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Power Control Strategies During Voltage Sags According to Spanish Grid Code

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Abstract. In order to connect any power converters into the grid there are some grid requirements to insure the safe operation of the grid. So, the control of the converters especially during abnormal condition-e.g. during voltage sags- is a very important key to guarantee the good behavior of the distributed generation system. In this paper four control strategies,will be stated in the literature, are discussed in order to ensure their ability to match the grid requirements when unsymmetrical voltage sags are produced in the network. The Spanish grid code did not give any information about the negative sequence, and it only represents the positive sequence components. Therefore, the main contribution of this paper is to verify the grid code with not only the positive sequence but also with the negative sequence. Moreover, the system is tested by simulation to show that the results cope well with the analytical equations.

Keywords
Positive and negative sequence controller, voltage sag, voltage ride through, grid code.

1. Introduction

Distributed generation systems are becoming a very important part of any grid system. So, the control of the power converters became essential in order to support the grid even under severe transient conditions. Therefore, grid codes become more restrictive recently. Power converters are designed and controlled not only to inject power into the grid during normal conditions, but also to support the grid during transient operation like voltage sags. The converters must remain connected to the grid during the fault and also reduce the active power injection and increase the reactive power injection according to the grid codes.

Most of faults in the grid are unbalanced faults. So, several research is done for controlling the reference current during unbalanced condition in order to inject reactive current to increase positive sequence and to decrease negative sequence voltage components. Different techniques [1-3] discuss the injection of positive and negative sequence currents.

In this paper, four different current control strategies are analyzed in order to study their ability to match the grid code, not only during symmetrical voltage sags but also during unsymmetrical voltage sags.

The organization of the paper is as follows. Section II gives an explanation about the grid code requirements; Section IIIdescribes the different strategies to calculate the reference current. Section IV explains the control techniques under grid code requirements. Finally, Section V shows the simulation results and a comparison between all the presented control techniques, just before the conclusions.

2. Spanish Grid Code Requirements

Spanish governments have promoted a sort of legal frameworks regarding grid connection and technical requirements. In 2004, the Spanish government published the RD 436/2004, which was mainly focused on renewable energy sources [4]. In 2006, The Spanish TSO (REE), had approved and issued the requirements for response to voltage dips of production facilities under the special regime (P.O.12.3) [5]. In 2010, the RD 1565/2010 was proposed and issued, [6], this issue was more toward not only wind farms, but also PV power plants. During the fault, renewable energy system must provide the required active and reactive current, in order to support the grid during the voltage sag.In a transient mode, the inverter must be controlled according to the injected active current (I_a) and reactive current (I_r) during the fault, according to the network code P.O. 12.2, as shown in Figure 1.

Table III behavior of each control technique

Control Technique	GCV	GPV	SICW	SYCW	p(t)	q(t)
1st	×	×	✓	×	×	✓
2nd	×	×	✓	×	✓	×
3rd	✓	×	✓	✓	×	×
4th	×	✓	×	×	✓	✓

GCV - Grid code current verification, GPV - Grid code power verification, SICW - Sinusoidal current waves, SYCW - Symmetrical current waves, p(t) instantaneous active power, and q(t) instantaneous reactive power.

6. Conclusion

In order to control the active and reactive power during abnormal behavior of the grid, it is mandatory to control the positive and negative reference currents. In this paper, different control techniques during voltage sags are studied. Moreover, in order to verify the Spanish grid code using these strategies two cases are considered: first, only positive sequence current is imposed, and second, positive and negative sequence current are imposed.

The results show that, in order to inject the most unfavorable situation of the grid, 3rd technique is the only technique that can gives the exact required limits of active and reactive currents. However, it has the disadvantage of power oscillation. On the other hand, 4th technique can verify the grid code if we assume that the grid code curves related to active and reactive power instead of currents. Moreover, other controls can be used with proper limits in order not to breaching the grid codes.

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