Cosimulation of a wind turbine with doubly fed induction generator with PSCAD and SIMULINK.

Aitor MILO, Ana Isabel MARTINEZ - Ikerlan.

IKERLAN is a private, non-profit organisation with a vocation for public service. Set up in 1974, it lies in the heart of what is today the **Mondragón Corporación Cooperativa** (Basque Country – Spain).
The IKERLAN Technological Research Centre works with industry to improve competitiveness through the application of technological knowledge to develop innovative products and new tools and methodologies for implementation in design and production processes.
IKERLAN offers a comprehensive research and development service -ranging from the research and conceptualisation phase to the materialisation or implementation phase- that will enable client-companies to develop new products, improve their manufacturing processes and complement the activities of their R&D department; in short, increase their capacity for innovation with the aid of a partner experienced in helping companies move ahead.
IKERLAN is divided into different units which are, in turn, subdivided into various knowledge areas: one of these areas is the Control Engineering area.

Nowadays, the Engineering Control area works in two main research lines:

- Virtual prototyping for complex systems control.
- Distributed Generation (Micro-grids and Wind Farms)

This article describes one of the works developed in the frameworks of the latter research line, i.e., Distributed Generation.

Figure 1: Wind Farm.

1. Introduction

The decisive role played by the simulation in the power systems planning and operation phases is well known.
Likewise, the increasing trend towards the liberalization of electric power markets in the world has led to a quantum leap in the number of agents', the increase of the transactions not planned in a centralized way and, consequently, an intensive use of the existing networks. All this implies an evident increasing need for the use of this type of simulation tool to guarantee the reliability of the electrical system.
This article is part of a global project for the study of the impact of integrating wind farms in the grid.
The study has been developed on the PSCAD electromagnetic transient simulation software.
This work describes the development of a model of wind turbine equipped with a doubly fed induction generator (DFIG) using the **co-simulation** of the simulation software's PSCAD and MATLAB-SIMULINK.
The model incorporates an active crowbar protection to avoid immediate disconnection of the generator when a disturbance occurs in the grid.
The control also incorporates the blocking and re-start sequences of the rotor converter.
The aim of this work is to analyze the impact of grid voltage fluctuations over the wind turbine and to validate the PSCAD software for this type of study.
To achieve this aim, simplified models of the different components of a wind turbine have been made to adapt them to the needs of the study.

2. Co-Simulation PSCAD & MATLAB-SIMULINK

To achieve the aim of the project, we use one of the main advantages of PSCAD: co-simulation with MATLAB-SIMULINK. The simplified model used, shown in figure 1, is the one implemented for the individual wind turbine.
The simplified model includes the turbine shaft model, the DFIG, the simplified models of converters, the protection system, the wind farm+substation transformer model and the equivalent grid model. All these elements are implemented in PSCAD and the generator converters control is developed in MATLAB/SIMULINK.
This partition of the system allows us to validate the algorithms of generator converters controls developed in MATLAB/SIMULINK prior to implementing them in a real-world application.

3. Mechanical model

To achieve precise analysis of the dynamic behaviour of the wind turbine during grid disturbances, it is recommended to use the two masses model to represent the generator – turbine shaft system.
Figure 3 shows the used physical model of the generator - turbine mechanical system.
The PSCAD software library provides a dedicated model of this system: the "Torsional Shaft Model". This component can simulate the dynamics of up to 6 masses connected to a single rotating shaft.

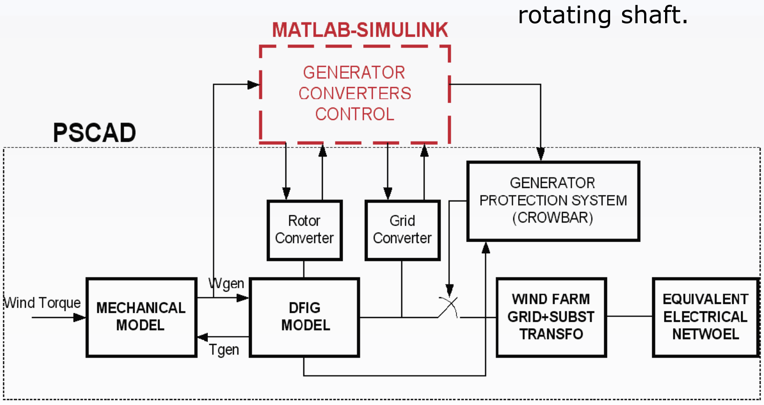

Figure 2: Simplified wind turbine model with interface to grid model.

(continued on page 3)

Cosimulation of a wind turbine with doubly fed induction generator with PSCAD and SIMULINK. (continued)

Aitor MILO, Ana Isabel MARTINEZ - Ikerlan.

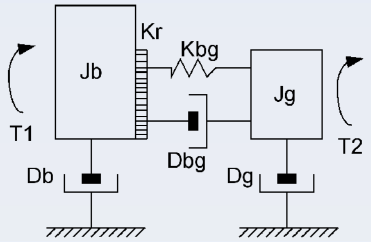

Figure 3: Two masses model.

Jb: Wind turbine rotor Inertia.
Jg: Generator rotor Inertia.
Kr: Gearbox.
Kbg: Shaft stiffness.
Dbg: Mutual Damping turbine-generator coefficient.
Db: Turbine rotor Damping coefficient.
Dg: Generator rotor Damping coefficient.

