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A New Decentralized PQ Control for Parallel Inverters in Grid-Tied Microgrids Propelled by SMC-Based Buck–Boost Converters

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Abstract: Nowadays, the microgrid (MG) concept is regarded as an efficient approach to incorporating renewable generation resources into distribution networks. However, managing power flows to distribute load power among distribution generators (DGs) remains a critical focus, particularly during peak demand. The purpose of this paper is to control the adopted grid-tied MG performance and manage the power flow from/to the parallel DGs and the main grid using discrete-time active/reactive power (PQ) control based on digital proportional resonant (PR) controllers. The PR controller is used to eliminate harmonics by acting as a digital infinite-impulse response (IIR) filter with a high gain at the resonant frequency. Additionally, the applied PR controller has fast reference signal tracking, responsiveness to grid frequency drift, and no steady-state error. Moreover, this paper describes the application of robust nonlinear sliding mode control (SMC)-technique-based buck–boost (BB) converters. The sliding adaptive control scheme is applied to prevent the output voltage error that occurs during DG failure, load variations, or system parameter changes. This paper deals with two distinct case studies. The first one focuses on applying the proposed control for two parallel DGs with and without load-changing conditions. In the latter case, the MG is expanded to include five DGs (with and without DG failure). The proposed control technique has been compared with the droop control and model predictive control (MPC) techniques. As demonstrated by the simulation results in MATLAB software, the proposed method outperformed the others in terms of both performance analysis and the ability to properly share power between parallel DGs and the utility grid.

Keywords: microgrids; PQ control; digital PR control; sliding mode control; parallel inverters; model predictive control; distributed renewable resources

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1. Introduction

The widespread use of fossil fuel, which may be exhausted by the end of the century, has been linked to a host of problems, including low air quality indices, environmental pollution, and a slew of others. In order to combat this, renewable, environmentally friendly clean energy is used and converted into electrical energy, which not only increases the diversity of energy usage but also reduces the consumption of fossil fuels for power-generating reasons. This energy comes from a variety of long-term sources such as solar, wind, and other distribution energy resources (DERs), all of which are being increasingly adopted to build microgrid (MG) resources. Power electronics converters are used to connect most DERs to the grid because of their controllability, flexibility, and monitoring capabilities [1–3].

In a variety of grid-related and industrial applications, DC/DC converters are used a lot to efficiently convert an unregulated voltage from the DERs to a regular one at the desired level to supply the inverters and operate DC loads in MGs. DC/DC power converters (buck, boost, and buck–boost) are the three primary types of DC/DC converters. They