A Comparison of Artificial Bee Colony Based FOPID and PID for SMIB System

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***Abstract* –The scheming of power transmission network is a complicated task due to the density of power system. This compound nature always causes a loss of the steadiness due to the fault. Whenever a fault is occurred in system, the whole system is disturbed leading to oscillation in rotor angle which leads poor power quality. The generator damage can occur due to increasing nature of oscillation. To lessen and get rid of these unsteady oscillations a power system stabilizer is needed which can produce a faultless compensatory signal. A comparative approach of performance of FOPID-type and PID- type power system stabilizer is presented in this paper for SMIB system considering small signal stability.**
Here an Artificial Bee Colony (ABC) is used for the parameter tuning of the stabilizer and the simulation is performed in MATLAB.

***Keyword* –ABC, FOPID, MATLAB, PID, PSS, SMIB.**

I. INTRODUCTION

A power plant consist of numerous synchronous generators which are planned to convert the mechanical energy to electrical energy which are supplied to the consumers. As the number of consumers are large , the load on the power system also increases. Due to this there is instability in transmission of power. A power system stabilizer is needed for the stability of the power system [1].
The dilemma of strength of steadiness is posed in a stern mode to promise a fine process of the generating system, and to beat the dilemma of oscillations. Electromechanical systems by recovering the damping of the system (steadiness), for these purposes signals stabilizers are introduced into the excitation system via its voltage [2]. These stabilizing signals will produce torques in phase with the speed variation of the generator for compensating for the phase delay introduced by the excitation system. The power system stabilizers[3] are beneficial in terms of cost and efficiency, are the usual means, not only to eliminate the negative effects of Voltage regulators, but also for damping electromechanical oscillations and steadiness of the system. These conventional stabilizers (often made in PI or PID) have the main disadvantage [4] poor adjustment to variations in system parameters and operating condition to be controlled (uncertainties). For the stability of the generating system in the presence of uncertainties, employ sophisticated control techniques such as: optimal, adaptive and robust rather than the conventional ones**.** One of the key qualities of regulators is the strength of steadiness that is the capability to sustain steadiness in the existence of variations or uncertainties. A Genetic Algorithm based power system stabilizer has been proposed [5]. For uninterrupted power delivery the steadiness of power system is required. Power system stability can be described as the aspect of a system that helps the system to preserve balance in normal conditions and also recover the balance condition under the state of interruption also. Different conditions could lead to the situation of unsteadiness in power system depending upon the type of process and system’s arrangement.
Preservation of synchronization is the key concern particularly for those power systems that depend upon synchronous machines. Apart from the synchronization dilemma, other issues occurring are loading problems such as voltage collapse etc.
The consistency of a electro energy system has been an key subject of learning in current decades. For secure operation of electro energy system, Power system steadiness is required. This provides a steady frequency and steady voltage within limits to consumers. A very consistent and cost efficient long term investment expertise is required in achieving this aim. Steadiness limits can express power transfer capacity. Steadiness (stability) has a huge impact to increase the consistency and the returns in a complex system. To achieve this, suitable control is mandatory to synchronize the generator after a fault occurs. This research work illustrates a fractional order proportional integral derivative controller and proportional integral controller for stabilizing the single machine infinite bus system using Artificial Bee Colony algorithm.

II. POWER SYSTEM STABILIZER (PSS)

A power system is said to be stable if it remain in a state of functional equilibrium under normal operating conditions and regain to an acceptable state of equilibrium after being subjected to a disturbance.
Power system stability can be divided into four different phenomena’s: wave, electromagnetic, electromechanical and thermodynamic. Here we consider only electromechanical phenomenon, which takes place in the windings of a synchronous machine. A disturbance in the electrical network will create power fluctuations between the generating units and the electrical network. In addition the electromechanical phenomenon will also disturb the stability of the rotating parts in the power system

[6]. Security of the power system relies on its ability to survive any disturbances which may occur without any interruption in the services. Figure 1 shows the functional block diagram of a typical excitation control system for a large synchronous generator [7].

