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Simple Electrical Circuit for Large Signal Modeling of DC Microgrids

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Abstract. In previous researches, the large signal models of DC microgrids have been developed without using any time averaging technique. Thus, the results obtained from available DC microgrid large signal models have not been verified by results from their detailed models. This paper presents a suitable large signal model for DC microgrids which has the same response as control area and detailed models.

Keywords

DC Microgrid, Distributed Generation, Energy Storage, Droop Control, Hysteresis Current Control.

1. Introduction

The interest in Distributed Resources (DR), including both Distributed Generation (DG) and energy storage resources, is increasing due to their technical, economical, reliability and environmental merits. Local aggregation of DR systems and electrical loads results in a Microgrid (μG) [1]-[4]. The DC Microgrid (DCμG) concept provides the best solution for the μG infrastructure because it is formed simply by integrating the available DC link stages in power electronic systems which interface with modern DR systems and loads [5]-[12]. As shown in Fig. 1, the DCμG has a lossless DC bus infrastructure as the common capacitive link of its Voltage Source Converter (VSC) systems. Generally, detailed and large signal modeling approaches are used to study power electronic systems [13]. Large signal modeling of DCμGs has been studied in several researches [5], [9], [10]. However, the large signal models of previous researches have not been verified by detailed models. The main goal of this paper is to develop a simple DCμG large signal model which can represent the same behavior of detailed model.

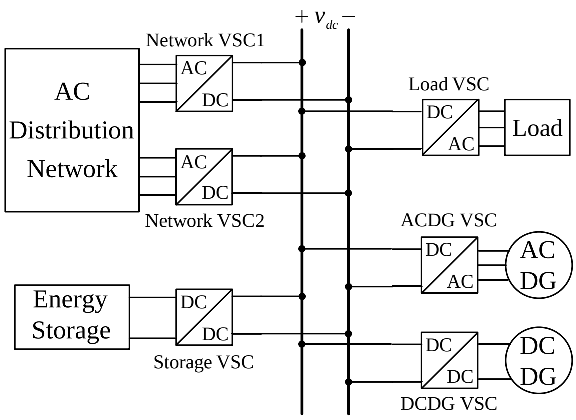

Fig. 1. General structure of DCμG

2. Proposed Large Signal Model of the DCμG

As a typical DCμG operation and control strategy, it is assumed that the network VSCs and the storage VSC have DCμG Voltage Regulator (DCVR) systems to control the DC bus voltage and the ACDG and DCDG VSCs have Power Regulator (PR) systems to apply their optimal or maximum power requirements. Each DCVR incorporates a current-voltage droop characteristic with a low-pass filter for DC voltage measurement [5]-[14]. Each PR incorporates instantaneous power-based reference current calculation for a hysteresis current controller [5]-[8], [15].

A novel electrical circuit is developed which represents the DCVR large signal model as a current source in parallel with a resistive-inductive branch. The large signal model of the PR can be presented as a constant power source, because it operates in active mode control condition obtained from sliding mode analysis. The large signal model of the load VSC can be presented as a constant power load, because it controls the load supply voltage independent of the DC μG voltage changes. Consequently, the large signal model of the DCμG shown in Fig. 1 is developed as illustrated in Fig. 2.

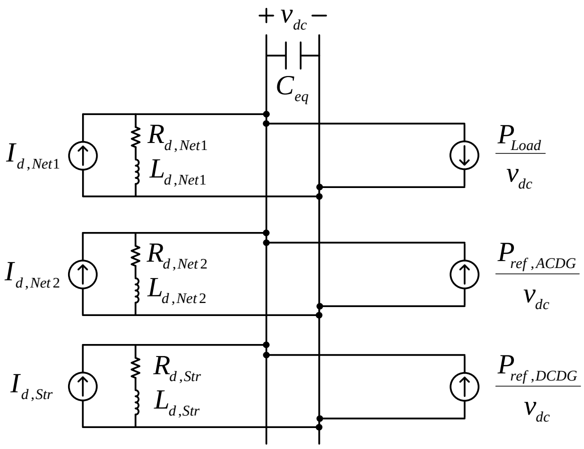

Fig. 2. Proposed large signal model of DCμG

3. Modeling Verification

Based on the concepts of the conventional Load Frequency Control (LFC) of AC power systems, an effective DCμG model named control area model has been developed in [8] which can provide the same results as compared to its detailed model. Unlike the LFC model, the DCμG control area model includes a wide range of changes [8]. It is shown that control area equation of the DCμG shown in Fig. 1 is the same as the electrical circuit equation of the large signal model in Fig. 10. Thus, the proposed DCμG large signal model can be verified by its control area model, and consequently, its detailed model.

4. Conclusion

This paper has presented a novel and simple large signal model for the DCμG system including several DRs and loads. The proposed model has been verified by the DCμG control area and detailed models. As a result, the proposed DCμG model provides an efficient modeling approach for studying the DCμG stability and control issues as well as DCμG subsystems interacting with each other within the DCμG or within a DC power park including multiple DCμGs.

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