Wind Energy Systems and Power Quality: Matrix versus Two-Level Converters

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

[1] University of Beira Interior
Covilhã, Portugal
e-mail: **ruimelicio@gmail.com**, **catalao@ubi.pt**

[2] Instituto Superior de Engenharia de Lisboa
Lisbon, Portugal
e-mail: **vfmendes@isel.pt**

Abstract. This paper presents data of the actual installed electric power capacity for the renewable energy power systems in Portugal. Also, this paper presents a contribution consisting in a modulation strategy for simulation of a wind energy system with different topologies for power converters, consisting on a matrix and a two-level converter. Although more complex, this modulation strategy is justified for more accurate results.

Key words

Wind energy systems, power quality, power electronics, modelling and simulation.

1. Introduction

Electricity restructuring has offered to us additional flexibility at both level of generation and consumption. Also, since restructuring has strike the power system sector, developments in distributed generation technologies opened new perspectives for generating companies [1], in order to consider their energy supply portfolio with adequacy and advantage. Adequacy and advantage due to a better generation mix, concerning not only the traditional economic perspective, but also politic developments with strong social impact in power systems, imposing the internalization of costs formerly externalized. Distributed generation technology is said to offer a clean energy source with fast ramp capability, and it goes on penetrating more and more power systems. Distributed generation technology includes, for instances, arrays of solar photovoltaic panels, wind farms, hydroelectric, biomass and tidal power plants. Among distributed generation technology, wind farms are the most commonly viewed on power systems, even envisaged as competing with the traditional fossil-fuelled thermal power plants in the near future.

The European Commission concerned with the climate change, due to the emission of greenhouse gases, put forward a set of proposals to create a new Energy Policy for Europe, cutting its own CO_2 emissions by at least 20% by 2020 and 50% until 2050, increasing the share of renewable energy sources in the overall generation mix. Hence, it is expected that wind energy will turn out to be an important part of the Energy Policy for Europe. In Portugal, the total installed wind power capacity reached 2037 MW in September 2007, and continues growing.

The increasing share of wind in power generation will change considerably the dynamic behaviour of the power system [2], and may lead to a new strategy for power system frequency regulation in order to avoid degradation of frequency quality [3]. Hence, network operators have to ensure that consumer power quality is not compromised [4]. New technical challenges emerge due to increased wind power penetration, dynamic stability and power quality, implying research of more realistic physical models for wind energy systems. Power electronic converters have been developed for integrating wind power with the electrical grid. The use of power electronic converters allows for variable speed operation of the wind turbine and enhancement in power extraction. In variable speed operation, a control method designed to extract maximum power from the turbine and provide constant grid voltage and frequency is required [5].

This paper is concerned with modelling and simulation in Matlab/Simulink of a wind energy system with different topologies for the power converters, namely a matrix converter and a two-level converter. We use pulse modulation by space vector modulation associated with sliding mode for controlling the converters. We introduce power factor control at the output of the converters. Also, we present the harmonic behaviour for the current injected in the electric network, in steady-state simulation, using the Fast Fourier Transform, FFT [6]. Finally, we present the electric behaviour for the power and the current at the output of the converters.

2. Matrix Converter

The matrix converter is an AC/AC converter, with nine bidirectional commanded IGBT's. The configuration of the system that will be simulated is shown in Figure 1.

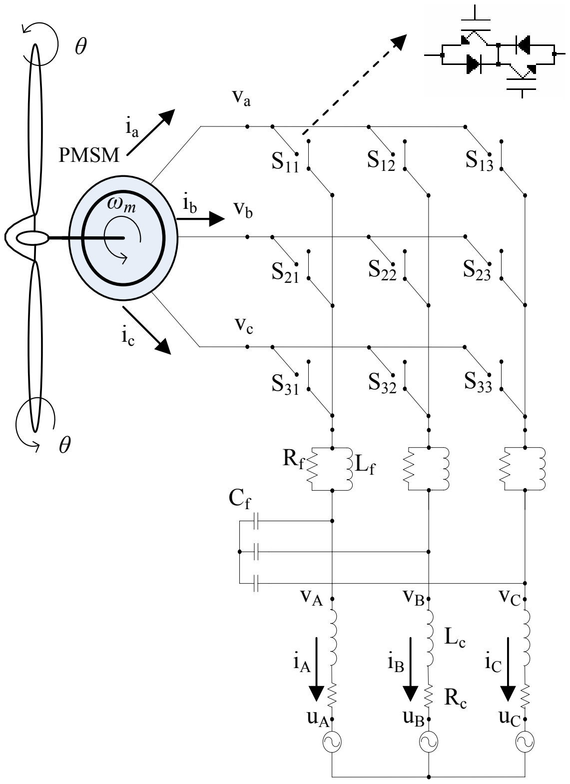

Fig. 1. Wind energy system with matrix converter

3. Two-Level Converter

The two-level converter is an AC/DC/AC converter, with six unidirectional commanded IGBT's, used as a rectifier, and with the same number of IGBT's, used as an inverter.

4. Control Method

The controllers used in the converters are PI controllers. Pulse modulation by space vector modulation associated with sliding mode is used for controlling the converters.

5. Simulation Results

The harmonic behaviour computed by the FFT, for the current injected in the electric network for the matrix converter, is shown in Figure 2.

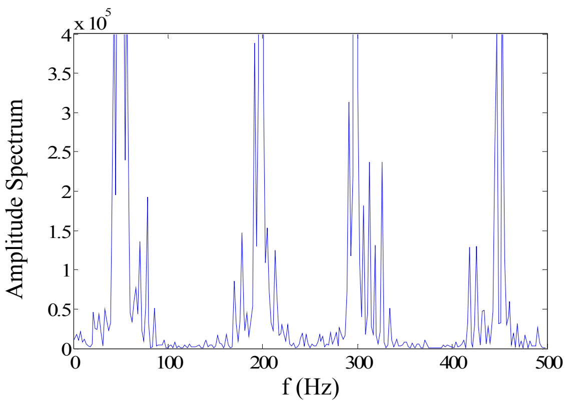

Fig. 2. The harmonic behaviour for the current for the matrix converter

The harmonic behaviour computed by the FFT, for the current injected in the electric network for the two-level converter, is shown in Figure 3.

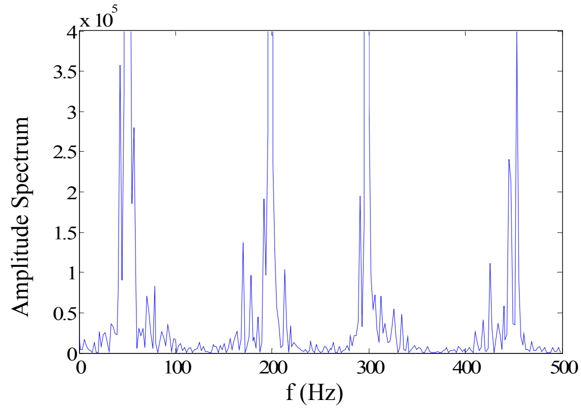

Fig. 3. The harmonic behaviour for the current for the two-level converter

6. Conclusion

A case study using Matlab/Simulink is presented for two power converter topologies integrating wind power with the electrical grid: two-level and matrix converters. Pulse modulation by space vector modulation associated with sliding mode is used for controlling the converters, and power factor control is used at the output of the converters. Also, we present the harmonic behaviour for the current injected in the electric network, in steady-state simulation, using FFT. The results show that the two-level converter has an enhanced behaviour comparatively to the matrix converter.

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