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Modelling and Simulation of Microturbine as Distributed Generation and Present a New Method for Islanding Detection

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Abstract

Nowadays, distributed generations (DGs) have taken a special role in power systems. Distributed generations have received significant attention as a means to improve the performance of the electrical power system, provide low cost energy, and increase overall energy efficiency. A problem with such generators is the unwanted islanding phenomenon. Islanding detection an important and challenging issue to power engineers. Several methods based on passive and active detection scheme have been proposed in the literature. While passive schemes have a large non detection zone (_DZ), concern has been raised on active method due to its degrading power quality effect. In this paper, a new technique to detect islanding conditions has been proposed for micro turbine (MT) as distributed generation. The performance of the proposed method based on passive methods is much more appropriate than that of previous methods. The simulation results performed in Simulink-MATLAB, clearly show improved operation of this method.

Keywords: micro turbine, distributed generation, islanding phenomenon, non detection zone

1. Introduction

Distributed generations have been broadly used and are expected to be an important element in the future power systems. These generation systems have characteristics which are different from those of conventional large capacity fossil and nuclear generation systems. Distributed generation (DG) with its various distributed resource (DR) technologies has many advantages when connected to the power system [1]. DGs are energy sources that are located near the load. By locating sources near the load, transmission and distribution costs are decreased and delivery problems mitigated. DGs application can relieve transmission and distribution assets, reduce constraints, and improve power quality and reliability [1]. DGs are constituted by a variety of small, modular distributed generation (DG) technologies that can be combined with energy management and storage systems. DG devices enable renewable energies utilization and more efficient utilization of waste heat in combined heat and power (CHP) applications and lowering emissions. [2]. Deregulation of the electric utility industry, environmental concerns associated with central electric power plants, volatility of electric energy cost, and rapid technological developments of DG systems all

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support the proliferation of DG units in electric utility systems. When the distributed generation systems are operated in parallel with utility power systems, especially with reverse power flow, the power quality problems become significant. Power quality problems include frequency deviation, voltage fluctuation, harmonics and reliability of the power system. In addition, most important problem is an islanding protection. Islanding happens when one or more DGs supply local loads without getting connected to a power grid [2]. In most cases, this phenomenon can occur unintentionally, which causes problems due to the instability in consumer voltage and frequency and inconsistency in the reconnection to the power system such as creating the hazard for line repair technicians and equipment damages. Therefore, according to IEEE-1547 standard, islanding state should be identified and distributed generations disconnected within 2 seconds [3][4]. To detect Islanding state many methods have been proposed so far. These methods can be classified in two broad categories of active and passive classifications [5]. The following techniques can be mentioned as the active methods: Impedance measurement method [6], Frequency domain analysis [7], Changing voltage amplitude and reactive power method [8], the mid-harmonic method [9]. And, the techniques which can be mentioned as the passive methods: Voltage and frequency relays [10], Rate of change of frequency relay (df/dt) [11], Output power speed changes [10], Unbalanced voltage and total current (or voltage) harmonic distortion (THD) [12]. Passive methods do have a NDZ and active methods reduce the NDZ close to zero but making a compromise with the output power quality. The main emphasis of the proposed scheme is to reduce the NDZ to as close as possible and to keep the output power quality unchanged. In this paper a new method has been proposed for islanding detection that the performance of the method is based on instantaneous measurement of the Micro turbine rotor speed changes and measurement phase of angle voltage at the point of common coupling (PCC). As regards, parameters that can be changed in islanding mode are rotor speed of microturbine and phase angle of the voltages at PCC. This new method will help to reduce the NDZ without any perturbation that deteriorates the output power quality.

2. Microturbine Model

Microturbines are very small gas combustion turbines, featuring a single shaft structure with no gearboxes and rotating at very high speed, typically between 50,000 and 120,000 rpm/min; as a consequence these machines are always equipped with permanent magnet synchronous generators to produce electricity. The designs of microturbines are composed of the following parts [13][14]: (a) Turbine: There are two kinds of turbines, high speed single shaft turbines and split shaft turbines. All are small gas turbines. (b) Alternator: In the single shaft design, an alternator is directly coupled to the single shaft turbine. The rotor is either a two or four pole permanent design, and the stator is a conventional copper wound design. In the split shaft design, a conventional induction or synchronous machine is mounted on the power turbine via gearbox. (c) Power electronics: In the single shaft design, the alternator generates a very high frequency three phase signal ranging from 1500 to 4000 Hz. The high frequency voltage is first rectified and then inverted to a normal 50 or 60 Hz voltage. In the split shaft design, the power inverters are not required. (d) Recuperator: The recuperator is a heat exchanger which transfers heat from the exhaust gas to the discharge air before it enters the combustor. This reduces the amount of fuel required to raise the discharge air temperature to that required by the turbine. (e) Control and communication: Control and communication systems include full control of the turbine, power inverter and start-up electronics as well as instrumentation, signal conditioning, data logging, diagnostics, and user control communications. The microturbine model considered is based on the following assumptions: (a) The recuperator is not included in this model as it is mainly used to raise the efficiency of the system. (b) The temperature control and acceleration control have no impact on the normal operating conditions; therefore, they can be omitted in the turbine model. (c) The micro turbine does not use any governor, so, the model is not included in the model [13][14]. For load following analysis purposes a simplified block diagram for the microturbine can be represented as shown in Fig.1. The real power control is described as conventional PI control function as illustrated in Fig. 2. The real power control variable Pin is then applied to the input of the micro-turbine. In control system of the micro turbine, Pdem is the demanded power, Pref is the reference power, Pin is the power control variable to be applied to the input of the micro-turbine, Kp is the proportional gain and Ki is the integral gain of the proportional-integral controller. For turbine model GAST model is used which is most commonly used dynamic models of gas turbines [13] [14]. This model is simple and follows typical guidelines as shown in Fig. 3.

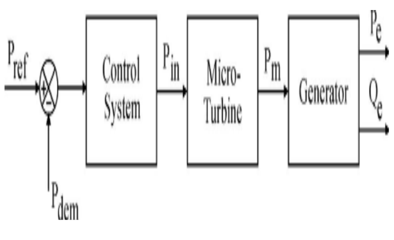

Fig. 1 Micro-turbine model

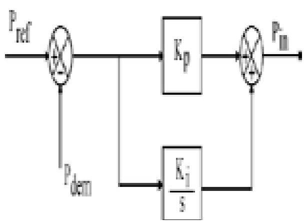

Fig. 2 Control system model

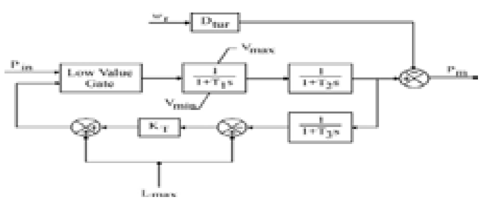

Fig. 3 Turbine model