Simulation of Malfunctions in a Wind System Powered by a DFIG

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***Abstract* — The paper is about the simulation of malfunctions in an onshore wind energy conversion system powered by a doubly fed induction generator with a two-level power converter, handling only the slip power. These malfunctions are analysed in order to be able to investigate the impact in the wind power system behaviour by comparison before, during and after the malfunctions. The malfunctions considered in the simulation includes are localized in the DC-link of the converter and in the phase change in rectifier.**

Keywords: Wind system, malfunctions, DFIG, modelling, simulation.

I. INTRODUCTION

Environmental problems such as global warming and habitat preservation have to be faced by the society in nowadays in order to achieve a sustainable development. One of the causes for the global warming is said to be the increase on the level of CO_2 in the atmosphere due to fossil fuel burning [1]. So wind power exploitation is important. Onshore wind energy conversion systems (WECSs) are a promising option. So, further attention has to be paid to eventual consequences of possible malfunctions in order to avoid outages. As wind energy is increasingly integrated into power systems, the electric grid stability and power quality may be threatened [1]. The stability threaten is due not only to the intermittence and variability of wind energy, but also to malfunctions on the power electronic parts of the WECS, leading to a non anticipated shutdown. For instance, as the malfunctions simulated in a WEC powered by a DFIG.

This paper presents a study concerning the simulation of malfunctions in a WECS powered by a doubly fed induction generator (DFIG) operating under variable speed wind turbine is presented. This WECS is equipped with controllers namely: pitch controller, speed controller and voltage controller. The stator of the DFIG is directly connected to the electric grid and the rotor is connected to the electric grid through a two-level converter. The power converter has to handle only a fraction (20% – 30%) of the total power, i.e., has to handle only the slip power. For instance, if the rotor speed is in the range of ± 30% around the synchronous speed, the converter has a power rating about 30% of the rated turbine power, reducing the losses of energy in the power electronic converter in comparison with a system where the converter has to handle the total power [2,3]. Simulation studies are carried out in order to evaluate the performance of the WECS under malfunctions.

II. MODELING

In this section is developed a mathematical model that represents the dynamic of a WECS. The model should be thorough enough to be used as a simulation model. The development of the mathematical model is based on the standard model developed in [4,5]. The WECS is powered by a doubly fed induction generator (DFIG) system running with a variable speed wind turbine. The generator rotor is connected to the electric grid through a two-level power converter topology [6] which handling only the slip power. The converter is an AC-DC-AC converter, having six commanded insulated gate bipolar transistors (IGBT), used as a rectifier and with the same number of commanded IGBT's used as an inverter. The stator of the DFIG is directly connected to the electric grid. The configuration of the WECS with DFIG and two-level power converter linked to the electric grid is shown in Figure 1 [5,7].

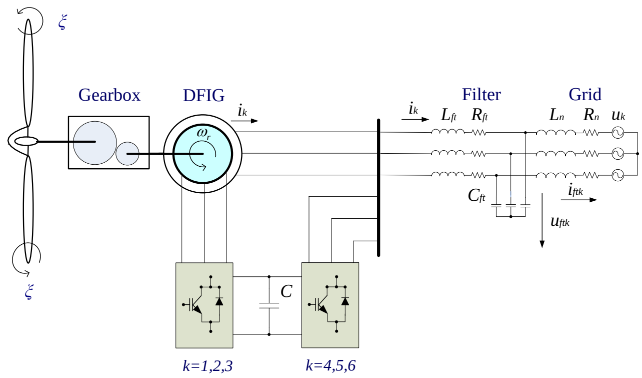

Fig. 1. Configuration of the WECS [5].

The drive train model is configured by a two-mass model has a first mass to concentrate the inertia of the turbine blades, hub and low-speed shaft inertia and a second mass to concentrate the generator inertia and high-speed shaft.

III. CONTROL STRATEGY

The controllers used for controlling the converters are PI controllers. Pulse width modulation by space vector modulation associated with sliding mode is used for controlling the converters. The sliding mode control ensures the choice of the most appropriate space vector. The power semiconductors present a finite switch frequency. Thus, for a value of the switching frequency, an error $e_{\alpha\beta}$ will exist between the reference value and the control value. In order to guarantee that the system slides along the sliding surface $S(e_{\alpha\beta},t)$, it is necessary that the state trajectory near the surfaces verifies the stability conditions [3,4], given by,

$$S(e_{\alpha\beta},t)\,\frac{dS(e_{\alpha\beta},t)}{dt}<0\,, \qquad (1)$$

IV. SIMULATION RESULTS

The model for the WECS powered by a doubly fed induction generator and the two-level converter topology is implemented in Matlab/Simulink. The current at the output of the converter for the malfunction in the DC-link of the converter is shown in Figure 2.

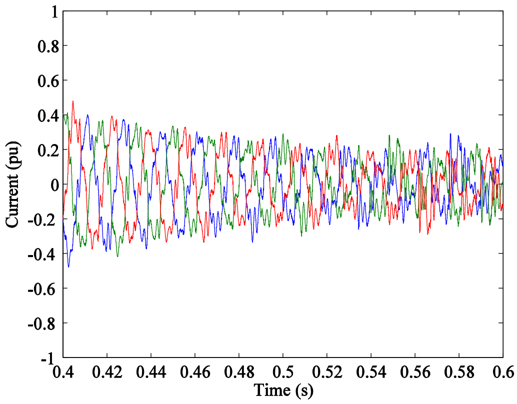

Fig. 2. Voltage at output of the converter.

Figure 2 reveal the impact of the malfunction in the DC-link is characterized besides the decrease in amplitude by the current having more harmonic components. The decrease in amplitude of the current is due to a reduction in the electronic power.

The current at the output of the converter is shown in Figure 3.

Figure 3 allows to conclude that current has a change in the amplitude almost of a kind of an amplitude modulation effect, but the worst is the arriving at a significant high values of amplitude. Consequently, in order to protect the electric integrity of the WECS, a protection circuit breaker has to operate, i.e., an inevitable shown-down is due to occur.

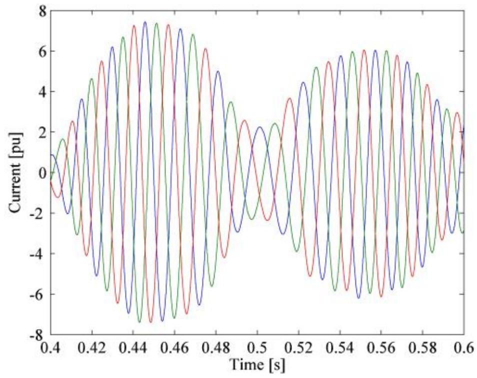

Fig. 3. Current at output of the converter (phase change).

V. CONCLUSION

A critical issue in two-level converters is the voltage of the DC-link capacitors. Simulation results have shown that during the malfunction in the DC-link of the converter the voltage and the current present a significant harmonic behavior.

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