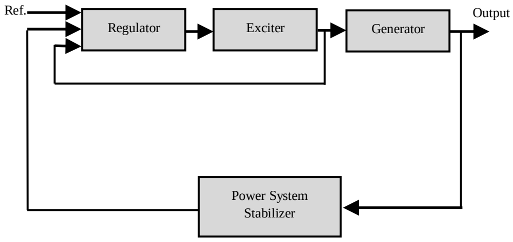

Figure 1: Functional block diagram of a synchronous generator excitation control system [7]

For the effective damping of oscillations of the rotor/turbine shaft, power system stabilizers are used. The conventional PSS was first suggested in the 1960s and classical control theory, defined in transfer functions, was employed for its design. Later the revolutionary work of DeMello and Concordia [8] in 1969, control engineers, as well as power system engineers, have exhibited great interest and made significant assistances in PSS design and applications for both single and multi-machine power systems.

Optimal control theory for stabilizing SMIB power systems was developed by Anderson [9] as well as by Yu [10]. These optimal controllers were linear. Adaptive control techniques have also been proposed for SMIB, most of which involve linearization or model approximation. Klein et al. [7, 11] presented the simulation studies into the effects of stabilizers on inter-area and local modes of oscillations in interconnected power systems. It was shown that the PSS location and the voltage characteristics of the system loads are significant factor in the ability of a PSS to increase the damping of inter-area oscillations. Nowadays, the conventional lead-lag power system stabilizer is widely used by the power system utility [12]. Other types of PSS such as proportional-integral power system stabilizer (PI-PSS) and proportional-integral-derivative power system stabilizer (PID-PSS) have also been proposed [13-14].

III. PROPOSED METHOD

SMIB with PID and FOPID

The PID controllers are described and named according to their nature of gains and proportional parameters. The controller output is the function of these parameters:

$$u(t) = K_P e(t) + K_I \int_0^t e(\tau) d\tau + K_D \frac{d}{dt} e(t) \quad (1)$$

Equation 1 shows the transfer function of PID controller.

Where, K_P: Proportional gain, a tuning parameter

K_I: Integral gain, a tuning parameter

K_D: Derivative gain, a tuning parameter

e: Error

t: Time or instantaneous time

τ: Variable of integration; takes on values from time 0 to t.

The FOPID controller has three parameters similar to PID controller along with the two additional parameters namely; the integral order λ, and the differential order μ. The transfer function of $PI^{\lambda}D^{\mu}$ controller is given by [16]:

$$G_c(s) = K_P + K_I s^{-\lambda} + K_D s^{\mu}, \quad \lambda, \mu > 0 \quad (2)$$

The differential equation for the $PI^{\lambda}D^{\mu}$ controller in the time domain is given by [18]:

$$u(t) = K_P e(t) + K_I D^{-\lambda} e(t) + K_D D^{\mu} e(t) \quad (3)$$

The PID and FOPID parameters are tuned using artificial bee colony technique.This method (inherited from nature) compute the value of K_P, K_I and K_D based on their previous values.

Power System Stability Analysis using ABC

Fitness Function for PSS

$$f(d_v) = \int_0^t |(d_r - d_v)| \, dt \quad (4)$$

Where,

$d_r = 0$ (Reference speed deviation)

$$d_v = f(v)$$

This fitness function is in terms of Integral absolute error (IAE).

Artificial Bee Colony Algorithm

Artificial Bee Colony Algorithm is based on an intelligent behaviour of honey bee colony that searches new food sources around their hive was considered to compose the algorithm. This colony of artificial bees consists of three groups of bees called employed bees, onlookers and scouts. While a half of the colony consists of the employed artificial bees, the other half includes the onlookers. There is only one employed bee for every food source. It means that the number of employed bees is equal to the number of food sources around the hive.

