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Dynamic performance enhancement of microgrids by advanced sliding mode controller

Mohammadhassan Abdollahi Sofla [a,*], Gevorg B. Gharehpetian [b]

[a] *Electrical Engineering and Computer Science Dept., University of Toledo, Ohio, US*
[b] *Electrical Engineering Dept., Amirkabir University of Technology, Tehran, Iran*

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ABSTRACT

Dynamics are the most important problems in the microgrid operation. In the islanded microgrid, the mismatch of parallel operations of inverters during dynamics can result in the instability. This paper considers severe dynamics which can occur in the microgrid. Microgrid can have different configurations with different load and generation dynamics which are facing voltage disturbances. As a result, microgrid has many uncertainties and is placed in the distribution network where is full of voltage disturbances. Moreover, characteristics of the distribution network and distributed energy resources in the islanded mode make microgrid vulnerable and easily lead to instability. The main aim of this paper is to discuss the suitable mathematical modeling based on microgrid characteristics and to design properly inner controllers to enhance the dynamics of microgrid with uncertain and changing parameters. This paper provides a method for inner controllers of inverter-based distributed energy resources to have a suitable response for different dynamics. Parallel inverters in distribution networks were considered to be controlled by nonlinear robust voltage and current controllers. Theoretical prove beyond simulation results, reveal evidently the effectiveness of the proposed controller.

1. Introduction

In the last decade, technological innovations, a changing economic and regulatory environment has resulted in a renewed interest for distributed energy resource (DER) [1]. Integrating advanced technologies, control methods and integrated communications into the current electricity grid results in Smart Grids [2] which can be called an energy infrastructure of the future *intelligent cities*. Smartness in the integrated energy systems which called are *microgrids* (MG) refers to the ability to control and manage energy consumption and production. MG is a cluster of loads and distributed energy resources (DERs) operating as a single controllable system that provides both power and heat to its local area by using advanced equipments and control methods. Inverter-based MG control structure has two parts (1) inner controllers of inverters and (2) power sharing control [3]. High frequency dominant modes can be controlled by inner controllers [4]; therefore, the objective of this paper is to improve response of the inverters to different voltage disturbances. MG has some special characteristics which should be considered in defining controllers. Conventional controllers based on proportional integrator (PI) regulators have been improved by different methods such as voltage flux vector control [10] and positive- and negative-sequences control [11,12]; although, by these methods the inner controllers have shown better response for disturbances in an unbalanced system but the voltage regulation performance might not be fast enough for voltage-sensitive loads and to mitigate fast voltage disturbances in the subcycle range, such as capacitor switching transients [13] or loads with fast dynamics. PI regulators with their pole (infinite gain) at zero-frequency are not best to regulate the fundamental frequency and reject higher harmonic disturbances [8]. Moreover, the linear controllers are model dependent, which for the MG are not the appropriate choice. *Voltage flux vector control combined with fuzzy* has shown better total harmonic distortion (THD); this method also shows better robustness in comparison with only conventional controllers [14]. But, fuzzy controller has not shown a fast dynamic response which is necessary for the MG application [13]. Stability of extended H^{∞} model shows sufficient performance for specific periodic uncertainties [15,16]. Moreover, H^{∞} controller by designing well can act like P^{+} resonance controller [7] to control resonance which is a potential problem especially for the islanded MG. But, H^{∞} controller can work well with known disturbances and it may not guarantee voltage tracking capability under parametric uncertainty [5]. However, voltage disturbances are not periodic by nature, and there are some unknown disturbances in the MG [13]. Deadbeat controller has very fast response for disturbances but high total harmonic distortion (THD) of this controller is an important drawback [17]; also, deadbeat system is sensitive to parametric variation of the plant [18].

* Corresponding author.
E-mail address: Mohammadhassan.AbdollahiSofla@utoledo.edu (M.A. Sofla).

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