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Transient Stability Analysis of Multi Machine System by PSS Parameter Design using GA

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Abstract— **In this paper the desirable tuning of parameter of Power System Stabilizer by the method of genetic algorithm is described. PSS parameters will be so selected which will stabilize power system oscillations and transform it to an easy optimization problem to be solved using Genetic GA. There is a lot of advantage of Genetic Algorithm (GA) for tuning the parameters of PSS. It is not dependent of the complication of performance index. The results of above mentioned method have been analyzed and compared here on 3-machine 9 bus system. The GA technique for tuning the PSS parameter is an a better alternate way to the classical fix gain design for stabilizer because it is as simple as classical PSS and at it also guarantees a robust, appropriate performance on a vast range of power system operating condition.**

Keywords— ***Power System Satiability, Coordinated Design, PSS, Genetic Algorithm***

I. INTRODUCTION

In the days of early sixties, maximum generators were interconnected and the most efficient were Automatic Voltage Regulators. The system stability can be improved by the use of closed loop feedback control. Over many years a lot of considerable effort had been experimented in lab research and on-site practical studies for designing such controllers. This device now called as a Power System Stabilizer (PSS). PSS is an auxiliary control device employed on synchronous generator, used in interconnection with excitation system to give control signals for improving the power system oscillations damping and to improve limits of power transfer. Over past many years, many techniques/methods has been developed and changed to design PSSs and various intelligent controllers which has designed with artificial neural network controllers (ANN) and fuzzy logic controllers which are intelligent schemes. Also, now a days, there are various other new techniques for optimizing the PSS parameter e.g. particle swarm optimization (PSO) and Genetic Algorithm (GA). The designs of stabilizers earlier were based on idea derived by the classical control method. A lot of such kind of designs are practically realized and widely used in actual system. The feedback of these controllers appropriately phase compensated signals deduced from power transfer, speed and frequency of operating generators. We will take either single or different combination. All these input signals generate an extra rotor torque so that low frequency oscillations can be damped. The phase lag and lead compensation and gain of the stabilizer are tuned by using suitable mathematical models, added by a better understanding of the operation.
These controller's main principle of operation is based on the concept of damping torque and synchronizing torque in the generator. In other way, GA is the strongest and best algorithm to get the best parameters.

II. GENETIC ALGORITHM

The application of Genetic Algorithm in PSS design gives better flexibility regarding controller design and fitness function. Additionally to the constraints on the parameter limits, the optimized problem based on GA can easily achieve control performance constraint, such as closed-loop minimum performance.

By the help of GA we will get an optimal tuning for PSS parameters simultaneously, which will take care of interactions among different PSSs. For power system fitness calculation Flow chart of GA has been shown [3]. The main characteristics of GA is a path to conduct research. This algorithm is a solution to the problem of "population" and make them to get a better result for many generations of "evolution" that may be the general form of the GA. Population we are considering at the time of the algorithm is a collection of candidate solutions. During the generation of an algorithm, some members have been "born" in population, while some "die" out. The 'goodness' of the solution represented by an individual can be measured by how fit an individual is. Better the solution and higher the fitness obviously, this will dependent on problem being solved.

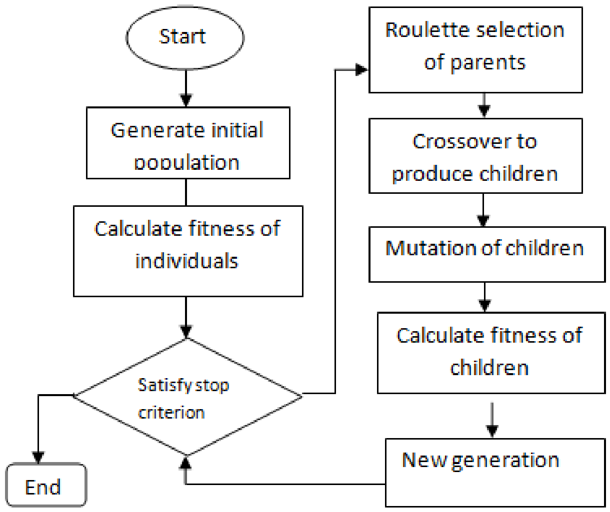

Fig.1.Flow Chart For Genetic Algorithm

III. PROBLEM STATEMENT

A. Power System Network

The complex and nonlinear network which is 3-machine interconnected power system network can be illustrated by a set of differential (mathematical) equations by collecting linearized models for each of these separately: generator, load, and controls in power system and by linking them suitably via the suitable power system network algebraic equations. Generators have been represented by 3rd order model in power system and the objective is the one of designing the PSS parameter. A 3-machine system has been linearized about the operating point for a given working condition. It is being used for simulation in time domain.

