

## Chapter 12

# ANN–Based Self–Tuning Frequency Control Design for an Isolated Microgrid

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### **ABSTRACT**

*The increasing need for electrical energy, limited fossil fuel reserves, and the increasing concerns with environmental issues call for fast development in the area of distributed generations (DGs) and renewable energy sources (RESs). A Microgrid (MG) as one of the newest concepts in the power systems consists of several DGs and RESs that provides electrical and heat power for local loads. Increasing in number of MGs and nonlinearity/complexity due to entry of MGs to the power systems, classical and nonflexible control structures may not represent desirable performance over a wide range of operating conditions. Therefore, more flexible and intelligent optimal approaches are needed. Following the advent of optimization/intelligent methods, such as artificial neural networks (ANNs), some new potentials and powerful solutions for MG control problems such as frequency control synthesis have arisen. The present chapter addresses an ANN-based optimal approach scheduling of the droop coefficients for the purpose of frequency regulation in the MGs.*

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## INTRODUCTION

According to the rapid growth of energy consumption in the world, the conventional power systems are faced with problems such as environmental issues, high cost of establishing new power plants, the existing restrictions on building transmission lines and shortages of fossil fuels. To overcome these problems and due to increasing customers demand for service with high reliability, increasing efficiency postponing construction of new transmission lines, reducing congestion in distribution feeders and reducing losses, a new concept known as distributed generation (DG) was introduced (Barker & De Mello, 2001; Willis & Scott, 2000).

A DG is a source of electrical power which is connected to distribution system and even placed directly in the consumer side (Ackermann, Andersson, & Soder, 2001). Generation units with less than ten megawatts (DGs) together with loads and storage devices may perform a Microgrid (MG) that is connected to distribution system by point of common coupling (PCC). Emerging number of MGs in power systems can change the power systems operation and control, significantly.

These changes imply a requirement for new control schemes in modern power systems. The power system is currently undergoing fundamental changes in its structure, not just with the deregulation issue and the use of competitive policies, but also to the use of new types of power production, new technologies, and rapidly increasing amounts of DG/RESs among small electric networks so called Microgrids (MGs).

Increasing in number of MGs in the power systems opens the way for looking new control strategies with a more control hierarchy/intelligence and decentralized property particularly in the field of frequency regulation. Similar to the conventional generating units, droop control is one of important control method for a MG with multiple DG units. The DG units must automatically adjust their set points using the frequency measurement to meet the overall need of the MG. But, unlike large power systems, the drooping

system is poorly regulated in MGs to support spinning reserve as an ancillary service for secondary frequency control. The main challenge is to coordinate their actions so that they can provide the regulation services.

The variability and uncertainty are two major attributes of variable renewable energy sources (RESs) in the MGs. The MG is a relatively novel concept in modern electric industry, consisting of small power systems owning the capability of performing isolated from the main network. A MG can tackle all distributed energy resources including DG, RESs, distributed energy storage systems and demand response as a unique subsystem, and offers significant control capacities on its operation. The MGs are usually based on loads fed through low/medium voltage level, mostly in distribution radial systems. Although the concept of MG is already established, the control strategies and energy management systems for MGs which cover power interchange, system stability, frequency and voltage regulation, active and reactive power control, islanding detection, grid synchronization, and system recovery are still under development.

The possibility of having numerous controllable DG units and MGs in distribution networks requires the use of intelligent, optimal, and hierarchical control schemes that enables an efficient control and management of this kind of systems. Generally for the sake of control synthesis, nonlinear systems such as MGs are approximated by reduced order dynamic models, possibly linear, that represent the simplified dominant systems' characteristics. However, these models are only valid within specific operating ranges, and a different model may be required in the case of changing operating conditions. On the other hand, due to increasing of nonlinearity and complexity of MG systems, classical and nonflexible control structures may not represent desirable performance over a wide range of operating conditions. Therefore, more flexible and intelligent approaches are needed.

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