In our system we have used the "Torsional Shaft Model" component of PSCAD and we have developed, in blocks, the physical model of figure 3 (figure 4). The results obtained were identical in both cases.

4. Electric model

For the DFIG component, we use the "Wound rotor Induction Machine" component of the PSCAD library. The rest of the components, resistors and inductors, wind turbine transformer and wind park transformer, simplified model of the grid, power meters, current meters and volt meters for measuring the electrical magnitudes for controlling, and breakers for the performances of the protections, are also configured using PSCAD's library.

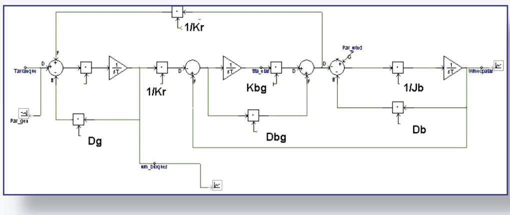

Figure 4: Two masses model.

PSCAD allows the development of personalized controls, in FORTRAN, which can interact with the rest of the components in the simulation. Taking advantage of this possibility, personalized controls have been developed to integrate the protections of the wind turbine. This protection system is developed in the block "Crowbar protection". This block integrates a function in FORTRAN that manages the activation sequences of generator protection.
The main goal of this protection is to avoid the immediate disconnection of the wind turbine when a disturbance appears in the grid.

5. Simulation results

Figure 5 shows the developed wind turbine model.
When the wind turbine is at rated operation, a voltage drop (figure 6) is applied at the access of the wind park.
When the fault occurs, the rotor control disconnects since this disconnection causes the rotor to accelerate. When the rotor current or the DC-link voltage exceed the limits, the protection is activated. The crowbar protection and the generator control are able to reduce the rotor current and to maintain the DC-link inside the security limits. Once the fault is cleared, the rotor control restores the wind turbine's normal operation. The corresponding simulation results are shown in figure 7.

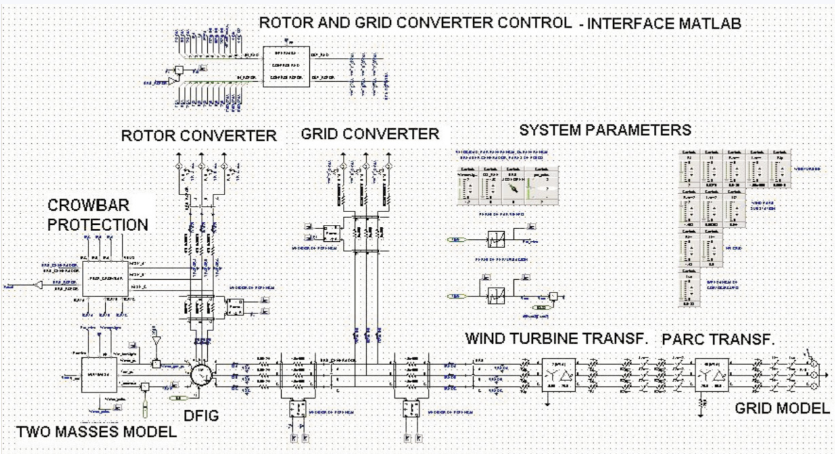

Figure 5: Wind turbine model.

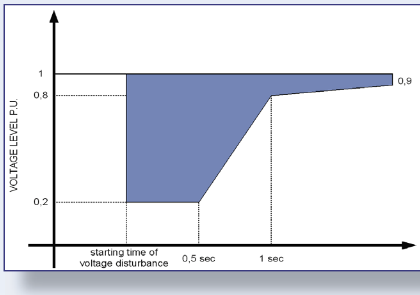

Figure 6: Voltage drop.

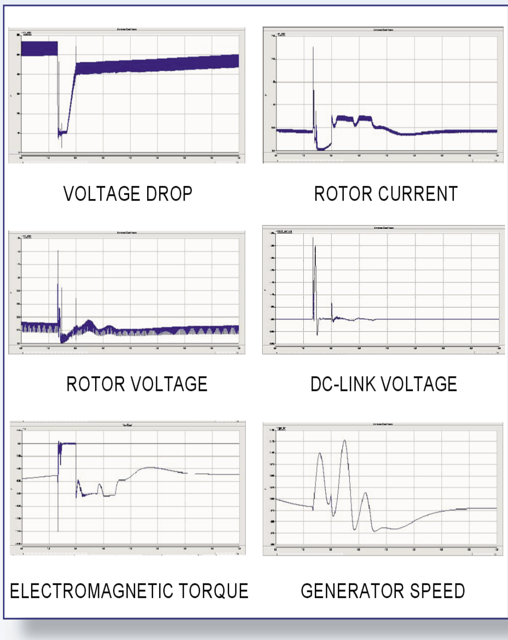

Figure 7: Simulations results.

6. Conclusion

The results obtained with the model developed in PSCAD-MATLAB shows the validity of this tool for the study of transient phenomena in wind turbines.
Despite the disadvantage that the slowing down of the simulation entails by using cosimulation, it is interesting to observe the behaviour of the control algorithms that will later be incorporated into the wind turbine control hardware.
This step will allow not only the simulation acceleration but also the multiplicity of wind generator models. This multiplicity will contribute to study the impact of the integration of wind farms in the electrical grid and vice versa.