International Journal of Energy Optimization and Engineering
Volume 5 • Issue 3 • July-September 2016

Application of Modified Biogeography Based Optimization in AGC of an Interconnected Multi-Unit Multi-Source AC-DC Linked Power System

Dipayan Guha, Department of Electrical Engineering, Dr. B.C. Roy Engineering College, Durgapur, India
Provas Kumar Roy, Department of Electrical Engineering, Jalpaiguri Government Engineering College, Jalpaiguri, India
Subrata Banerjee, Department of Electrical Engineering, National Institute of Technology, Durgapur, India

ABSTRACT

An attempt has been made for the effective application of biogeography based optimization and its modified version to solve load frequency control (LFC) problem. Two-area interconnected multi-unit multi-source power system having thermal, hydro and gas power plant without and with AC-DC link is considered for study. Proportional-integral-derivative controller is used as secondary controller in LFC system and its gains are tuned by proposed algorithms through minimization of integral time absolute error based objective function. The results confirm the effectiveness of proposed algorithms after comparing results with other evolutionary algorithms like differential evolution (DE), teaching learning based optimization (TLBO) for the similar test system. The robustness of proposed algorithm is checked with different objective functions like integral square error, integral absolute error, integral time square error criterions and under different loading conditions. Critical analysis of results reveals that proposed method gives better performance than that obtained with DE, TLBO.

KEYWORDS

Biogeography based Optimization (BBO), Load Frequency Control (LFC), Transient Analysis

1. INTRODUCTION

Modern power system network becomes more and more complicated with increasing of load demand. To ensure quality of electric power supply with stability, high efficiency and high reliability under normal and disturbed conditions, consistency of system frequency and interchange power has to be maintained “Sudha, Raju, Sekhar (2012)”. Power system network comprises several controlled area connected by tie-line. Stabilizing area frequency and interchange power oscillations after sudden step load perturbation (SLP) are the main concerns of power system engineers which lead to the attention in automatic generation control (AGC) or load frequency control (LFC) “Khodabakhshian, Pour, Hooshmand (2012)”. LFC is an important area of power system operation and control. The main objectives of AGC are: (i) maintain system frequency and tie-line power to their scheduled values, (ii) to mismatch power allocation among the units within each control area at their scheduled values.

DOI: 10.4018/IJEOE.2016070101

A multitude technique is available in the literature to ensure better solutions of LFC problem over last two-three decades. Classical PI-controller "Sathya, Ansari (2015)", "Sahu, Panda, Sekhar (2015)" is the most widely used controller strategy in LFC area due to its simplicity and applicability. Literature review reveals that optimum design of proportional plus integral (PI) controller gives week transient performance, therefore researchers proposed proportional plus integral plus derivative (PID) controller to improve the dynamic responses of the system instead of PI-controller "Bahgaat, Sayed, Hassan and Bendary (2014)", Mohanty, Panda, Hota (2014)", "Sahu, Panda, Padhan (2015)". Apart from classical control techniques, many advanced methods have been applied to LFC area, like H_∞ control "Dey, Ghosh, Ray, Rakshit (2012)", intelligent controller "Prakash, Sinha (2014)", "Karnavas (2010)", sliding mode based controller "Ouassaida, Maaroufib, Cherkaoui (2012)", reinforced learning neural network "Saikia, Mishra, Sinha, Nanda (2011)", fractional order based controller "Debbarma, Saikia, Sinha (2014)", fuzzy logic controller "Arya, Mathur, Gupta (2012)" etc. "Sabahi, Ghaemi, Pezeshki (2014)" proposed type-II fuzzy logic controller based on feedback error learning approach and highlights effectiveness of designed controller by comparative analysis. "Yazdizadeh, Ramezani, Hamedrahmat (2012)" designed a decentralized robust optimal MISO PID controller based on characteristic matrix Eigen values and Lyapunov method for LFC problem and applied the designed controller to investigate the performances of power plant having two large dams in KHOZESTAN (a province in southwest of Iran).

Because of the inherent characteristic of changing of loads, the operating point of power system changes continuously during normal operation. Hence, finding of optimum gains of classical or advanced controller to meet the desired transient specifications is a challenging task for power system engineers. Recently, many researchers were proposed several heuristic optimization algorithms for fine tuning of advanced or classical controller for LFC system. "Mohanty, Panda, Hota (2014)" presents differential evolution (DE) approach for finding optimal gains of integral (I), PI and PID controller for multi-source power system and show its superiority by comparing results with optimum feedback controller. "Farhangi, Boroushaki, Hosseini (2012)" introduced emotional learning based optimization technique based intelligent controller for LFC system with generation rate constraint (GRC) of steam turbine and compare results with that of PI, fuzzy logic and hybrid neuro-fuzzy controllers. "Yesil (2014)" in his article proposed interval type-2 fuzzy PID-controller and big-bang big-crunch (BB-BC) algorithm is used to design the same for an interconnected four area power system. Beside these, bacteria foraging optimization algorithm (BFOA) "Ali, Abd-Elazim (2013)", craziness based particle swarm optimization (CRPSO) "Gozde, Taplamacioglu (2011)", hybrid firefly-pattern search algorithm (hFA-PS) "Sahu, Panda, Padhan (2015)", artificial bee colony algorithm (ABCA) "Naidu, Mokhlis, Bakar (2014)", "Dutta, Roy, Nandi (2014)", cuckoo search algorithm (CSA) "Dash, Saikia, Sinha (2014)", teaching learning based optimization (TLBO) "Barisal (2015)", hybrid optimization technique "Roy, Mandal (2013)" etc. are successfully applied to LFC and other area of power system for better output.

In this article, an attempt has been made for effective application of biogeography-based optimization (BBO) algorithm for the design of PID-controller in an interconnected power system. A modified migration strategy is applied to original BBO for a higher degree of convergence and fast damping of frequency, tie-line power oscillations. The power system network is studied without and with AC-DC tie-line. Initially, integral time absolute error (ITAE) based fitness function is considered for designing of the controller and later, three more fitness functions are designed for better comparison and verification of the robustness of designed controller. The potential and effectiveness of proposed algorithm is established by comparing results with other heuristic algorithms like DE, TLBO and optimum feedback controller. Comparative results show that proposed approach outperforms DE, TLBO and optimum feedback controller. Finally, sensitivity analysis is performed to check robustness of power system with BBO-based PID-controller under wide variations of loading conditions.

Rest of the paper is organized as follows: In section 2, mathematical modeling of test system with choice of the objective function is elaborated. Section 3 gives an overview of original BBO