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Adaptive PSS using a simple on-line identifier and linear pole-shift controller

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ABSTRACT

Implementation of an adaptive power system stabilizer (APSS) and experimental studies are presented in this paper. The APSS consists of an adaptive linear element (ADALINE) based identifier that identifies the power system as a third-order discrete auto-regressive moving average (ARMA) model and a pole-shift controller. The ADALINE is modeled so that its weights have a one-to-one relationship with the ARMA model parameters. The weights are updated at each sampling interval to track the dynamic characteristics of the actual system. The on-line updated ARMA parameters are used in the PS control algorithm to calculate the new closed-loop poles of the system that are always inside the unit circle in the *z*-plane. The calculated control is such that it achieves regulation of the system to a constant setpoint in the shortest interval of time. Experimental studies on a physical model of power system verify that the proposed adaptive PSS effectively damps the oscillations and improves power system stability.

1. Introduction

Power systems are complex multicomponent dynamic systems in which the system characteristics fluctuate with varying loads and varying generation schedules. The almost universally adopted fixed parameter conventional lead-lag compensators (called the conventional PSS or CPSS in the power utility industry) have some major limitations:

- As they are designed off-line, they require further tuning during commissioning.
- As they are tuned for one operating condition, they cannot achieve the same level of performance for varying operating conditions [1–4].
- As the power system configuration or conditions change with time, they require retuning at appropriate intervals for continued good performance.

In order to overcome the limitations of CPSS, adaptive control techniques [4–6] have been applied and are shown to improve the dynamic performance of the power system. A commercial version of the adaptive power system stabilizer (APSS), using recursive least squares (RLS) identification and pole-shift (PS) controller has been implemented and tested in the field [7].

ANNs have the ability to achieve mappings between the input and the output [8]. Once trained, the ANN can store the 'a priori' conditions and new information can be added on-line [9]. Applications of ANNs for power system control and identification have been reported in various publications [9–12].

Use of an ANN identifier to track and identify the non-linear plant in real-time and a neuro-controller to damp power system oscillations is described in [9,10]. A drawback of such ANN based techniques is the "black-box" like description between the input–output pairs. Also it doesn't involve any analytic treatment to prove the stability of the closed-loop system.

A more precise approach of using an ANN for identifying the model parameters and an analytical technique to compute the control signal is described in this paper. The generating unit is represented by a third-order discrete auto-regressive moving average (ARMA) model [5]. An adaptive neural network consisting of linear adaptive neurons called an ADALINE [13] is used to track the dynamic behavior of the generating unit. The APSS consists of an adaptive linear element (ADALINE) is modeled so that its weights have a one-to-one relationship with the ARMA parameters. Starting with off-line trained weights, the weights are further updated on-line and the information analyzed at each sampling interval to determine the characteristics of the actual system. The PS control algorithm [5] uses the on-line updated ARMA parameters to calculate the new closed-loop poles of the system that are always inside the unit circle in the *z*-plane. The calculated control is such that it achieves regulation of the system to a constant setpoint in the shortest interval of time.

Computer models of the power system can only approximate the dynamics of the system to a certain extent. There is always

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