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Effective Optimization Technique for Robust Power System Stabilizer Based on ABC

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***Abstract*— improving power system stability is one of the important issues in interconnecting systems. Power system stabilizer (PSS) is used to increase damping and dynamic stability of power system. To have effective PSS, optimization of its parameters is necessary. In this paper Artificial Bee Colony (ABC) is used to optimize PSS parameters. The proposed algorithm is applied to a single machine power system (SMIB). SMIB system performance is analyzed is case of without PSS, with Conventional PSS and optimized one. At the end simulation results show the effect of the proposed algorithm in damping the oscillations to enhance the Power System stability.**

***Index Terms*—** ABC, Dynamic stability, PSS, SMIB

LIST OF SYMBOLS	
A system state matrix	$\Delta e_q'$ Is the quadrature axis voltage
B system input matrix	ΔE_{fd} Is the excitation voltage
X vector of state variable	T'_{do} Time constant of excitation circuit
U vector of input reference signal	T_M Mechanical torque
M inertia constant	T_e Electrical torque
$\Delta\omega$ Speed deviation	x_d Synchronous reactance in d-axis
$\Delta\sigma$ Angle deviation	x'_d Transient reactance in d-axis

I. INTRODUCTION

Modern interconnected systems are nonlinear time varying system and operation situation can vary over a wide range. In these kinds of systems, small signal oscillation is one of the major problems in power system operation [1]. Some reason like as increasing the size of units, high speed excitation system has effect on small signal stability [2]. Low frequency oscillations present limitations on the power-transfer capability, thus power system need power system stabilizer (PSS) to enhance system damping [3]. Over the past four decades, various control methods have been proposed for PSS design to improve overall system performance. Several techniques such as root locus [4] and sensitivity analysis [5] and robust control [6] have been used in the design of PSS. Customarily, for small signal stability studies of a single machine infinite bus (SMIB) power system, Heffron-Phillips model is useful. This model gives credible results [7, 8]. The Heffron-Phillips model also is used for designing and tuning the classical power system stabilizers.

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II. System modeling

Figure 1 shows the system that considered for small signal stability. The synchronous generator considered is equipped with a PSS. The detail of study can be found in [9].

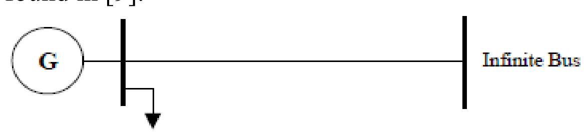

Fig.1: SMIB model

The state space that described system is as follow:

$\dot{x} = Ax + Bu$ (1)

$y = Cx + Du$ (2)

By adding PSS to the system the matrix A, B, C and D will be changed. Matrix A will be as follow:

$$[A'] = \begin{bmatrix} & & [A] & & 0 & 0 \\ & & & & 0 & 0 \\ & & & & 0 & 0 \\ & & & & 0 & K_A/T_A \\ 0 & (-K_1/M) & (-K_2/M) & 0 & -1/T & 0 \\ 0 & -K_C K_1 T_1/MT_2 & -K_C K_2 T_1/MT_2 & 0 & K_C\left(\frac{T_W - T_1}{T_W T_2}\right) & -\frac{1}{T_2} \end{bmatrix} \quad (3)$$

Matrix x is as follow:

$x = [\Delta\omega, \Delta\delta, \Delta e'_q, \Delta E_{FD}, x_5, u_E]^T$ (4)

The structure of PSS that used in this study is showed in figure 2.

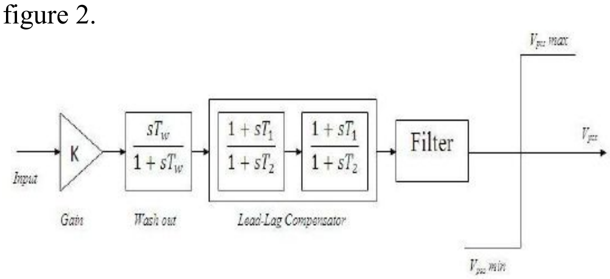

Fig.2: structure of PSS

As it's clear, PSS has gain, washout, lead-lag compensator, filter and limiter. Gain shows the amount of damping, the washout circuit works as high pass filter, lead-lag compensator provide lead phase, filter attenuate the torsional dynamics of the generator.

