Electrical Power and Energy Systems 33 (2011) 1296–1308

Contents lists available at ScienceDirect

Electrical Power and Energy Systems

journal homepage: www.elsevier.com/locate/ijepes

Multi-objective PID controller tuning for a FACTS-based damping stabilizer using Non-dominated Sorting Genetic Algorithm-II

Sidhartha Panda

Department of Electrical and Electronics Engineering, National Institute of Science and Technology, Berhampur, Orissa 761 008, India

ARTICLE INFO

Article history:
Received 6 January 2010
Received in revised form 9 February 2011
Accepted 3 June 2011
Available online 5 July 2011

Keywords:
Multi-objective optimization
Non-dominated Shorting Genetic Algorithm-II
Pareto optimal set
Flexible AC Transmission System
Power system stability
Proportional Integral Derivate (PID) controller

ABSTRACT

Design of an optimal controller requires optimization of multiple performance measures that are often noncommensurable and competing with each other. Design of such a controller is indeed a multi-objective optimization problem. Non-Dominated Sorting in Genetic Algorithms-II (NSGA-II) is a popular non-domination based genetic algorithm for solving multi-objective optimization problems. This paper investigates the application of NSGA-II technique for the tuning of a Proportional Integral Derivate (PID) controller for a Flexible AC Transmission System (FACTS)-based stabilizer. The design objective is to improve the damping of power system when subjected to a disturbance with minimum control effort. The proposed technique is applied to generate Pareto set of global optimal solutions to the given multi-objective optimization problem. Further, a fuzzy-based membership value assignment method is employed to choose the best compromise solution from the obtained Pareto solution set. Simulation results are presented and compared with a conventionally designed PID controller under various loading conditions and disturbances to show the effectiveness and robustness of the proposed approach. Finally, the proposed design approach is extended to a multi-machine power system to damp the modal oscillations with minimum control efforts.

1. Introduction

Despite significant strides in the development of advanced control schemes over the past two decades, the classical Proportional-Integral-Derivative (PID) controller and its variants remain the controllers of choice in many industrial applications [1,2]. PID controller structure remains an engineer's preferred choice because of its structural simplicity, reliability, and the favorable ratio between performance and cost. Beyond these benefits, it also offers simplified dynamic modeling, lower user-skill requirements, and minimal development effort, which are issues of substantial importance to engineering practice. The performance of the PID controller depends on its setting of parameters. A lot of tuning methods have been presented in the literatures; these include designs based on guess-and-check or trial and error tuning method, such as Ziegler–Nichols (Z–N) and Cohen–Coon methods (C–C). These conventional methods are hard to provide the desired performance and some fine tuning is further required. Design of an optimal PID controller requires optimization of multiple performance measures that are often non-commensurable and competing with each other. Owing to multiple and conflicting objectives, an optimal PID controller that simultaneously minimizes all objectives is usually not attainable. For example, while designing a control system, we would usually like to have a high-performance controller, but we also want to achieve desired performance with little control efforts (cost). One approach to design the optimal controllers is the classical weighted-sum approach where the objective function is formulated as a weighted sum of the objectives. But the problem lies in the correct selection of the weights to characterize the decision-makers preferences. In recent years, the multi-objective problems are solved to find non-inferior (Pareto-optimal, non-dominated) solutions [3]. Control systems optimization problems involving the optimization of multiple objective functions require high computational time and effort [4–6]. As conventional techniques are difficult to apply, modern heuristic methods are preferred to obtain Pareto optimal set [7–9].

The Non-dominated Sorting Genetic Algorithm (NSGA) proposed by Srinivas and Deb [10] has been widely used successfully applied to solving many multi-objective problems. However, the main demerit of this approach has been its high computational complexity of non-dominated sorting, lack of elitism, and need for specifying a tunable parameter called sharing parameter. To address all the above issues Deb et al. [11] proposed an improved version of NSGA, called NSGA-II which has a better sorting algorithm, incorporates elitism and no sharing parameter needs to be chosen a priori. By using of Pareto optimal set and Pareto optimal front which NSGA-II algorithm offers, designer can select the

E-mail address: panda_sidhartha@rediffmail.com

0142-0615/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.ijepes.2011.06.002