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Energy Procedia 17 (2012) 202 – 207

Energy Procedia

2012 International Conference on Future Electrical Power and Energy Systems

The Application of Nonlinear PID Controller in Generator Excitation System

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Abstract

Aimming at the control problem of generator excitation system, this paper brings forward a kind of nonlinear PID controller. The controller's proportional, integral and differential values are nonlinear functions of error function that the algorithm is simple and easy to realize. Simulation results show that the generation excitation system designed with this controller is much better than the traditional PID controller. It solves contradiction between rapidity and overshoot and then the dynamic performance and control accuracy of terminal voltage have been improved.

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Keywords:excitation system; nonlinear PID controller; simulation;

1. Introduction

The traditional PID controller has advantages of simple structure, good robustness etc, so it is widely used in excitation system design process. Therefore generator excitation system control technology has very important practical significance based on PID controller.

Currently on PID control methods are mainly divided into two types: (1) designs based on traditional PID control theory have conflict between rapidity and overshoot. Hence control effect is not very good;(2) Design methods based on intelligent PID control theory such as neural network PID control, fuzzy control PID control etc, are improvement to traditional PID control. Intelligent PID control effect is superior to traditional PID control, but it suffers many limitations, such as great calculation and poor real time performance[1-2].

This paper puts forward a kind of nonlinear PID control method, is applied to generator excitation control system design. This control method is simpler that proportional gain, integral gain, differential gain changes with error control. Because nonlinear PID controller has advantages of rapidity, high precision and without overshoot, it can achieve good control effect.

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2. Mathematical Model of excitation system

The mathematical model of single-machine infinite system is shown in figure 1:

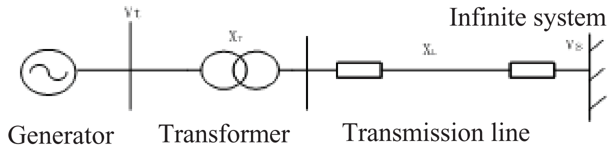

Figure 1 Single-machine infinite system

Ease of Use

Selecting a Template (Heading 2)

Where: V_t —generator voltage; X_T —transformer circuit reactance; X_L —circuit reactance of transmission line; V_s —bus voltage of infinite system .

This paper adopts third-order system model described by equation (1) with the following three order ordinary differential equation:

$$\begin{cases} \dot{\delta} = \omega - \omega_0 \\ \dot{\omega} = \dfrac{\omega_0}{H} P_m - \dfrac{D}{H}(\omega - \omega_0) - \dfrac{\omega_0}{H} \dfrac{E'_q V_s}{x'_{d\Sigma}} \sin\delta \\ \dot{E}'_q = -\dfrac{x_{d\Sigma}}{T_{d0} x'_{d\Sigma}} E'_q + \dfrac{(x_d - x'_d) V_s \cos\delta}{T_{d0} x'_{d\Sigma}} + \dfrac{1}{T_{d0}} V_f \end{cases} \tag{1}$$

Where: ω —generator rotor angular velocity; ω_0 —generator synchronous speed; δ —generator power-angle; H —inertia moment of generator rotor; P_m —Input mechanical power; D —damp coefficient; E'_q —transient electric potential; $x'_{d\Sigma}$ —d shaft transient total circuit reactance; $x_{d\Sigma}$ —d shaft total circuit reactance; x_d —d shaft synchronous circuit reactance; x'_d —d shaft transient circuit reactance; T_{d0} —time constants of exciting windings; V_f —exciting voltage.

3. The principles of nonlinear PID controlle

According to response curve of the general system step, literature [3] gives a kind of nonlinear PID controller design method. The structural principle is shown as follows.

3.1 .Choice of proportional gain k_p

Because $e(t)$ is larger as the initial response stage, k_p should greatly be large in order to guarantee quicker response speed. When error value $|e(t)|$ gradually reduces, and then k_p decreases. When $|e(t)|$ gradually, increases, k_p also increases. It can make the system to produce a small overshoots and return to steady-state value. So the general form of the error change $|e(t)|$ is shown in figure 2

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