III. **Artificial Bee Colony** (**ABC**)

In this paper ABC algorithm is use to optimizations PSS parameter. Dervis Karaboga introduced Artificial Bee Colony algorithm in 2005 [10]. ABC algorithm was formed by observing the activities and behavior of the real bees, while they were looking for the nectar resources and sharing the amount of the resources with the other bees. The flowchart of ABC is presented in figure 3:

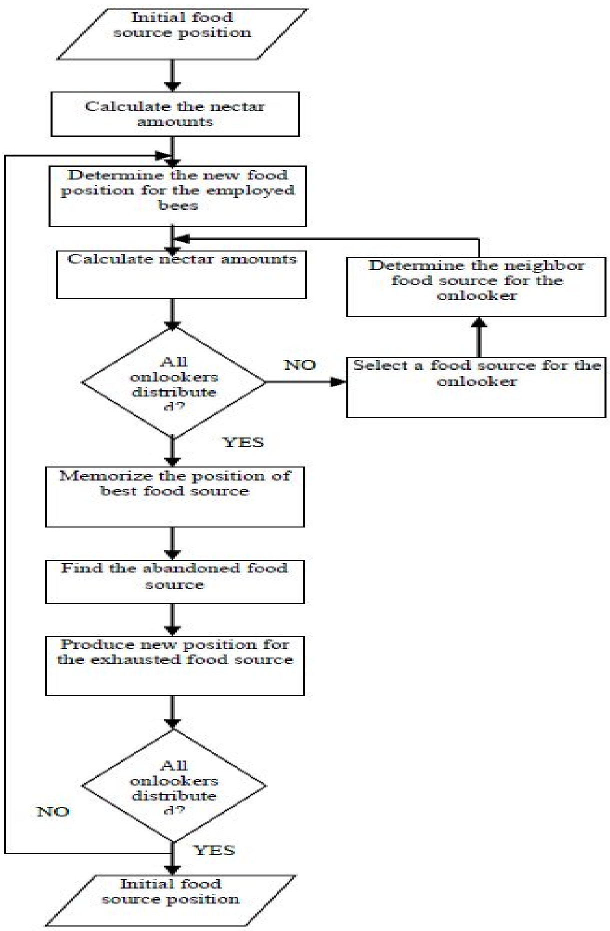

Fig.3: Flowchart of the ABC algorithm

To increase damping of power system modes, an objective function is defined as follow:

$J = \max(\sigma_i)$ (5)

By this objective function real part of eigenvalues is shifted to left side of S-plane. Its cause the system stability be better so that setting time and overshoot will improves. The problem constraints are the optimized parameter bounds, so it's as follow:

Optimize J

Subject to:

$T_1^{min} \le T_1 \le T_1^{max}$ (6)

$T_2^{min} \le T_2 \le T_2^{max}$ (7)

$K_C^{min} \le K_C \le K_C^{max}$ (8)

T optimal set of PSS parameters is obtained by employs Artificial Bee Colony (ABC) algorithm to solve this optimization problem.

Simulation results

In this part, simulation results are presented. Result of conventional model and optimized one are presented in part A and B respectively.

A. *Conventional model*

The results of system with PSS but without optimization are presented here. Rotor angle deviation (Δδ) and the rotor speed deviation (Δω) are presented in figures 4 and 5.

