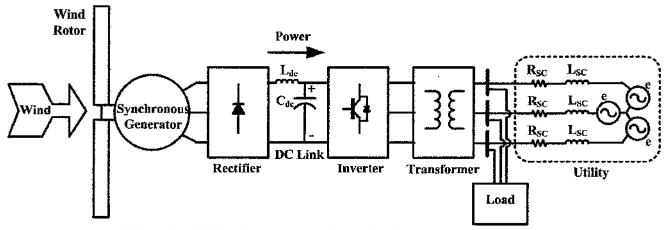

Fig. 1. Wind system physical structure

The mechanical power withdraw from the wind, and supplied to the electric generator shaft, is given by (1) [2] e [3]. In this equation, A represents the area swept by the blades, ρ the specific weight of the air and V_{wind} the wind speed. C_p, from (2) to (4), is the power coefficient, corresponding to the Betz limit.

$$P_{mech} = \frac{1}{2}\rho A C_p V_{wind}^{\ 3} \quad (1)$$

Where:

$$C_p(\lambda,\beta) = 0{,}22\left(\frac{116}{\lambda_i} - 0{,}4\beta - 5\right)e^{\frac{-12{,}5}{\lambda_i}} \quad (2)$$

$$\lambda_i = \frac{1}{\frac{1}{\lambda + 0{,}08\beta} - \frac{0{,}035}{\beta^3 + 1}} \quad (3)$$

$$\lambda = \frac{V_{blade}}{V_{wind}} = \frac{\omega R}{V_{wind}} \quad (4)$$