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Fast harmonic simulation method for the analysis of network losses with converter-connected distributed generation

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ABSTRACT

The use of distributed generation (DG) in low voltage grids is becoming more common. The impact of the DG units is considered, with an emphasis on the effect of DG on the network losses. These losses consist of fundamental and harmonic losses. The converter-connected DG units have a different influence on these two terms of the total losses. The aim of this paper is to present a fast harmonic simulation model that can be applied to study the influence of a DG unit on the total losses and elucidate the importance of the harmonic losses in proportion to the total losses.

1. Introduction

Electrical power systems are nowadays evolving from centralised systems, where generator plants are connected to the transmission networks, to a decentralised system, with smaller generation units connected directly to the distribution networks and thus near consumption. The main incentives for this evolution are the environmental concerns (use of renewable energy, use of combined heat and power) and the security of supply (diversity of energy sources, markets with large number of actors). The injections of power by the distributed generators may change the magnitude and even the direction of the power flow in the distribution network. This has several implications for the operation and planning of the network and has several technical and economic consequences [1–23]. In this framework, it is clear that DG units affect the network losses, which are defined as the difference between the energy sent out from the generating stations and the energy metered at the customer premises. Losses occur in all systems of electricity transmission and distribution. These are usually divided into two categories: technical (related to the characteristics of the carrier equipment, supply and demand patterns) and commercial (energy not accounted for, for example, theft and meter errors) [19,24,25].

There are different types of DG units from a constructional and technological point of view [13], which have a different influence on the distribution network. The impacts of DG on the network are given in the next section, with emphasis on the influence of DG on the network losses [14,18,19]. The calculation of these network losses is applied in several optimisation programs to quantify an optimal size and location of the DG unit [3,8,16,17,20]. In these programs the power quality can be taken into account. Harmonic losses are rarely considered, although it is known that several DG topologies may have a negative influence on the total harmonic distortion and thus on the harmonic losses [9].

This paper will present a fast harmonic simulation method. The network considered in the simulations will be modelled as precisely as possible. The presented model can be used to investigate the influence of converter-connected DG units on the harmonic losses in distribution networks, as will be shown in this paper.

The presented simulation model can, for instance, be applied by the Distribution Network Operators (DNOs) to assess the influence of the DG units connected to their networks.

2. Impact of DG on the distribution networks – an overview

The impact of the DG unit on the distribution network is observed in several commercial and power quality aspects of the grid. In the following paragraph an overview is given of the most important impacts.

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