Automatic Generation Control of Thermal-Thermal-Hydro Power Systems with PID Controller using Ant Colony Optimization

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ABSTRACT

In this work, Artificial Intelligence (AI) based Ant Colony Optimization (ACO) algorithm is proposed for Load Frequency Control (LFC) of interconnected multi-area hydrothermal power systems. Area 1&2 are thermal power systems and area 3 is a hydro power system, all the areas are interconnected through the appropriate tie-line. Thermal and hydro power plants are applied with reheat turbine and electric governor respectively. Investigated power system initially applied with conventional Proportional-Integral (PI) controller and controller parameters are optimized by using trial and error method considering Integral Time Absolute Error (ITAE) objective function. After that, the system is equipped with Proportional – Integral – Derivative (PID) controller and controller parameters are optimized by using ACO algorithm with ITAE objective function. The superiority of the proposed algorithm has been demonstrated by comparing conventional controller. Finally, The Simulation results of multi-area power system prove the effectiveness of the proposed optimization technique in LFC scheme and show its superiority over conventional PI controller.

Keywords: Ant Colony Optimization, Interconnected Power System, Load Frequency Control, Objective Function, Optimization, Performance Index, Proportional - Integral Controller, Proportional - Integral - Derivative Controller

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1. INTRODUCTION

The LFC of multi-area power system mechanism, balance the total power generation with fluctuated load to maintain the frequency deviation within the specified/scheduled value. This power balance is achieved by means of controlling prime mover, to match load variations through the control of load reference in selected generating unit. Different types of LFC schemes have been developed from the past few decades and recent years (Jagatheesan and Anand, 2014a; Jagatheesan and Anand, 2014b; Jagatheesan, et al. 2014; Padhan, et al. 2014; Roy, et al. 2014; Francis and Chidambaram, 2015; Zare, et al. 2015; Chidambaram and Paramasivem, 2012; Dash, et al. 2015; Sahu et al. 2015; Dey, et al. 2013; Samanta, et al. 2013; Chakraborty, et al. 2013; Dey, et al. 2014; Azar and Serrano, 2014; Azar and Vaidyanathan, 2015; Zhu and Azar, 2015; Hassanien, et al. 2015). Conventional and classical controller based power systems are getting trouble while achieving power balance during the sudden load disturbance.

The main of the Load Frequency Control (LFC) or Automatic Generation Control (AGC) is to maintain power balance between load with generation and keep the system parameters with in the specified limit during sudden/ continuous load variations. From the literature, it is clearly shows that many control, optimization techniques and controllers are developed and implement in multi-area interconnected power systems (Hassan, et al. 2014; Padhan, et al. 2014; Roy, et al. 2014; Francis and Chidambaram, 2015; Zare, et al. 2015; Chidambaram and Paramasivem, 2012; Dash, et al. 2015; Azar and Serrano, 2014; Azar and Vaidyanathan, 2015; Zhu and Azar, 2015; Hassanien, et al. 2015). Dynamic performance of multi-area reheath thermal power system is improved in (Jagatheesan, et al. 2014) by introducing HVDC link parallel to tie-line with a conventional PI controller. Gain values of the PI controller in three area reheath thermal power systems (Jagatheesan and Anand, 2014) are obtained using three different objective functions with non linearity and boiler dynamic effects. In (Jagatheesan and Anand, 2014a), performance of mechanical governor is compared with electric governor with and without considering appropriate GRC non linearity effects in all areas.

In order to overcome this drawbacks of afore mentioned controller is replaced by introducing AI based control technique in power system (Azar and Serrano, 2014; Azar and Vaidyanathan, 2015; Azar and Zhu, 2015; Zhu and Azar, 2015; Azar and Serrano, 2015; Hassanien, et al. 2015). Due to enormous growth in industries and technology load is continuously variable and it affects the quality of power supply generated by the power system. In order to overcome this issue, generating units are interconnected through the tie-line. When the size of the power system increases complexity also increases. Nowadays complexity of the power system is solved by introducing evolutionary computational techniques (Hassan, et al. 2014; Padhan, et al. 2014; Roy, et al. 2014; Francis and Chidambaram, 2015; Zare, et al. 2015; Chidambaram and Paramasivem, 2012; Dash, et al. 2015). Such as Adaptive Fuzzy, Firefly Algorithm (FA) (Dey, et al. 2014), Oppositional Biogeography Based Optimization (OBBO), Beta Wavelet Neural Network (BWNN), Improved Particle Swarm Optimization (IPSO), Cuckoo Search Algorithm (Day, et al. 2013) and Bacterial Foraging Optimization (BFO) (Paramasivam and Chidambaram, 2010), fuzzy logic controller (Anand and Ebinezer, 2009), Particle Swarm Optimization (PSO) (Mohammed, et al. 2009), Bacterial Foraging (BF) (Ali and Abd-Elazim, 2011), Cuckoo search (Dey, et al. 2014; Chidambaram and Paramasivam, 2013), Artificial Bee Colony (ABC) (Paramasivam and Chidambaram, 2010), Ant Colony Optimization (ACO) (Omar, et al. 2013; Ying-Tung Hsiao, et al. 2004), Genetic Algorithm (GA) (Chidambaram and Paramasivam, 2009; Ghosal, 2004), Imperialist competitive Algorithm (ICA) (Taher, et al. 2014), Firefly Algorithm (FA) (Dey, et
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