Chapter 13

Power System Load Frequency Control Using Combined Intelligent Techniques

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ABSTRACT

The load frequency control (LFC) is to maintain the power balance in the electrical power system such that the system's frequency deviates from its nominal value to within specified limits and according to practically acceptable dynamic performance of the system. The control strategy evolved may also result in overall high efficiency (fuel saving) and minimum additional equipment to avoid cost, maintenance etc. The supplementary controller i.e. of a diesel or steam turbine generating unit, called the load frequency controller, may satisfy these requirements. The function of the controller is to generate, raise or lower command signals to the speed-gear changer of the prime mover (i.e. diesel engine) in response to the frequency error signal by performing mathematical manipulations of amplification and integration of this signal. The speed-gear changer must not act too fast, as it will cause wear and tear of the engine and, also, should not act too slow, as it will deteriorate system's performance. Therefore, an optimum load frequency controller is required for satisfactory operation of the system. In this Chapter, intelligent controllers for the LFC problem are analyzed and discussed. The use of any single technique or even a combination of genetic algorithms, fuzzy logic and neural networks is explored instead of conventional methods.

INTRODUCTION

Advancing microprocessor technologies have brought automation capabilities to new levels of applications. Load frequency control of power systems (also called automatic generation control – AGC), is one of many important industrial application areas, which may greatly benefit from such advances. However, development and deployment of such applications are often difficult because of the complex dynamics of actual processes. Conventional control theory is based on mathematical models that describe the dynamic behavior of controlled systems. This is based on the deterministic nature of systems, but its applicability is reduced by computational complexity, parametric and structural uncertain-

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ties, and the presence of nonlinearities. These characteristics often make the controller design complicated and unreliable. A potential solution is offered by shifting the attention from modeling of the process to extracting the control knowledge of human experts. This artificial intelligence approach, implemented in intelligent control systems (ICSs), utilizes the fact that human operators normally do not handle the system control problem with a detailed mathematical model but rather with a qualitative or symbolic description of the controlled system. ICSs have two unique features: ability to make decisions and learning from data or experience. Decision making capabilities provide for the controllers to operate in real-time process-control environments, at both micro and macro levels of system operations. Learning capabilities make it possible for the controllers to adapt their knowledge to specified performance criteria, to reason about potential dynamics of the environment, to predict advantageous features, or even to acquire the needed knowledge.

In this chapter intelligent load frequency controllers which have been developed recently will be demonstrated, which are (most of them) using a combination of fuzzy logic, genetic algorithms and neural networks, to regulate the power output and system frequency by controlling the speed of the generator with the help of fuel rack position control. The aim of these intelligent controllers is to restore the frequency to its nominal value in the shortest time possible whenever there is any change in the load demand. The action of the controllers should be coupled with minimum frequency transient oscillations and zero steady-state error. The design and performance evaluation of the controllers' structure are illustrated with the help of results of relevant case studies applied to single-area or interconnected power systems. It will be clearly shown that this type of controllers exhibit extremely satisfactory performance and overcome the possible drawbacks associated with other conventional techniques.

The chapter is organized as follows: At the next Section, a brief literature review will be reported accompanied by the relevant background and definitions. The electrical power system industry environment will also be discussed. Typical models of a single-area as well as interconnected electrical power systems in the traditional as well as in the open-market environment will be demonstrated to which the associated controllers will be applied. The conventional integral and/or proportional type controller is also reviewed and the reproduction of the results derived from its application to a single area power system is presented. A Section follows, referring to the philosophy of the intelligent controller design. Brief reviews of the main aspects of the three aforementioned modern intelligent techniques are presented. For illustrations purposes, a fuzzy logic controller is also designed and applied to the same single-area power system. In The final Section an effort is made to overcome the drawbacks of the previous methods by incorporating a structure which combines the three modern intelligent methods. The controller developed is actually an on-line neural network, driven by a genetic algorithm based self-learning fuzzy logic controller (NNGAFLC). Some cases of study are being investigated and a comparison is made to show the relative goodness of the control strategy employed.

RELEVANT BACKGROUND AND CONVENTIONAL APPROACHES

Brief Literature Review

Many investigations in the area of automatic generation control of isolated and of interconnected power systems have been reported in the past throughout the last decades A number of control strategies have also been proposed to achieve improved performance. The proportional

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