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Study on Three-phase Stability Simulation Model of Distributed Generation System for Multi Energy Utilization

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Abstract

There are many different kinds of energy in future multi-energy system, such as electric, gas, heat and hydrogen. Distributed generation system integrated as microgrid is one of the most important use form of multi-energy system for customer-side. Considering typical grid-connected distributed generation system and three phase unbalanced feature of low-voltage micro-grid, three-phase stability simulation technique is a very important analysis tool for system-level energy optimization management, design of control strategy, structure stability and so on. A unified interface model of grid-connected system for synchronous generator and inverter is discussed in this paper. The unified model is given in three conventional *dq* coordinates and described by Norton model which is the parallel connection of injection current source and constant admittance matrix. Based on the characteristics of the unified interface model and detailed dynamics of distributed sources, an alternative implicit trapezoidal integration algorithm is developed for the stability simulation of distributed generation system. The significance of the proposed modeling method is validated by test example simulation results.

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Keywords: stability simulation, distributed generation system, interface model, alternative implicit Trapezoidal integration algorithm

1. Introduction

In future multi energy system, there are many different kinds of energy, like electric, gas, heat and hydrogen. Distributed generation system integrated as microgrid is one of the most important use form of multi-energy system for customer-side.

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Microgrid contains many distributed generation elements with different dynamic property and operation laws. It brings challenges to emulation technique of control, protect, planning and energy dispatch. Based on characteristics of transmission network, traditional electromechanical transient simulation algorithm usually adopts 120 coordinate to improve simulation efficiency. But the unbalanced characteristic of distributed generation system is notable, so its stability simulation algorithm needs to adopt phase coordinate model. In many papers, detailed distributed source model usually substituted by simplified model. In reference [1], stability algorithm of three phase modeling in low voltage microgrid is discussed, and this paper adopts node contraction in reference [2]. But it doesn't adopt detailed model of photovoltaic generation system and battery energy storage system, and it only models asynchronous machine in low voltage wind generation system regardless of dynamics of shafting, pitch control system.

This paper takes solid oxide fuel cell, active stall wind turbine generator, battery energy storage system as research object. Using an actual low voltage micro-grid as example, results with detailed model and simplified model are compared. From these results, we can see that adopting simplified model could lead to distortion of simulation results.

2. Typical DG dynamic simulation model[3]

In distributed power generation system, the source using electric rotating machinery can connect to grid directly. If the output of generator is alternating current with high frequency or direct current, it can connect to grid by inverter or transducer. Some energy storage device need inverter to connect to grid. The following are the dynamic simulation model and control strategy of those elements.

Take solid oxide fuel cell as example[4], its fuel cell stack, fuel control system and single-stage inverter circuit grid-connected control system are shown in figure 1.

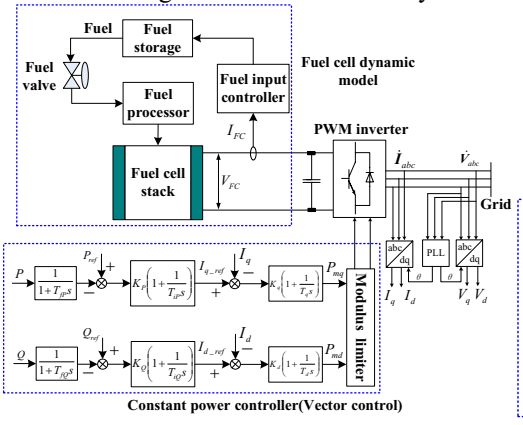

Fig.1 The structure for fuel cell grid-connected system

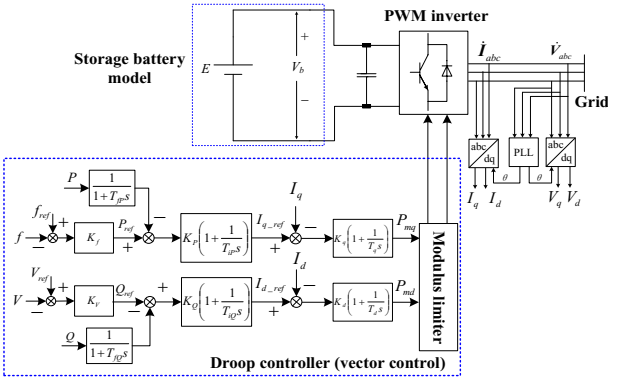

Fig.2 The basic structure for battery energy storage grid-connected system

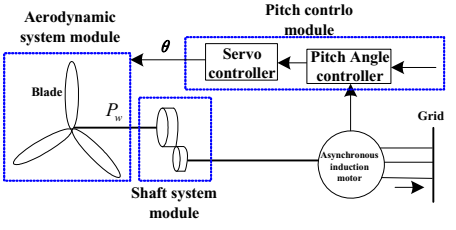

Fig.3 The structure for wind grid-connected system

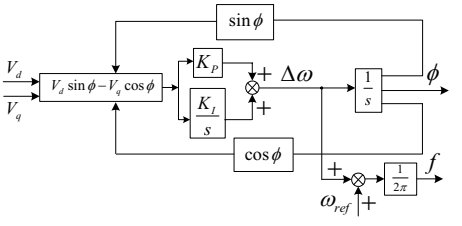

Fig.4 The basic structure for PLL