Tuning of Power System Stabilizer (Unitrol D) in Benghazi North Power Plant

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ABSTRACT

The use of power system stabilizers (PSSs) to damp power system swing mode of oscillations is of practical important. The authors purpose is to retune the power system stabilizer (PSS1A) parameters in Unitrol D produced by ABB- was installed in 1995 in Benghazi North Power Plants (BNPPs) at General Electricity Company of Libya (GECOL). Power systems are steadily growing with larger capacity, so the optimal values of the power system stabilizer (PSS1A) parameters should be retuned. A particle swarm optimization technique (PSO) is used to determine the parameters of the PSS off-line. The objective is to damp the local and inter-area modes of oscillations that occur following power system disturbances. The retuned power system stabilizer (PSS1A) can cope with large disturbance at different operating points and has an enhanced power system stability. The MATLAB package with SIMULINK is used for the design and simulations.

Keywords: Lead-Lag Compensations, Particle Swarm Optimization (PSO), Power System Stabilizer (PSS), Simulink, Static Excitation System

1. INTRODUCTION

Benghazi north power plants (BNPPs) are the biggest power plants working in General Electricity Company of Libya (GECOL).

Excitation systems (Kunder, 1994) of the generators in BNPP was chosen for investigation because its work has the biggest impact on dynamic stability of the GECOL. A fast static excitation system (PID-system) UNITROL D (Klein, Rogers, & Kundur, 1991) produced by ABB was installed in 1995.

Power system are steadily growing with ever larger capacity. Formerly separated power systems are interconnected to each other. Modern power systems have evolved into systems of very large size. With growing generation capacity (Klein, Rogers, & Kundur, 1991; Kunder, Paserba, Ajjarapu, Andersson, Bose, & Canizares, 2004), different areas in a power system are added with even large inertia. As a consequence in large interconnected power systems, low frequency oscillations have an increasing importance.

The ability of a power system to maintain stability depends to a large of extent on the controls available on the system to damp the electromechanical oscillations (Klein, Rogers,
The basic function of an excitation system is to provide direct current to the field winding of the synchronous machine (Kunder, 1994). The protective functions ensure that capability limits of the synchronous machine, excitation system, and other equipment are not exceeded.

The excitation system also performs control and protective functions important for satisfactory performance of the power system by controlling the field voltage and by that the field current. The control functions include the control over voltage and reactive power flow (IEEE Standard 421.5-2005, 2006), and the enhancement of system stability.

The exciter is the main component in the AVR loop. It delivers the DC power to the generator field. It must have adequate power capacity (in the low megawatt range for large generators) and sufficient speed of response (rise time less than 0.1 seconds). The basic role of AVR is to provide constancy of the generator terminal voltage during normal small and slow changes in the load.

The power system stabilizer (PSS) uses auxiliary stabilizing signal to control the excitation system so as to enhance damping of power system oscillations through excitation control. Commonly used inputs are shaft speed, terminal frequency, and power. Where frequency is used as an input, it will normally be terminal frequency, but in some cases a frequency behind a simulated machine reactance (equivalent to shaft speed for many studies) may be employed.

The Power System Stabilizer (PSS) is used to improve the damping of the power system oscillations and the general stability of the power generation including transmission system. By means of power system oscillations, two modes of oscillations are to be deemed; “Local plant oscillations“ with typical range of oscillations from 0.8 to 2.0 Hz and “Inter-area oscillations“ with typical range of oscillations from 0.1 to 0.7 Hz.

The PSS designed using root-locus, frequency-domain, and state-space methods are introduced in Chow, Boukarim, and Murdoch (2004). The intelligent technologies such as Artificial Neural Network (ANN) and Fuzzy Logic have matured enough to be applied in many control fields (Fukuda & Shibata, 1992). However its difficult to implemented practically and there is no general theory available to assist the developer in the design if ANN and Fuzzy Logic. In Jalili and Mohammadi (2005) the transient stabilizer and voltage regulator is designed based on simple neuron structure and the online tuned performed by back propagation algorithm.

In this paper, particle swarm optimization technique (PSO) (Kennedy & Eberhart, 1995; Gating, 2004) is used to search for the optimal values of the AVR & (PSS1A) parameters.

The effectiveness of the IEEE standard AVR & PSS (Klein, Rogers, & Kundur, 1991) is illustrated by applying the AVR & PSS1A to single machine infinite bus. The single machine infinite bus is designed in SIMULINK with parameters of the generator no. 3 at BNPP as shown in Appendix B.

The paper proceeds as follows. In section 2 the basic idea of the fast static excitation system is presented. In section 3 introduces the (PSS1A) power system stabilizer model as IEEE standard. In section 4 the theory of the PSS is explained. In section 5 the overview of the particle swarm optimization is introduced. Section 6 system description that explained the three phase generator of BNPP is introduced. In section 7 the simulation study that explained the power system model used in study and the simulation results that shows the PSS performance is introduced.

2. ST1A EXCITATION SYSTEM MODE

The computer model of the fast static exciter potential-source controlled-rectifier excitation system shown in Figure 1 is intended to represent systems in which excitation power is supplied through a transformer from the generator terminals (or the unit’s auxiliary bus) and is regulated by a controlled rectifier (Kunder, Paserba, Ajjarapu, Andersson, Bose, &
Improved Pseudo-Gradient Search Particle Swarm Optimization for Optimal Power Flow Problem