ROBUST FUZZY SLIDING-MODE POWER SYSYTEM STABILIZER

BEHROOZ REZAEEALAM

ABSTRACT. A fuzzy sliding-mode control system that combines the merits of sliding-mode control and the fuzzy inference mechanism is proposed. First a sliding-mode controller with an integral operating switching surface is designed. Then a fuzzy sliding-mode controller is investigated in which a simple fuzzy inference mechanism is used to estimate the upper bound of uncertainties, then chattering is reduced. A detailed sensitivity analysis for a one-machine-infinite-bus system reveals that the fuzzy sliding-mode power system stabilizer is quite robust to wide variations in operating load and system parameters.

1. Introduction

A typical configuration of a single-machine infinite-bus power system is shown in Fig.1. The generator is equipped with an automatic voltage regulator (AVR) to control its terminal voltage and improve its dynamic stability limits. However, the AVR may add negative damping to the system and worsen its relative stability [1,2]. Conventional power system stabilizers (PSS) are proposed in [1,2] to improve stability by adding a phase lead to the system.

Since power systems are highly nonlinear, conventional fixed-parameter PSSs cannot cope with great changes in operating conditions. There are two main approaches to stabilizing a power system over a wide range of operating conditions, namely adaptive control [3-5] and robust control [6-8]. Adaptive control is based on the idea of continuously updating the controller parameters according to recent measurements.

However, adaptive controllers have generally poor performance during the learning phase, unless they are properly initialized. Successful operation of adaptive controllers requires the measurements to satisfy strict persistent excitation conditions; otherwise the adjustment of the controller's parameters fails.

Robust control provides an effective approach to dealing with uncertainties introduced by variations of operating conditions. Among many techniques available in the control literature, H_∞ and variable structure control have received considerable attention as PSSs. The H_∞ approah is applied to the design of a PSS for a single machine infinite-bus system in [6]. The basic idea is to carry out a search over all possible operating points to obtain a frequency bound on the system transfer function. Then, a controller is designed so that the worst-case frequency response of the losed loop system lies within prespecified frequency bounds. It is noted that the H_∞ design requires an exhaustive search and results in a high order controller.

On the other hand, the variable structure control is designed to drive the system to a sliding surface on which the error decays to zero [7-9]. Perfect performance is achieved even if parameter uncertainties are presented. However, such performance is obtained at the cost of high control activities (chattering).

In this study, a fuzzy sliding-mode control system which combines the merits of the sliding-mode control and the fuzzy inference mechanism is proposed. In the sliding-mode controller a switching surface that includes an integral operation [9] is designed, when the sliding mode occurs the system dynamic behaves as a robust state feedback control system. Furthermore, in the general sliding-mode control, the upper bound of uncertainties, which include parameter variations and external load disturbance, must be available. However, the bound of uncertainties is difficult to obtain in advance in practical applications. A fuzzy sliding-mode controller is investigated to resolve this difficulty, in which a simple fuzzy inference mechanism is used to estimate the upper bound of uncertainties.

Simulation results for a one-machine-infinite-bus system are presented to show the effectiveness of the proposed control strategies in damping oscillation modes.

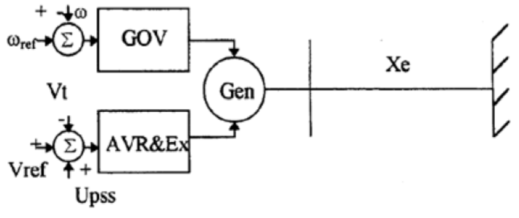

Fig.1 Basic components of a single-machine infinite-bus power system

Key words and phrases: Power system stabilizer, Fuzzy sliding-mode control..