B. Power System Stabilizer Structure

Power system stabilizer has been used for overcoming negative damping effect of high gain exciter. The PSS acts as a auxiliary controller to excitation system. Inputs to the PSS may be change in frequency, speed, power or a combination of three. The output produced is a voltage signal inserted in excitation system for controlling the output of exciter [6]. Basic idea of the PSS is to insert a pure damping term to counter negative damping effect of exciter.

Let PSS have a transfer function G(s) and the change in the speed be the input to the (PSS). The output of the PSS be ΔV_{PSS}. The output of PSS is added as a supplementary signal to the exciter reference hence

$$T_A \frac{d\Delta E_{fd}}{dt} = -\Delta E_{fd} + K_A(\Delta V_{ref.} + \Delta V_{PSS} - \Delta V_t) \tag{1}$$

How the PSS output ΔV_{PSS} effects the synchronizing and damping torque can be analyzed by finding the transfer function between ΔV_{PSS} and the electrical torque ΔT_e.

$$\Delta T_e = \frac{K_2 K_3 K_A}{(1+sK_3T'_{do})(1+sT_A)+K_3 K_A K_6}\Delta V_{PSS} \tag{2}$$

Hence, PSS improves the damping of system by providing a positive damping torque. Since, introducing zeros or poles alone is not possible a practical method is to take PSS transfer function as

$$G(s) = K_{PSS}\frac{sT_W(1+sT_1)}{(1+sT_W)(1+sT_2)} \tag{3}$$

Where, K_{PSS} is the gain, is the washout filter time constant. T_1, T_2 the lead-lag network time constants. n is the number of lead-lag network blocks. The block diagram of the PSS is shown in fig.2

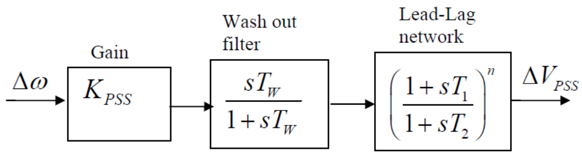

Fig.2 Block diagram of PSS

C. PSS Parameter Design Using GA

GA method has been applied for designing PSSs in a 3-machine 9-bus system network. The diagram (single line) for above system has been shown in Fig 3. Here, it is considered that every machine is equipped with AVR and a Power system stabilizer. For optimization the problem, 3- machine 9-bus system network is mentioned.

Objective functions defined are as given below:

$$f = \sum_{i=1}^{n} \Delta w * tdt \tag{4}$$

Minimize f subject to

$K_i^{min} < K_i < K_i^{max}$ i=1, 2

$T_{ni}^{min} < T_{ni} < T_{ni}^{max}$ i=1, 2, 3, 4

$T_{di}^{min} < T_{di} < T_{di}^{max}$ i=1, 2, 3, 4

IV. CASE STUDY

3-machine 9-bus system

A 3-machine 9-bus power system structure has been represented in Fig.3 [1]. It is considered effectiveness and reliability of the proposed method for evaluating the nominal three cases, normal, light and heavy baggage designated. In this case we will analyze the transient stability the behavior of transients and overshoot and settling time.

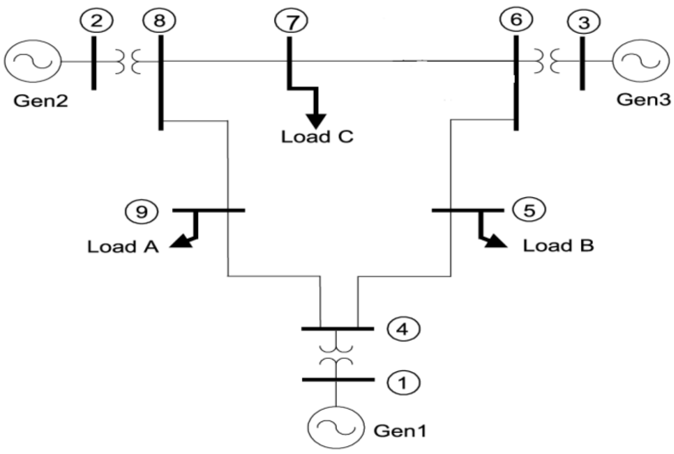

Fig.3

A. *PSS Design based on GA*

Here, PSS according to participation factor have been connected to generator G2 and G3 in test power system. The parameters of PSS should be so tuned optimally that transient stability of overall system is improved in a robust method under different operating states and system disturbances.

