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Comparative seeker and bio-inspired fuzzy logic controllers for power system stabilizers

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ABSTRACT

Seeker optimization algorithm (SOA) is a new heuristic population-based search algorithm. In this paper, SOA is utilized to tune the parameters of both single-input and dual-input power system stabilizers (PSSs). In SOA, the act of human searching capability and understandings are exploited for the purpose of optimization. In SOA-based optimization, the search direction is based on empirical gradient by evaluating the response to the position changes and the step length is based on uncertainty reasoning by using a simple fuzzy rule. Conventional PSS (CPSS) and the three dual-input IEEE PSSs (namely PSS2B, PSS3B and PSS4B) are optimally tuned to obtain the optimal transient performances. From simulation study it is revealed that the transient performance of the dual-input PSS is better than the single-input PSS. It is further explored that among the dual-input PSSs, PSS3B offers the best optimal transient performance. While comparing the SOA with recently reported optimization algorithms like bacteria foraging optimization (BFO) and genetic algorithm (GA), it is revealed that the SOA is more effective than either BFO or GA in finding the optimal transient performance. 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 parameters.

1. Introduction

The problem of low frequency electromechanical oscillations arises from the usage of fast acting, high gain automatic voltage regulator (AVR) in modern generator excitation system [1]. Any form of disturbances such as sudden change in loads, change in transmission line parameters, fluctuation in the output of the turbine and faults, 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. Transfer of bulk power across weak transmission lines may also invite this problem of low frequency oscillation. The usage of power system stabilizer (PSS) is a very common and widely accepted solution, prevailing in the utility houses, to tackle this problem. The PSS adds a stabilizing signal to AVR which modulates the generator excitation. 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 the PSS) design approach based on a single-machine-infinite-bus (SMIB) linearized model in the normal operating condition has some deficiencies.

On the other hand, the two inputs to dual-input PSS are machine shaft speed ($\Delta\omega_r$) and the change in electrical torque (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 [2] and those models are taken in the present study.

Pole-placement or eigenvalue assignment for single-input single-output system has been reported in literature [3]. A robust PSS tuning approach [4] based upon lead compensator design has been carried out by drawing the root loci for finite number of extreme characteristic polynomials. In [4], 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. [5]. In [5], plant uncertainties are expressed in the form of a linear fractional transformation. Results obtained in [5] are compared to the results obtained in [6] based on quantitative feedback theory.

Linear quadratic control [7] has been applied for coordinated control design. The problem has been formulated as a standard

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