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Energy Procedia 12 (2011) 368 – 376

Energy Procedia

ICSGCE 2011: 27–30 September 2011, Chengdu, China

Simulation and Control Strategy of a Micro-Turbine Generation System for Grid Connected and Islanding Operations

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Abstract

The paper adopts the method of modularized modeling, creating an electro-mechanic simulation model for a Micro-turbine Generation System (MTGS), including the micro-turbine engine, permanent magnetic synchronous generator, rectifier and inverter. In this paper, control strategy for grid-connected and islanding operations of a micro-turbine generation system is researched, the former adopts output voltage control strategy to maintain the output voltage of the load, and the latter adopts a dual closed-loop control algorithm based on PQ decoupling. A new control strategy to regulate the output power of MTGS based on the combination of decoupled control of output voltage and hysteresis current control is also introduced. Simulations have been done, and result proves the feasibility of the strategy.

Selection and/or peer-review under responsibility of University of Electronic Science and Technology of China (UESTC).

Keywords: Micro-turbine Generation System; Modeling and Simulation; Matlab/Simulink; Island operation/Grid-connected

1. Introduction

With the continuous development of society and economy, distributed energy, which is paid more attention to, stands out for its advantage in efficiency, energy saving and environmental protection. Among them, micro-turbine (MT), as a typical representation, could generate constant power output and present unparallel advantages. Since micro-turbine is equipped with mutual technology, it could expect broader commercial applications [1].

Generally, micro-turbine refers to gas turbines, with its power ranging from tens of kW to several hundred kW. In accordance with coaxial case of power turbine and generator, MT is divided into single-

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doi:10.1016/j.egypro.2011.10.050

shaft and split-shaft forms. To simplify the analysis, the paper mainly study single-shaft micro-turbine, which consists of gas turbine, generator, compressor, combustor and regenerator[2]. The alternating current in IP and IF is transformed to rated 380V/50 Hz AC power through power electronic devices, which could be used directly to supply the load, thus forming a typical micro-turbine generation system.

A series of research have been made on modeling MTGS[3]-[6]. In reference [4], the paper establishes a typical mechatronic simulation model, to achieve coordination of control and design between systems. In [5], the mathematical models are made, based on the working theory of MTGS. However, the model is so complicated that it is hard to connect other networks, thus the control strategy is inconvenient to research on. In order to avoid such problems, ready-made modules for generators and power transition section in Matlab/Simulink are used, to build the model and make relevant researches on control strategy of grid-connected and islanding operations.

2. Model Description

2.1. Micro-turbine

Micro-turbine discussed in the paper is the single-shaft heavy duty one. The control system is made up of speed control, temperature control and acceleration control, as shown in Figure.1. Among them, speed control allows the machine to maintain a certain speed under constant load, while temperature control could ensure appropriate turbine inlet temperature, in case that it affected turbine's safety and life of system. Besides, acceleration control is mainly used to start the unit. The overall simulation model is shown in Figure 2, with valuing the parameters by referring to [4].

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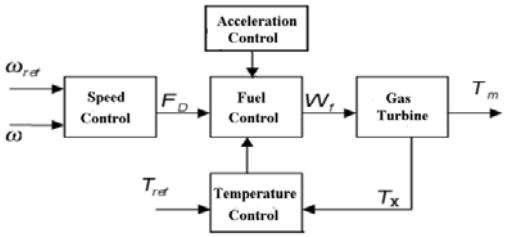

Fig. 1. Microturbine control system architecture

2.2. Section of generator and power conversion

In order to simplify the analysis, ready-made modules of SimPowerSystems are chosen to simulate the section. Module of permanent magnet synchronous generator (PMSG) can only be set at specific capacity, speed and output power, which makes experiment conditions limited. Therefore, common ac synchronous generator with constant excitation voltage is applied to replace PMSG. Rectifier is the ordinary three-phase controlled module, while the inverter is triggered by PWM, by which output voltage and power can be controlled.