TABLE I

OPTIMAL VALVES OF PSS PARAMETER BY GA

Gen	K	Tn1	Tn2	Td1	Td2
2	1.7276	2.1763	1.6328	.1945	1.7700
3	4.3632	2.5501	.3687	.8333	1.3709

The parameters of PSSs calculated using GA, Mutation probabilities and crossover have been chosen 0.5 and 0.07 respectively. Number of individuals in every generation has been selected as 100.

B. *Time Domain Simulation (Nonlinear)*

To evaluate or check how robust and effective proposed controllers are, simulation studies have been done for many fault disturbances and different fault clearing sequences.

1) *Normal Loading Condition*

Initially our system is loaded at 1 per unit, all the three machine are supplying power.
Initially machine is running at 1 per unit, here is the result when we are applying 3-phase 6-cycle fault at t=10 sec.
I have taken time starts from zero when fault occur.

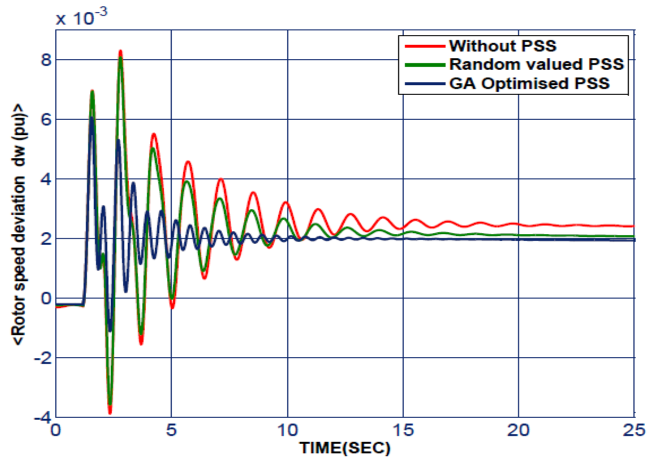

Fig.5

Fig. 5 shows the speed of machine 2 after applying 3-phase fault under nominal condition. red line represent speed without PSS, red line represents speed with random valued PSS and blue line represent PSS optimised(desirable) speed.in blue line the overshoot is reduced and its settling time is less.

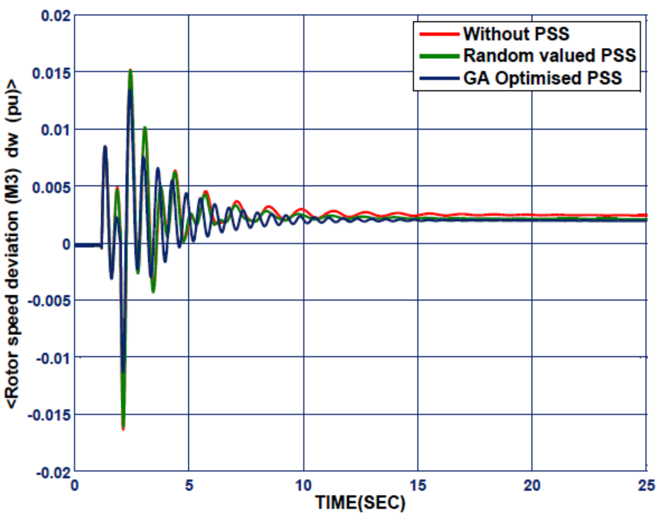

Fig.6. speed of machine 3

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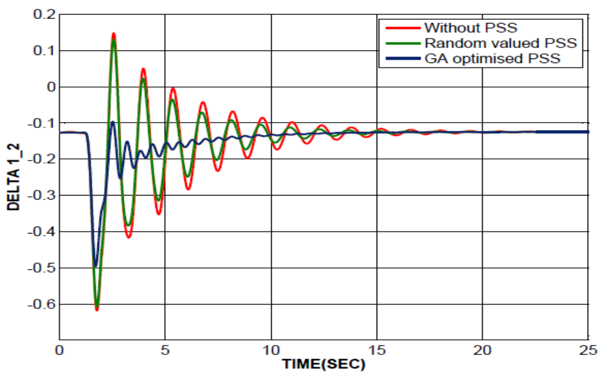

Fig.7 delta 1_2

Fig. 7 shows angle difference between machine 1 and 2

II) Lightly Loaded Condition

In lightly loaded condition loading here is lying between0 .8 to 1 per unit.

