ROBUST PSS-PID BASED GA OPTIMIZATION FOR TURBO-ALTERNATOR

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Abstract-Proportional Integral Derivative (PID) controllers are widely used in many fields because they are simple and effective .Tuning of the PID controller parameters is not easy and does not give the optimal required response, especially with non-liner system. In the last two decades many intelligent optimization techniques were took attention of researchers like : Particle Swarm Optimization (PSO) and Genetic Algorithm (GA)techniques. The purpose of this paper is to present the modeling and simulation of conventional power system stabilizer (PSS-PID) .then we use Genetic Algorithm technique to find the best parameters of the optimal(PSS-PID) .The obtained results have proved that (G.A) are a powerful tools for optimizing the PSS parameters, and more robustness of the system IEEE SMIB .

Keywords- Genetic Algorithm, PID controller, PSS, power system stabilizer, Synchronous Generator

1 Introduction

In the recent years ,PID controller has been used widely for processes and motion control systems in industry. Now more than 90% control systems is still PID controller.

The Classical controllers PSS [1,2] (PI or PID) have a leading role in increasing static and dynamic stability degree, and damping electro mechanicals oscillations generated by the rotor (the inductor).However ,a robustness test (a disturbance injected on the EPS) showed that PID -AVR and PSS arehardly robust ,so ,in order to improve their efficiency(robustness),we used the (G.A) for the optimization and the adjusting of PSS parameters [3,4].

A genetic algorithm (GA) is a search technique used in computing to find exact or approximate solutions to optimization and search problems.

The basic principles of GA were first proposed by Holland 1970s. This technique was inspired by the mechanism of natural selection, a biological process in which stronger individual is likely tobe the winners in a competing environment. Genetic Algorithms have been subject to intensive research in the last decade, the latest results showing successful solutions to many problems.

The development covers a wide variety of designs and engineering applications. The solutions are, on several cases, more efficient, more elegant, and more complex than the solutions discovered by the human mind.

2 DYNAMIC POWER SYSTEM MODEL

In this paper a simplified dynamic model of power system, namely, a single machine connected to an infinite bus (SMIB) is considered. It consists of a single synchronous generator connected through a parallel transmission line to a very large network approximated by an infinite bus as shown in figure 1.

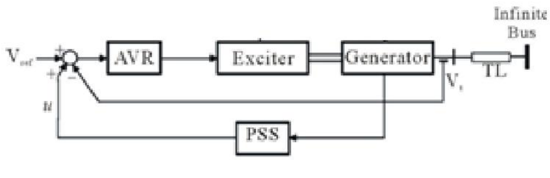


Fig.1 Block schematic diagram of the proposed SMIB Power system controller

Let the state variable of interest be the machine's rotor speed variation and the power system acceleration.

$$x1 = \Delta w \quad (1)$$

$$x2 = \Delta P = P_m - P_e \quad (2)$$

Where x1 is the speed deviation and x2 is accelerating power, Pm and Pe represents respectively the mechanical and electrical power. It is possible to represent the power system in the following form:

$$x1 = \Delta w \quad (3)$$

$$\alpha x_2 = f(x_1, x_2) + g(x_1, x_2)u \quad (4)$$

$$y = x_1 \quad (5)$$

Where α=1/2H and H is the per unit inertia constant of the machine. x=[x1x2] is the state vector of the system and f(x1,x2) and g(x1,x2) are nonlinear functions and u is the PSS (Power System Stabilizer) control signal .

3 PSS-PID CONTROLLER MODEL

The PSS-PID controller is well known and widely used to improve the dynamic response as well as to reduce or eliminate the steady state error. The derivative controller adds a finite zero to the open loop system transfer function and improves the transient response. The integral controller adds a pole at the origin, thus increasing system type by one and reducing the steady state error due to a step function to zero.The transfer function of a PSS-PID controller is given in the s-domain as follows:

$$\Delta E_f = \omega(p).\left[\left(\omega_{0u}(p) + \omega_{1u}(p)\right)\Delta U(p) + \left(\omega_{0\omega}(p) + \omega_{1\omega}(p)\right)\omega_{bf}(p).\Delta\omega_u(p) + \omega_{if}(p).\Delta i_f(p) + \omega_{uf}(p).\Delta u_f(p)\right] \quad (6)$$

E_{fd0}- value of the control signals in the steady state generator.

4 GENETIC ALGORITHMS

The control method is based on genetic algorithm (GA) to coordinate control of power system stabilizer (PSS) based stabilizer installed in single machine infinite – bus system (SMIB). The stabilizer design problem is transformed into an optimization problem where genetic algorithm (GA) will be applied to search for optimal parameter settings by maximizing the minimum damping ratio of all complex eigenvalues.

The effectiveness of the proposed control in improving the power system dynamic stability is verified through eigenvalue analysis, time – domain simulations under different loading conditions, and practical verifications.

Genetic algorithms (GA) are a stochastic global search method that emulates the process of natural evolution. The genetic algorithm starts with no knowledge of the correct solution and depends entirely on responses from its environment and evolution operators (reproduction, crossover and mutation) to arrive at the best solution.

