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Review of anti-islanding techniques in distributed generators

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ABSTRACT

In this paper a revision about different techniques for islanding detection in distributed generators is presented. On one hand, remote techniques, not integrated in the distributed generators, are discussed. On the other hand, local techniques, integrated in the distributed generator, are described. Furthermore, it is discussed how the local techniques are divided into passive techniques, based on exclusively monitoring some electrical parameters, and active techniques, which intentionally introduce disturbances at the output of the inverter, in order to determine if some parameters are affected.

Contents

1. Introduction

In recent years, a major global priority is the development of renewable energy. These energy sources produce low pollution compared with fossil fuels. From this point of view the distributed

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generation concept takes importance and it represents a paradigm shift in the centralized power generation [1,2].

Distributed generation can be defined as small-scale generation installed near to load with the ability to interact with the grid (buying or selling energy) [3]. One feature that should be taken into account (when the distributed generator-DG is injecting power to the grid) is the islanding condition.

The condition of "islanding" in distributed generators (DGs) is an electrical phenomenon that occurs when the energy injected to the power grid is interrupted due to various factors and the DGs continue energizing some or the entire load. Thus, the power grid stops controlling this isolated part of the distribution system, which contains both loads and generation. This situation may compromise security, restoration of service and the reliability of the equipment [4,6].

In the case of several Distributed Generation Systems connected to a low-voltage power grid, it is possible that the amount of energy generated by the distributed system agrees with the amount of energy consumed by the loads on the grid. Under this situation, there is no energy flow towards the power grid, so that the DGs may continue feeding the loads leading to an "islanding" condition. In addition, when the islanding condition happens, there is a primary security condition which forces the generator system to disconnect from the de-energized grid without taking into account the connected loads.

The "islanding" effect in inverters may result from a failure detected by the grid and the consequent switch opening, accidental disconnection of the grid because of equipment failure, sudden changes in the distribution systems and loads, intentional disconnection for maintenance services either on the network or in the service, human errors, vandalism or acts of nature.

There are many reasons why islanding should be anticipated in the grid connected distributed generation systems. The main reasons are safety, liability and maintenance of the quality of the supplied energy.

The main idea to detect the islanding condition is to monitor the output parameters of the inverters making up the DGs and/or other system parameters in order to determine if there have been changes that indicate islanding. Islanding detection techniques can be divided into remote and local ones. The latter techniques can be divided into passive and active ones, as shown in Fig. 1 [7].

Before defining the different methods for islanding detection, it is important to highlight two key features in order to better understand the islanding phenomenon. The first one is associated with the so-called "Non-detection zone" (NDZ), which can be defined as the range in terms of the difference between the power supplied by the DG inverter and that consumed by the load, in which an islanding detection scheme under test fails to detect this condition [8]. The second feature is associated with the type of loads (potential loads inside an isle), which can be modelled as a parallel RLC circuit. The reason for using an RLC load is the high difficulty to detect islanding with this kind of loads. Non-linear loads, such as loads that produce current harmonics, or constant power loads do not present a great difficulty for islanding detection [2].

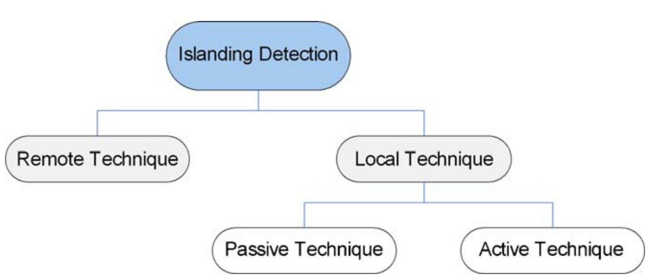

Fig. 1. Islanding detection techniques.

In particular, RLC loads with a high Q factor pose problems for island detection. The Quality Factor is defined by (1):

$$Q = R \cdot \sqrt{\frac{C}{L}} \tag{1}$$

This parameter describes the relationship between the stored and the dissipated energy in an RLC circuit.

For these reasons, the islanding detection is an important feature that should be considered when implementing distributed generation systems. In Sections 2 and 3 of this work the most representative techniques (local and remote) to islanding detection are addressed, indicating their operation scheme, advantages and disadvantages. Finally, some conclusions are presented about the most important aspects covered in this paper.

2. Local islanding detection techniques

These techniques are based on the measurement of some parameters (voltage, current, frequency, among others) on the distributed generator (inverter) side. They are classified as passive, based exclusively on the monitoring of these parameters, and active techniques, which intentionally introduce disturbances at the output of the inverter and observe whether the parameters outlined above are affected.

2.1. Passive techniques of islanding detection

These techniques are based on monitoring of grid voltage parameters such as voltage, current, frequency and/or their characteristics. The inverter energy conversion is interrupted when some parameter falls beyond certain previously established limits.

2.1.1. Over/under-voltage and over/under-frequency [5–7]

Techniques of over/under-voltage protection, OVP/UVP and over/under-frequency protection, OFP/UFP, allow the detection of islanding phenomenon through the measure of voltage and/or frequency at the Point of Common Coupling (PCC), and subsequent comparison with the limits set for proper operation [9]. If the measured values are outside the established range, the inverter is stopped or disconnected. Fig. 2 shows the power balance of the system.

Eqs. (2) and (3) describe the power balance of the system.

$$P_{\mathrm{LOAD}} = P_{\mathrm{DG}} + \Delta P \tag{2}$$

$$Q_{\mathrm{LOAD}} = Q_{\mathrm{DG}} + \Delta Q \tag{3}$$

The behaviour of the system when the grid is disconnected depends on the previous values of ΔP and ΔQ. It is worth to point out that the active power is directly proportional to the voltage. Therefore, if $\Delta P \neq 0$, the amplitude of the voltage will change.

$$V' = \sqrt{\frac{P_{\mathrm{DG}}}{P_{\mathrm{LOAD}}}} \cdot V \tag{4}$$

In the case of $P_{\mathrm{DG}} > P_{\mathrm{LOAD}}$, the voltage increases, otherwise it decreases, which might indicate whether the islanding conditions appears.

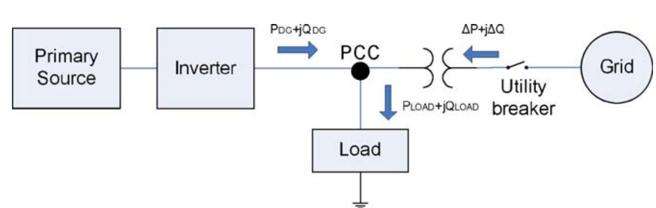

Fig. 2. Power balance of the system.