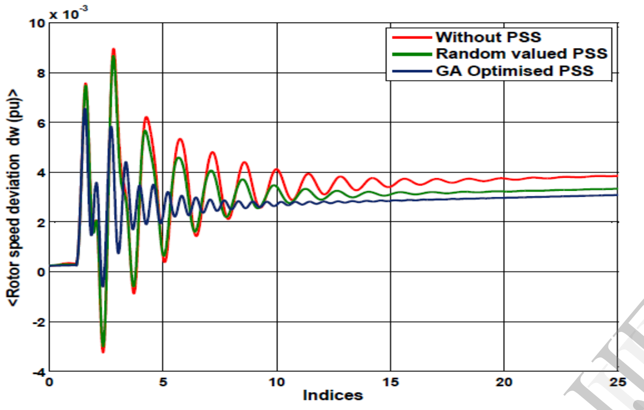

Fig.8

Speed of machine 2 under lightly loaded condition and here still optimized PSS is working.

III) Heavily Loaded Condition

In heavily loaded condition the loading here is varying between 1 to 1.2 per unit

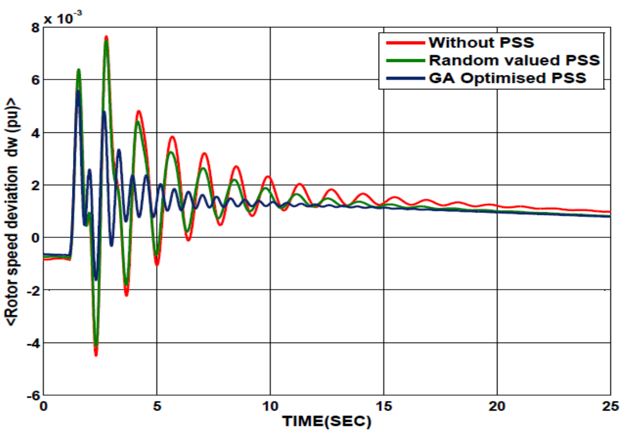

Fig.9

Speed of machine 2 under heavily loaded condition and here GA optimized PSS is still working.

IV) Voltage Terminal of Three Machine

Here under normal loading condition the terminal voltage of three machine is presented here-

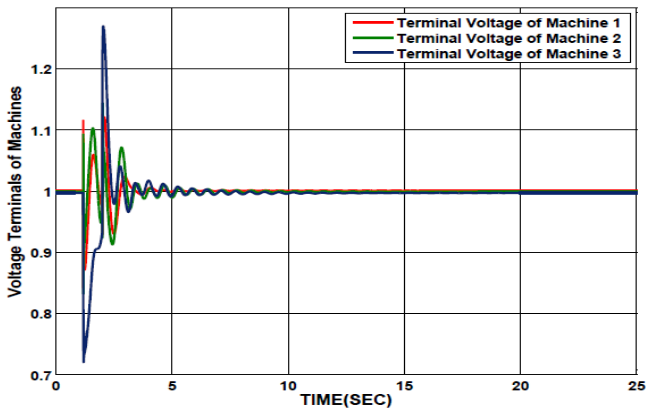

Fig. 10 3-Machine terminal voltage

v) Power Transfer by Machines

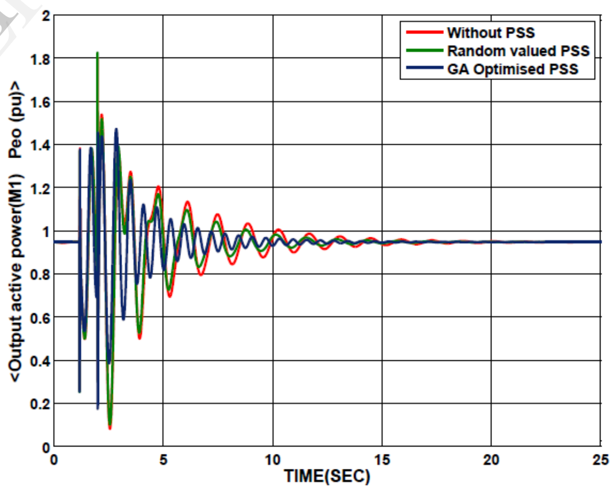

Fig.11. Power transfer by machine 1

Here power is transferred effectively by GA optimized PSS and it its settling time is also less.The independence of the Genetic Algorithm (GA) technique on the complexity of performance index is its great advantage in tuning PSS parameters. The efficiency of the GA technique has been tested here on 3-machine 9-bus multi machine power systems. It has been shown and approved by results being presented in this paper that GA in 3-machine 9-bus multi machine system can tune and optimize various PSS parameters. System can be made stable by the new values of PSS parameters and they are appropriate whereas classical approach could not guarantee such stability. So, the proposed technique for tuning of the parameters of PSS can be a better alternative to the conventional stabilizer design employing fixed gain because it has simplicity of conventional PSS and it also guarantees a robust acceptable performance over a vast range of different system operating conditions.

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