Main Steps of the ABC Algorithm

1. Send the scouts into initial food sources
2. Repeat

3. Send the employed bees onto the food sources and determine their nectar amounts
4. Calculate the probability value of the sources with which they are preferred by onlooker bees
5. Stop the exploitation process of the sources abandoned by the bees
6. Send the scouts to the search area for discovering new food sources, randomly
7. Memorize the best food source found so far
8. Until(requirements are met)

IV. SIMULATION AND RESULTS

The performance of proposed algorithm has been studied by means of MATLAB simulation. A fault is introduced at time t=5sec which leads to oscillations when stabilizer is not used. From results it is clear that the oscillations are minimized by using stabilizers. The settling time for PID is found to be t=12.9615seconds while for FOPID the settling time is much reduced as shown which is found to be t=8.7688seconds. Thus, FOPID works much better than the PID for stabilizing the SMIB system

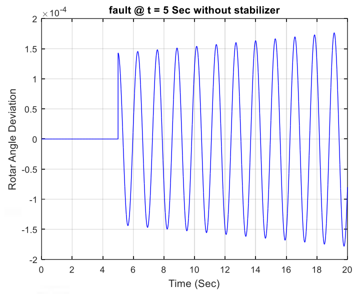

Figure 2: Rotor angle deviations without stabilizer

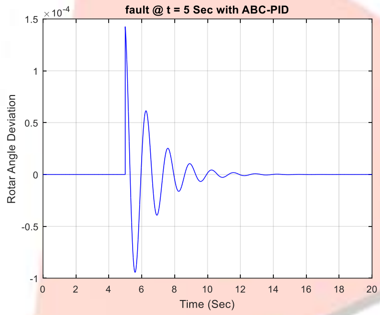

Figure3: Rotor angle deviations for ABC-PID

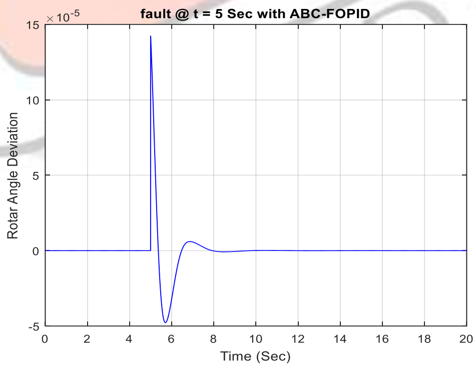

Figure 4: Rotor angle deviations for ABC-FOPID

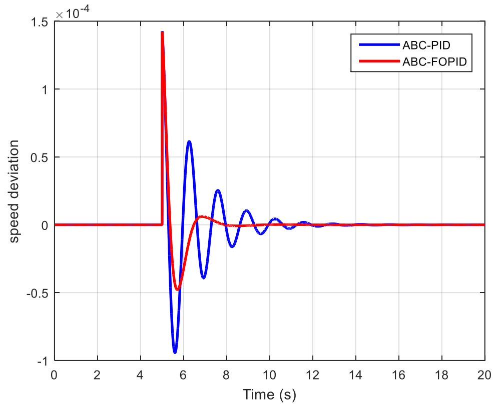

Figure 5: Comparison of ABC-FOPID and ABC-PID

ABC-PID : Settling Time (S) : 12.9615
ABC-FOPID : Settling Time (S) : 8.7688

V. CONCLUSION

This paper presents a designing of power system stabilizer for single machine infinite bus system. A fitness function is derived which is aimed to minimize rotor speed deviation as a function of stabilizers parameter. A proportional integral derivative controller (PID) and fractional order proportional integral controller(FOPID) has been utilized as a power system stabilizer and ABC based optimization technique is used for tuning of the parameters of the stabilizing device of the power system. It is found that a fractional order proportional integral derivative controller (FOPID) performs much better than a proportional integral controller for the damping of the oscillations. The settling time is much reduced when using FOPID type stabilizer.

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