Available online at www.sciencedirect.com

ScienceDirect

Procedia Technology 21 (2015) 295 – 302

Procedia Technology

SMART GRID Technologies, August 6-8, 2015

Design of Controller for Automatic Voltage Regulator using Teaching Learning Based Optimization

V. Rajinikanth[a,*], Suresh Chandra Satapathy[b]

[a]*Department of Electronics and Instrumentation Engineering, St. Joseph's College of Engineering, Chennai 600119, India*
[b]*Department of Computer Science and Engineering, ANITS, Visakhapatnam 531162, India.*

Abstract

In this paper, One Degree Of Freedom (1DOF) and Two Degrees Of Freedom (2DOF) Proportional + Integral + Derivative (PID) controller design is proposed and implemented on the Automatic Voltage Regulator (AVR) system using traditional Teaching Learning Based Optimization (TLBO) algorithm. Minimization of a multi-objective function guides the TLBO algorithm's exploration until the process converges with an optimal solution. A simulation study is carried to examine the performance of TLBO assisted controller design procedure for three, four and five dimensional searches. The performance of the proposed method is validated with most successful heuristic procedures, such as Particle Swarm Optimization (PSO), Bacterial Foraging Optimization (BFO) and Firefly Algorithm (FA). The result show that, 1DOF PID controller and PID controller with filter offers smooth reference tracking response and the 2DOF PID controller with the Feed Forward (FF) and Feed Back (FB) structure presents reduced time domain and error values compared to the alternatives.

Peer-review under responsibility of Amrita School of Engineering, Amrita Vishwa Vidyapeetham University

Keywords: AVR; PID controller; degrees of freedom; teaching learning based optimization; multi-objective function.

1. Introduction

In recent years, Heuristic Algorithm (HA) supported optimization is emerged as a powerful tool for discovering optimal solutions for a variety of engineering optimization problems [1-5]. In this work, newly developed Teaching Learning Based Optimization (TLBO) technique is adopted to solve the controller design problem. The TLBO was originally developed and implemented by Rao et al. to find most favorable solution for the constrained mechanical

* Corresponding author. Tel.: +91 9380593801.
*E-mail address:*rajinikanthv@stjosephs.ac.in

Peer-review under responsibility of Amrita School of Engineering, Amrita Vishwa Vidyapeetham University
doi:10.1016/j.protcy.2015.10.032

design problems [9]. This algorithm is theoretically similar to the teaching-learning scenario existing in the class room [10, 11]. In the proposed work, PID design problem for the Automatic Voltage Regulator (AVR) is addressed. Even though there exists a number of advanced controller structures, PID and enhanced forms of PID controllers are easy to tune and implement [6-8]. Hence, in this paper One Degree Of Freedom (1DOF) PID and Two Degrees Of Freedom (2DOF) PID controllers are designed and implemented on the benchmark AVR system using the traditional TLBO algorithm. The performance of the TLBO is validated using most successful HAs, such as Particle Swarm Optimization (PSO), Bacterial Foraging Optimization (BFO) and Firefly Algorithm (FA).

2. Automatic Voltage Regulator

Benchmark AVR system widely discussed in the literature is considered in this paper [3-5].

2.1 Principle

Detailed theoretical description about the AVR system can be found in [3]. During power generation process, common troubles, such as dissimilarity of load, limit deviation in transmission system, and turbine oscillation may produce oscillatory output in synchronous generator. This category of electro-mechanical fluctuation affects the firmness of power system. Hence, in modern power generating stations, in order to improve the dynamic stability and to assure the power quality, most of the synchronous generators are outfitted with an excitation unit, which is supervised by an AVR and a Power System Stabilizer (PSS) [4, 5]. Fig. 1. Illustrates the block diagram of the AVR system with linearized intermediate units. During closed loop operation, the controller is responsible to maintain stability, robustness and also to support smooth reference tracking performance based on the set value of terminal voltage.

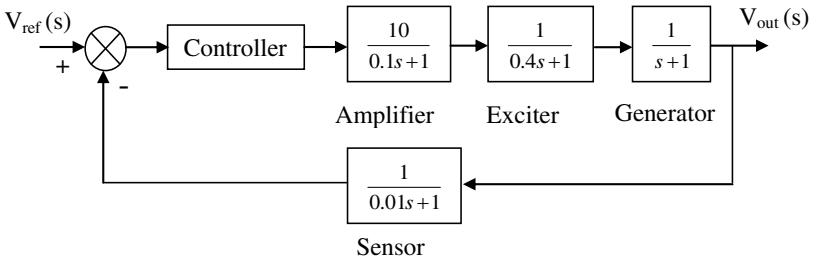

Fig. 1. Block diagram of the AVR system

2.2 Related previous works

Due to its significance, AVR system is widely considered by most of the researchers. Heuristic algorithm based approaches are already applied on the AVR system in the literature [3-5]. Most of the researchers proposed the PID controller design for the AVR system and the performance of the controller is validated for reference tracking response.Fig.1. indicates that, the delay time present in the higher order AVR system is very small and designing a suitable controller requires the following assumptions: (i) the system is linear, (ii) external disturbance acting on the system is negligible and (iii) the sensor part is free from the measurement noise. In the proposed work, traditional and enhanced forms of PID controller is considered to regulate AVR system and the controller design process in done using heuristic algorithms.

3. PID Controller

Based on the structure and number of initial parameters to be tuned, PID is classified as One Degree Of Freedom