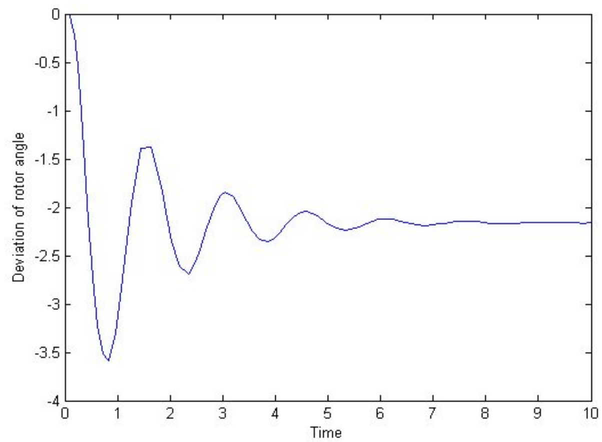

Fig.4: deviation of rotor angle

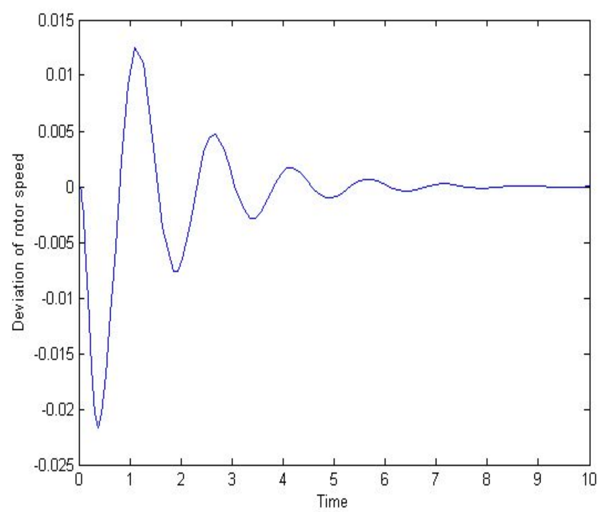

Fig.5: deviation of rotor speed

The result shows that angle and speed of rotor after period of time will be stable, so system is stable.

B. *ABC optimization*

In this section the results of the simulation system with ABC algorithm is presented. Figures 6 and 7 showed the rotor angle deviation (Δδ) and the rotor speed deviation (Δω) respectively.

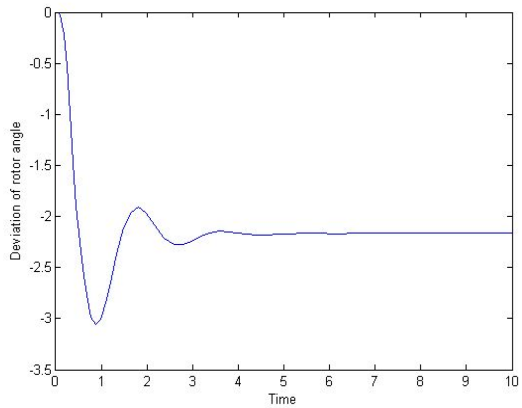

Fig.6 : deviation of rotor angle

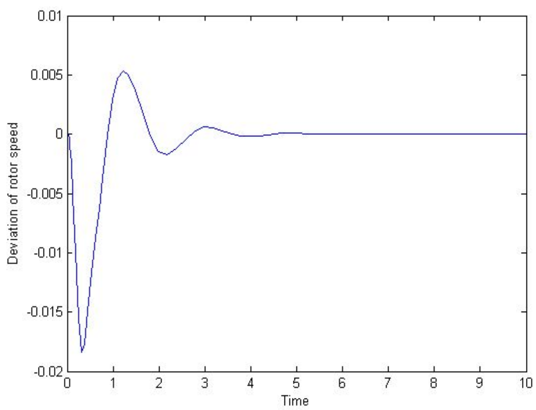

Fig.7: deviation of rotor speed

The results show that by using ABC, stability is improved. Difference between of ABC algorithm optimization and conventional model is presented in tables 1 and 2.

Table 1: Overshoot

	conventional	ABC optimization
$\Delta\delta$	0.79	0.206
$\Delta\omega$	0.013	0.005

Table 2: Settling time

	conventional	ABC optimization
$\Delta\delta$	7.54	4.21
$\Delta\omega$	7.62	4.35

Conclusion

PSS have been used to increase power system damping. This paper proposed effective technique to maximize real part of eigenvalue to have better dynamic performance. ABC algorithm is used to optimization PSS parameters for single machine connect to infinite bus so that better damping of low frequency oscillation was obtained. The conventional power system stabilizer is dynamic in nature and is required to be tuned according to power characteristics. Results show the overshoot and settling time is improved when proposed technique is applied.

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