A genetic algorithm is typically initialized with a random population. This population is usually represented by a real-valued number or a binary string called a chromosome. How well an individual performs a task is measured and assessed by the objective function, which assigns each individual a corresponding number called its fitness. The fitness of each chromosome is assessed and survival of the fittest strategy is applied. There are three mains operators for a genetic algorithm – reproduction, crossover and mutation.

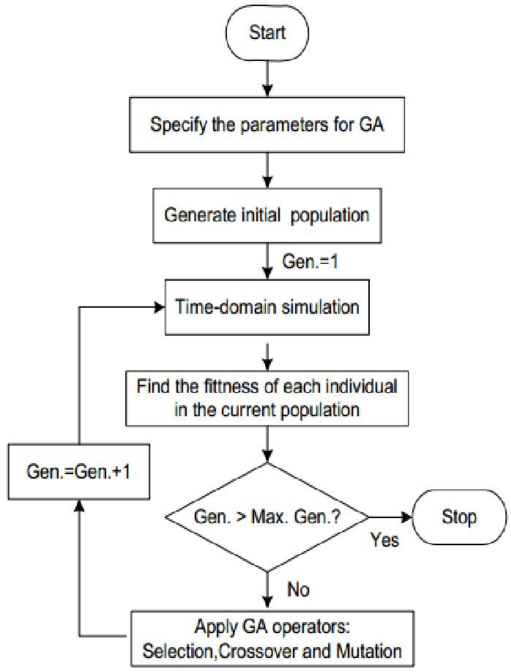


Fig.3 Flowcharts of genetic algorithm

5 GA BASED TUNING OF THE CONTROLLER

The optima value of PSS-PID controller parameters K1w, K2w, T1, T2 are to be found using GA.

All possible sets of controller parameters values are particles whose values are adjusted to minimize and maximize the objective function, which in this case is the error criterion, and it is discussed in detail. For the PSS-PID controller design, the controller settings estimated results in a stable closed loop system are ensured.

6 IMPLEMENTATION OF GA BASED PSS-PID CONTROLLER

6.1. Objective function

The purpose of the PSS use is to ensure satisfactory oscillations damping, and ensure the overall system stability to different operation points. To meet this goal, we using a function composed of two multi-objective functions [13].

This function must maximize the stability margin by increasing damping factors while minimizing the system real eigenvalues. Therefore, all eigenvalues are in the stability area, the multi-objective function calculating steps are:

1-formulate the linear system in an open –loop (without PSS);

2-locate the PSS and its parameters initialized by the G.A through an initial population;

3- Calculate the closed loop system eigenvalues and take only the dominant modes:

$\lambda = \sigma \pm jw$

4- Find the system eigenvalues real parts (σ) and damping factor ζ;

5- Determine the (ζ) minimum value and the (- σ) maximum value, which can be formulated respectively as: (minimum (ζ)) and (maximum -(σ));

6- Gather both objective functions in a multi-objective function F as follows:

$Fobj = -\max(\sigma) + \min(\xi)$

7- Return this Multi-objective function value the to the AG program to restart a new generation.

*The genetic algorithm parameters chosen for the tuning purpose are shown in table (1)

GA Property	Value/Methode
Population Size	100
Maximum Number of generations	120
The range of tuning parameters	5<K1W<10,5<K2w<10 0.0005<T1<0.1, 0.0001<T2<0.1
Function	$Fobj = -\max(\sigma) + \min(\xi)$
Selection Method	tournoi
Crossover Probability	0.7
Mutation Probability	0.01

Table 1 Parameters of GA

To show the performance of the control system, simulation time responses from the dynamic power system with the proposed genetic PSS-PID controller are carried out with MATLAB-SIMULINK.

