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Smart Control of UPCQ within Microgrid Energy System

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Abstract

One of the most popular issues in the future power distribution is the quality improvement of microgrid and the development of smart grid (SG). Many applications operating at the microgrid level can be considered as smart grid functions. This paper proposes the application of Fuzzy Logic (FL) technique within microgrid energy system based on the most modern power conditioning equipment devices such as Unified Power Quality Conditioner (UPQC). This technique is working together with the microgrid to track the disturbance of the smart grid and improve the quality of the system with a high flexibility. Furthermore, a control methodology developed based on a simulation technique to maintain the output voltage of the microgrid. Finally, experimental results show the high performance of the proposed Fuzzy Logic controller (FLC) compare to the classical proportional integration (PI).

KeyWords: Smart Controller; Microgrid; Active power conditioners; Voltage flicker; Sag; Swell; Unbalance voltage

1. Introduction

The Quality of power supply in microgrid is impaired due to several reasons such as the electronic components involved in microgrid that can lead to a variety of different power system disturbances including voltage waveforms distortion, equipment overheating, miss function in system protection, excessive neutral currents, light flicker, inaccurate reading of metering units, etc. Therefore, this degradation is seen as various phenomena. The end user of the electricity may suffer e. g. from supply interruptions, voltage dips, flicker, and harmonics and unbalance voltage. Microgrid is one of the expected local power supply system that consists of distributed generators, loads, power storage devices, heat recovery equipments and power electronics equipments [1]. Recently, the utilization of alternative energy sources (AES) is growing rapidly because of its economical and environmental benefits compared to the

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conventional large power plant. The optimal values of a healthy distributed network are defined by the European Standard EN 50160 and IEEE norms [2-3].

Many AES such as Photo-Voltaic, wind turbines and fuel cell, do not generate a 50Hz voltage, so they require an interface device to regulate the AC power. The advancement of SG system is another effort to the rapidly growing energy demands and the increasing service quality. SG is the system that is able to rapidly detect, analyze and response to various perturbations by integrating intelligent devices such as advanced control method and digital telecommunication on electrical network [4]. These smart devices help to build a more flexible and invulnerable power system. UPQC is one of the developed techniques that can be utilized to enhance the quality of power supply in the microgrid and is expected that the SG can be reliable, flexible, diverse and dynamically controllable [5]. The conversion systems are properly controlled as a smart device to permit the operation of the system either interconnected to the low voltage network, or operate in stand-alone mode, with a seamless transfer from the one mode to the other [6]. In the grid connected mode, the inverter system of microgrid usually works in the constant current control mode to provide pre-set power to the utility of power system [7].

One of the most attractive structures of energy conditioner is the two back-to-back connected DC/AC fully controlled converters. In this case, depending on the control scheme, the converters may have different compensation functions [8, 9]. For example, they can function as active series and shunt filters to compensate simultaneously load current harmonics and supply voltage fluctuations. It is a versatile device that can compensate almost all power quality problems such as harmonics, unbalance, flickers, sags, swells, etc. Recently more attention is being paid on mitigation of voltage sags and swells using UPQC [10-11]. The common cause of voltage sag and swell is sudden change of line current flowing through the source impedance. Thus, the swells are not as common as sags, but the effects of a swell can be more destructive than sag. For example, the excessive over voltage during swell condition may cause breakdown of components or equipments [12]. The concept of FL is to utilize the qualitative knowledge of a system to design a practical controller [13]. For a process controlling system, a fuzzy control algorithm embeds the intuition and experience of an operator. The control doesn't need accurate mathematical model of a plant, and therefore, it suits well to a process where the model is unknown or ill-defined and particularly designed with uncertain or complex dynamics.

Implementing a smart controller of UPQC applied to the microgrid is a novel idea in this work. A grid connected UPQC is presented to investigate the flexibility and venerability of the microgrid energy system. By using the smart controller of UPQC as smart devices the performance and power quality in microgrid energy system can be improved. The paper is organized as such that, section 2 illustrates the principle operation of UPQC and the control techniques are briefly described in section 3. Section 4 presents the implementation of FLC in the UPQC. Simulation results and conclusion are provided in section 5 and 6 respectively.

2. Principe operation of UPQC

The UPQC applied in this work is connected to microgrid energy system which is a combination of different AES connected into power grid system. The general configuration of the UPQC is shown in Fig. 1. The UPQC has the capability of improving power quality at the point of installation on microgrid energy systems or industrial power systems. The currents of the source are sinusoidal current and the phase angles are the same as the fundamental. In another words, with the function of the UPQC, the load is equal to a resistance. As the UPQC is a combination of series and shunt active power filters (APF), two active filters have different functions. The series active filter suppresses and isolates voltage-based distortions. The shunt active filter cancels current-based distortions. At the same time, it compensates reactive current of the load and improves power factor. There are many control methods to determine the