Voltage sag generators for analysing wind generators response

S. Martínez, C. Veganzones, F. Blázquez, N. Herrero, D. Ramírez, C. Platero, J. Rodríguez, J.A. Sánchez

Universidad Politécnica de Madrid
c/ José Gutiérrez Abascal, 2 – 28006 Madrid (Spain)
Tel.: 34 913363025, fax: 34 913363008, e-mail: **smartinez@inel.etsii.upm.es**

1. Brief introduction

This paper presents the justification of the need of voltage sag generating equipment for the test and possible certification of the wind generators response to such disturbances. It also includes an overview of the equipment currently used with similar objectives.

Key words: Voltage sag, wind generators testing.

2. Need of voltage sag generation equipment

The commitment acquired with the fulfilment of the Kyoto Protocol by most of the countries within the European Union and its area of influence makes foresee the massive insertion of renewable energy generation systems in its electric power network. In fact, nowadays in Spain, the power installed in wind farms is near 8 000 MW, from a total electric generation of about 50 000 MW [1].

In a near future, these penetration indices will demand the wind energy to take part, to some extent, in the control and stability assessment of the electric power system, as conventional power plants do, in such a way to contribute to the security and quality of the service [2].

To this respect, one of the main worries arising in the exploitation of electrical systems with high penetration of wind generation is to maintain the safety and reliability of the system in view of the appearance of the contingencies that inevitably take place in the network [3].

Particularly, a special worry exists with regard to the behaviour of wind farms faced with the appearance of voltage dips in the electrical network to which they are connected. There are doubts about the capacity of this type of generation to remain connected, both during the fault and during the subsequent recovery of the network, after the above-mentioned fault being correctly cleared. New grid code regulations in many countries consider as an objective that wind farms must contribute actively to grid stability: E.On, Vattenfall, Scottish & Southern, ESBNG (Irish Gridcode), etc.

In order to study the problem raised previously, it is necessary to analyze the behaviour of the different technologies currently used in the electrical generation of wind farms when facing to network voltage sags. A first step to reach this objective is the utilization of computer models, what allows, among other things, the study of different designs and control alternatives to face up to the problem.

The following step must be the direct verification over every wind generator at issue, by means of the corresponding laboratory tests. These must include the experimental response of the wind generator to a voltage sag applied to its terminals, under different operation conditions. To this goal, it is necessary to have a voltage sag generator, that is, a device or equipment capable of generating the suitable voltage-time profiles for applying at the terminals of the wind generation system being under test.

3. Voltage sag generators currently in use

Once the need of having available voltage sag generators appropriate for wind generators testing has been established, this paper presents an overview of the different equipment currently used to this aim. Its main operating characteristics and its suitability to the described purpose are analyzed. A comparative study is performed, with the objective of detecting possible limitations or shortages, with the view to make use of the voltage sag generator for the determination of the experimental response of the wind generator under test to this kind of disturbances.

Concisely, the different existing solutions for the generation of voltage sags can be arranged in three major groups.

A. Sag generators for power quality

Voltage sag generators are currently used in laboratories specialized in electric power quality. They are intended to the certification of the susceptibility of electrical equipment, such as semiconductor, appliances or industrial drives, to voltage sags in the supplying system, according to different international standards (SEMI F47, ITIC, CBEMA or IEC6100-4-11).

Among these, and from the point of view of a possible application to wind generators testing, it is worth noting the voltage sag generator from the Electric Power Research Institute (EPRI) [4]. Two aspects are remarkable: its high power rating and the simplicity of its layout, which is depicted in figure 1. This scheme could be adapted to the higher power ratings needed for wind systems, with a prior research about scale related problems [5].

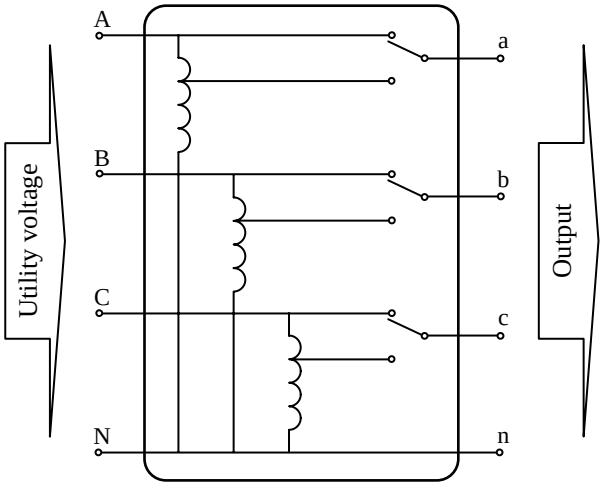

Fig. 1. EPRI's voltage sag generator

The main operational characteristic of this kind of high power sag generators is their ability to generate voltage-time profiles with abrupt drops and recoveries. This can be an obstacle in the development of a system complying with the desired profile characteristics, as described in Section 2.

B. Sag generators in the wind industry

Some industrial laboratories, specialized in wind energy, have used specific assemblies for the study of the response of full-scale wind generators to voltage sags [6]. They are based in a parallel configuration, where an impedance of low ohmic value is connected in parallel with the electrical system of the wind generator under test. Figure 2 shows the basic scheme.

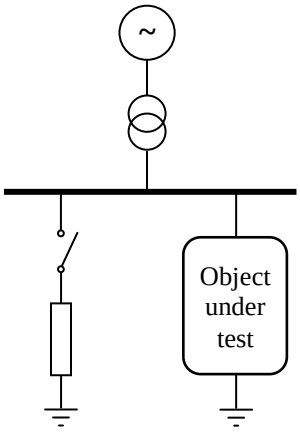

Fig. 2. Sag generator with parallel impedance configuration

The simplicity of the design allows for a higher power rating, up to the MVA scale. However, these sag generators are also characterized by a step-wise voltage-time profile. To avoid this drawback, some research is being carried out in order to use parallel impedances that allow a programmable variation of its ohmic value in real time, i.e., while the test is running.

C. Sag generators in research

Several University and Research centres are now working in the analysis of the response to voltage dips for different wind generator system technologies. In some of these centres, programmable sources or *ad hoc* electronic devices have been used to create voltage sags with the required profile. In spite of its versatility, rated power of these systems is still very small (few kVA) for its application in a full-scale wind generator test.

4. Conclusions

It has been established the need of having voltage sag generators appropriate for wind generator testing, as a tool to improve the operation security of electric systems with high wind energy penetration. In addition, an analysis has been performed over the currently existing sag generators, with the objective of establishing the basics for the design of new sag generation equipment with the specific features for this kind of tests.

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