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Online Tuning of Power System Stabilizer Employing Genetic Programming for Stability Enhancement

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Abstract

This paper aims to design optimal power system stabilizer (PSS) employing genetic programming (GP) to enhance system stability through damping the low-frequency oscillations out. GP is used to develop model equations for PSS parameters where the inputs are generator terminal voltage, active and reactive powers. The dynamic performance of the proposed technique is validated through the values of statistical performance measures. The mean squared error (MSE) and mean absolute percentage error (MAPE) are quite low whereas the coefficient of determination ($R^2$) is reasonably high for the developed model. In addition, the eigenvalue and minimum damping ratio analysis, as well as time domain simulation, were carried out, which also demonstrate the efficacy of the proposed model.

Keywords: Damping Ratio; Eigenvalue; Genetic Programming; Low-Frequency Oscillations; Power System Stabilizer.

1 Introduction

Power system networks are not only the largest but also the most complicated systems ever devised by human being and getting more sophisticated with the increase of electricity demand. The interconnected power system networks are continually going through different types of disturbances ranging from load-generation mismatches to different types of faults. Generally, the regular disturbances to the networks lead to low-frequency oscillations (0.2-2.5 Hz), commonly known as electromechanical oscillations which may become very dangerous to the system by leading towards system blackout [1]-[3]. In addition, the integration of renewable energy sources to both generation and distribution networks are also playing a vital role in generating small signal oscillations as the output of these renewable sources are fluctuating over time[4]. To maintain the system stability after being subjected to any kind of disturbances generators are equipped with power system stabilizers (PSSs) as reported in[1]–[4]. The main purpose of PSS is to enhance system stability by damping out the unwanted oscillations by generating control signal through excitation system of the generators. PSS uses the principle of phase compensation technique to tune its parameters to provide proper damping [5].

A PSS is generally consisting of amplifier gain, lead-lag compensation element, and limiter. Though conventional PSS uses different constant numbers for the parameters of PSS [6], but a handsome number of intelligent approaches have been reported in the literature for optimal design of the PSS to damp out the small frequency oscillations [7]. The intelligent approaches are becoming popular because of their robustness and better performances though the techniques are exhaustive. Genetic algorithm (GA), a well-known evolutionary algorithm is employed for optimal PSS design to reduce system instability by generating proper control signal [8][9]. Swarm intelligence technique like particle swarm optimization (PSO) is also used to design PSS in order to damp out the unwanted oscillations [10][11]. Artificial bee colony (ABC), another intelligent technique is also used to design optimal PSS to enhance power system stability by suppressing the electromechanical oscillations as reported in [12][13]. Senjyu
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