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An improved control scheme based in droop characteristic for microgrid converters

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ABSTRACT

In the present work, an improved version of the conventional-droop control for microgrid converter is presented. The modifications added to the control are based on a feed-forward current control that allows the converter to work in several modes, both when it is grid connected or in island. The use of this control represents the main contribution of this paper, permitting the inverter to work as a grid supporting source or ancillary services provider when it works grid connected. In this mode the converter varies the injected active and reactive power with the variation of voltage module and frequency using the same main control loop as when it is working in island mode.

1. Introduction

Distributed generation (DG) technologies have achieved a drastic increase during the last years derived from recent technological developments [1]. The influence of this type of generation on the distribution network stability can be positive or negative depending on the distribution system and the DG system operating characteristics [3]. The massive installation of DG systems can produce an important reduction of the electrical losses both in transmission and distribution networks, as well as CO_2 emissions. Another consequence would be a significant reduction in the investment on electrical facilities. Additionally, production of energy from waste heat through co-generation or combined cooling heat and power (CCHP) can give rise to an integrated high efficiency energy system. However, an increased use of DG systems in electrical networks without correct addressing coordination issues can result in a harmful influence in the electrical network, including problems in voltage regulation, voltage flicker generation due to sudden changes in generation levels of DG, increase of harmonics, and variations in short circuits levels, affecting the reliability and safety of the distribution system [4]. Fortunately, those problems can be avoided with an organized introduction of these resources in the electrical networks [5]. Additionally, the DG system can be used as ancillary services provider for voltage control, load regulation and spinning reserve [6].

The most suitable way to insert DG systems into the electrical network is through the use of microgrids. A microgrid, can be defined as a cluster of loads and microsources operating as a single controllable system providing both power and heat to its local area [7]. There exist different microgrid management philosophies that can be roughly categorized into three different groups [9]. The first group consists on a set of microgrids with a *physical prime mover* management in which a large unit absorbs all transient active and reactive power imbalances to maintain the voltage magnitude and frequency. The concept is very similar to the one used in conventional centralized generation systems. The cost of the central unit and the loss of stability when a fault occurs in that unit are the main problems of this approach. In the second group, the control system is based on a *virtual prime mover*. In this case a central control unit measures the microgrid state variables, and dispatches orders to microsources using a fast telecommunication system. This control scheme avoids the high cost of the central *physical prime mover* but the communication system bandwidth limits the expansion of the microgrid and additionally, a back-up system is needed in case of communication failure. The third approach is based on a *distributed control*. In this case, each unit responds automatically to variations in the local state variables. A number of researchers consider this type of control the most appropriate because neither a communication system nor a large central unit is needed [7,10,11]. Nowadays, there are some important projects on microgrids launched around the world [8,9] using the different microgrid management philosophies abovementioned.

Control of local state variables is commonly implemented in microgrid converters using a so called *droop characteristic* control. This type of control was first introduced for parallel connected inverters in a *standalone system* [12]. Recently, droop control has

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