ABSTRACT

This paper presents a method to get the optimal tuning of Proportional Integral Derivative (PID) controller parameters for an AVR system of a synchronous generator using Particle Swarm Optimization (PSO) algorithm. The AVR is not initially robust to variations of the power system parameters. Therefore, it was necessary to use PID controller to increase the stability margin and to improve performance of the system. Fast tuning of optimum (PID) controller parameter yield high quality solution. New criteria for time domain performance evaluation was defined. Simulation for comparison between the proposed method and Ziegler-Nichols method is done. The proposed method was indeed more efficient also. The terminal voltage step response for AVR model will be discussed in different cases and the effect of adding rate feed back stabilizer to the model on the terminal voltage response. Then the rate feedback will be compared with the proposed PID controller based on use of (PSO) method to find its coefficients. Different simulation results are presented and discussed.

Keywords: Automatic Voltage Regulator (AVR), Particle Swarm Optimization (PSO), Proportional Integral Derivative (PID) Controller, Simulation, Terminal Voltage Response

1. INTRODUCTION

The main function of AVR loop is to control the generator terminal voltage. This means keeping regulated voltage within prescribed limits as possible as could be. Increasing or reducing terminal voltage is performed by proportional process for excitation voltage/current. This directly increases or reduces the reactive power output of the generator. This process is restricted by two limits; AVR loop limitations and generator capability.
Electricity must be consumed at the same instant it is produced. Therefore, the total generation must meet the total load requirement of both active and reactive power. The load active demand is voltage and frequency dependent. It is generally increases as voltage or frequency increases (within the safe operational limits). The electrical loads are not constant forever but unfortunately, most of the loads vary regularly or randomly all over the time. In order to improve the performance of the AVR systems, the PID controller is normally used since it has simple structure. In addition, it is robust to variations of the system parameters. The reason of this acceptability is for its simple structure which can be easily understood and implemented.

Easy implementation of hardware and software has helped to gain its popularity. Several approaches have been documented in literatures for determining the PID controller parameters. Most famous methods are Ziegler Nichols tuning, as given in Ziegler JG, and Nichols NB (1942), neural network, as given in Q.H. Wu, B.W. Hogg, and G.W. Irwin, (1992), fuzzy based approach as given in A. Visioli (2001), and Genetic Algorithm as given in R.A. Krohling, and J.P. Rey (2001).

Particle swarm optimization (PSO) technique is used in tuning the parameters of the proposed (PID) controller of a synchronous generator. This PSO technique is very efficient in solving continuous non-linear optimization problems. The performance index used for tuning the controller considers both the set point and disturbance responses. Beside the robust stability of the closed loop system is guaranteed by specifying finite bound on the maximum sensitivity function. The results of the simulation show that when the PSO method is used the performance of the tuned PID controller is significantly more efficient and the response is better in quality.

2. AVR MODEL

The Automatic Voltage Regulator (AVR) of the synchronous generator is responsible for controlling the terminal voltage and reactive power output of the generator and consequently its terminal voltage. A simple (AVR) consists of amplifier, exciter, generator and sensor. The block diagram of AVR with PID Controller is shown in Figure 1. The linear model for each of the AVR elements is given in the following discussion as given in (H. Saadat, 1999).

1. **Amplifier Model:** The amplifier model is represented by a gain $K_A$ and a time constant $\tau_A$; the transfer function is:

$$ V_E = \frac{K_A}{1 + \tau_A S} $$
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