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Automatic generation control application with craziness based particle swarm optimization in a thermal power system

Haluk Gozde *, M. Cengiz Taplamacioglu

Gazi University, Faculty of Engineering, Department of Electrical & Electronics Engineering, 06750 Maltepe, Ankara, Turkey

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In this study, a novel gain scheduling Proportional-plus-Integral (PI) control strategy is suggested for automatic generation control (AGC) of the two area thermal power system with governor dead-band nonlinearity. In this strategy, the control is evaluated as an optimization problem, and two different cost functions with tuned weight coefficients are derived in order to increase the performance of convergence to the global optima. One of the cost functions is derived through the frequency deviations of the control areas and tie-line power changes. On the other hand, the other one includes the rate of changes which can be variable depends on the time in these deviations. These weight coefficients of the cost functions are also optimized as the controller gains have been done. The craziness based particle swarm optimization (CRAZYPSO) algorithm is preferred to optimize the parameters, because of convergence superiority. At the end of the study, the performance of the control system is compared with the performance which is obtained with classical integral of the squared error (ISE) and the integral of time weighted squared error (ITSE) cost functions through transient response analysis method. The results show that the obtained optimal PI-controller improves the dynamic performance of the power system as expected as mentioned in literature.

1. Introduction

An interconnected electric power system generates, transports and distributes electric energy. The aim of such these systems is to supply electric energy with nominal system frequency and terminal voltage, values and tolerances of those are defined by some power quality standards. According to power system control theory, a nominal system frequency depends on the balance between generated and consumed real powers [1]. The difference between generated power and instant load demand causes changing of nominal system frequency at the normal state. If the amount of generated power is less than the demanded amount, speed and frequency of the generator units begin to decrease, and vice versa. Hence, the amount of production of the synchronous generators is made sense for frequency deviations occurred in the power system in order to maintain that balance. For this purpose, an automatic generation control concept is used. The aim of automatic generation control is that the steady state error of the system frequency deviations following a step load demand is made zero error.

When the literature is investigated, it can be seen that early works on AGC was initiated by Cohn [2]. However, a modern optimal control concept for AGC designs of interconnected systems is put forward by Elgerd and Fosha for the first time [3]. They suggested a proportional controller and different feedback form to develop optimal controller. Until the present day, lots of different control strategies such as conventional, adaptive, variable structure, robust and some based on artificial intelligence have been reported [4]. However, gain scheduling adaptive control can be distinguished from the other control techniques because it makes the process which is under control less sensitive to changes in process parameters and in particular, it is also simpler to implement than the other modern control techniques. For these reasons, it is carried out to AGC system, frequently.

The first gain scheduling control method for AGC of interconnected power system was proposed by Lee and coworkers in 1991 [5]. Their controller provided better control performance for a wide range of operating conditions than the performances obtained so far. Later on, Rubaai and Udo presented a multi-variable gain scheduling controller by defining a cost function with a term representing the constraints on the control effort and then minimizing that with respect to the control vector [6]. Since the conventional gain scheduling methods may be unsuitable in some operating conditions due to the complexity of the power systems such as nonlinear load characteristics and variable operating

* Corresponding author. Tel.: +90 312 2311340; fax: +90 312 2308434.
E-mail addresses: halukgozde@gmail.com (H. Gozde), taplam@gazi.edu.tr (M.C. Taplamacioglu).

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