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Chaotic ant swarm optimization for fuzzy-based tuning of power system stabilizer

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ABSTRACT

In this paper, chaotic ant swarm optimization (CASO) is utilized to tune the parameters of both single-input and dual-input power system stabilizers (PSSs). This algorithm explores the chaotic and self-organization behavior of ants in the foraging process. A novel concept, like craziness, is introduced in the CASO to achieve improved performance of the algorithm. While comparing CASO with either particle swarm optimization or genetic algorithm, it is revealed that CASO is more effective than the others in finding the optimal transient performance of a PSS and automatic voltage regulator equipped single-machine-infinite-bus system. Conventional PSS (CPSS) and the three dual-input IEEE PSSs (PSS2B, PSS3B, and PSS4B) are optimally tuned to obtain the optimal transient performances. It is revealed that the transient performance of dual-input PSS is better than single-input PSS. It is, further, explored that among dual-input PSSs, PSS3B offers superior transient performance. Takagi Sugeno fuzzy logic (SFL) based approach is adopted for on-line, off-nominal operating conditions. On real time measurements of system operating conditions, SFL adaptively and very fast yields on-line, off-nominal optimal stabilizer variables.

1. Introduction

Usage of fast acting, high gain automatic voltage regulator (AVR) in modern generator excitation system invites the problem of low frequency electromechanical oscillation. Transfer of bulk power across weak transmission lines; any disturbance such as sudden change in loads, change in transmission line parameters, fluctuation in the output of the turbine and faults, etc. also invites the problem of low frequency oscillations (typically in the range of 0.2–3.0 Hz) under various sorts of system operating conditions and configurations. The very common and widely accepted solution, prevailing in the utility houses to address this problem, is the usage of power system stabilizer (PSS). The PSS adds a stabilizing signal to AVR that modulates the generator excitation. Here, its main task is to create a damping electrical torque component (in phase with rotor speed deviation) in turbine shaft, which increases the generator damping. A practical PSS must be robust over a wide range of operating conditions and capable of damping the oscillation modes in power system. From this perspective, the conventional single-input PSS (machine shaft speed ($\Delta\omega_r$) as single input to PSS) design approach based on a single-machine-infinite-bus (SMIB) linearlized model in the normal operating condition has some deficiencies.

The two inputs to dual-input PSS, unlike the conventional single-input ($\Delta\omega_r$) PSS, are $\Delta\omega_r$ and ΔT_e. The processed output of the PSS is ΔV_{pss} that acts as an excitation modulation signal and the desired damping electrical torque component is produced. Modeling of IEEE type PSS2B, PSS3B, and PSS4B are reported in [1] and those models are taken in the present study.

Pole-placement [2] or eigenvalue assignment for single-input single-output system has been reported in the literature. A robust PSS tuning approach [3] based upon lead compensator design has been carried out by drawing the root loci for finite number of extreme characteristic polynomials. In [3], such polynomials have been obtained by using Kharitonov theorem to reflect wide loading condition. An approach based on linear matrix inequalities (LMIs) for mixed H_2/H_∞-design under pole region constraints has been reported by Werner et al. [4]. In [4], plant uncertainties are expressed in the form of a linear fractional transformation. Results obtained in [4] are compared to the results obtained in [5] based on quantitative feedback theory.

Linear quadratic control [6] has been applied for coordinated control design. The problem has been formulated as a standard LQR and a full feedback control was obtained from the solution that retains the dominant modes of the closed loop system. Structural constraints, such as, simple and decentralized control, feedback of only measured variables, etc. have been in use in

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