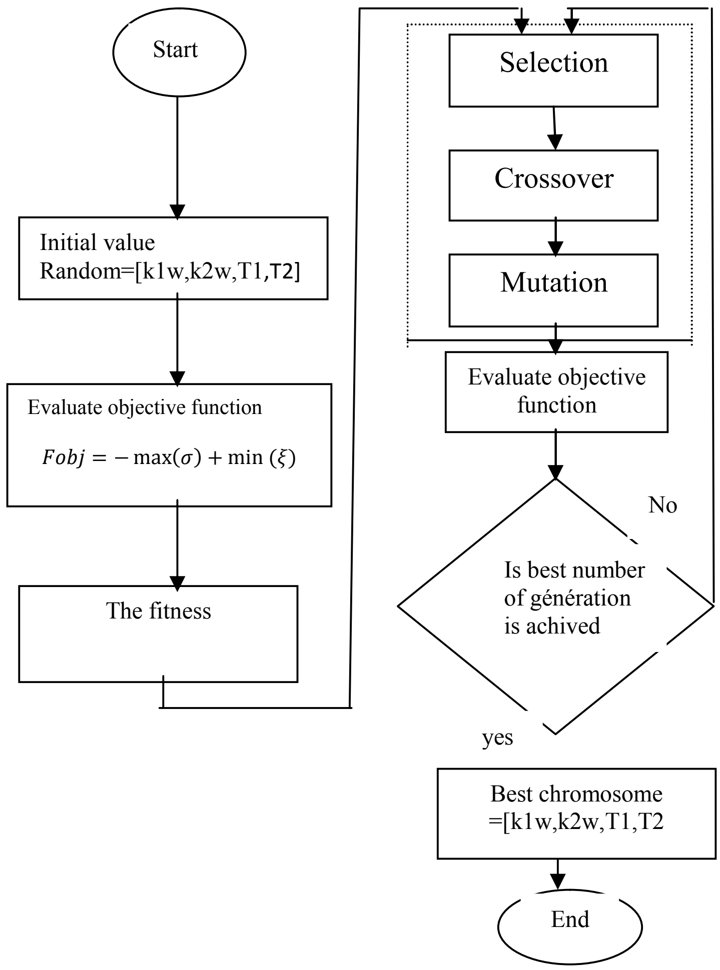


Fig.4 The algorithm for the computation of PSS-PID parameters using genetic algorithm.

7 THE SIMULATION RESULT UNDER MATLAB-SIMULIK

To evaluate the effectiveness of the proposed PSS-GA to improve the stability of power system, the dynamic performance of the proposed PSS was examined under different loading conditions. The performance of the GA based PSS is compared with the PSS.

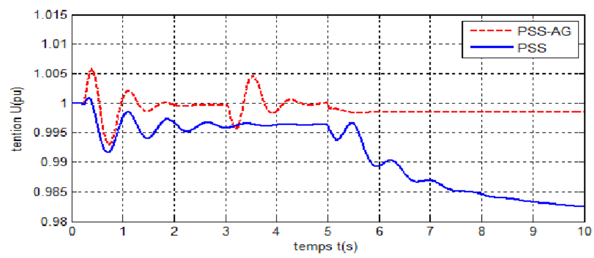
We simulated three operating: the under-excited, the rated . and the over-excited.

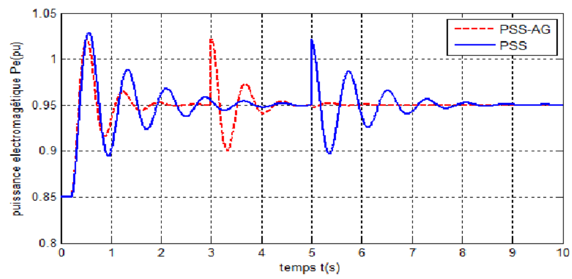
Our study is interested in the Powerful Synchronous Generators of type: TBB-500 (parameters in Appendix 2)

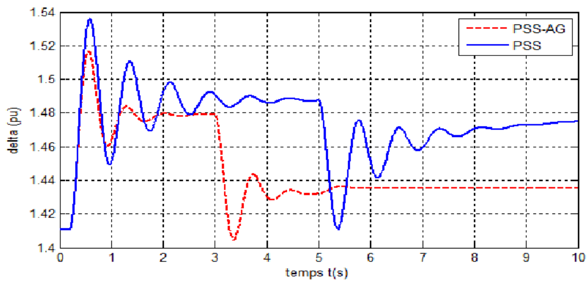
	Nominal	under-excited	Over-excited
Q	0.1896	-0.0292	0.6445
K1w	6.3137	4	8.7059
K2w	9.7647	7.2549	10
T1	0.0532	0.0352	0.0785
T2	0.0828	0.0314	0.0718
σ	-3.5494	-3.2351	-3.7382
ξ	0.3030	0.3947	0.5171

Table.2 The optimized parameters for PSS-PID (K1w,K2w,T1,T2 and σ,ξ)

In the Figures A,B and C show an example of simulation result with respectively 'Ug' the stator terminal voltage; 'Pe' the electromagnetic power system, 'g' Slip, 'delta' The internal angle.







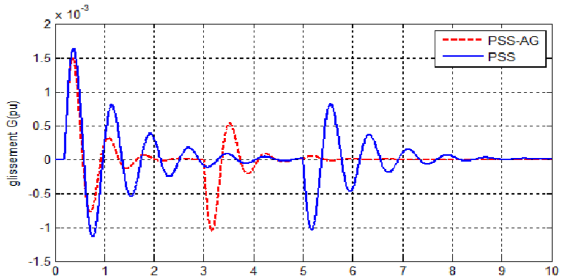
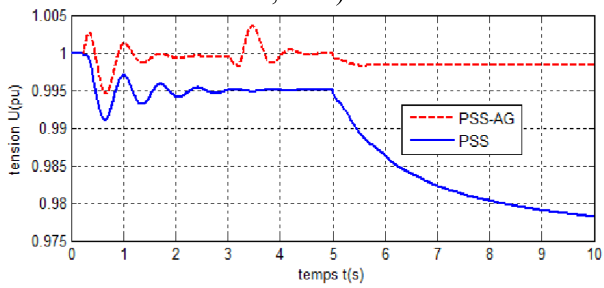
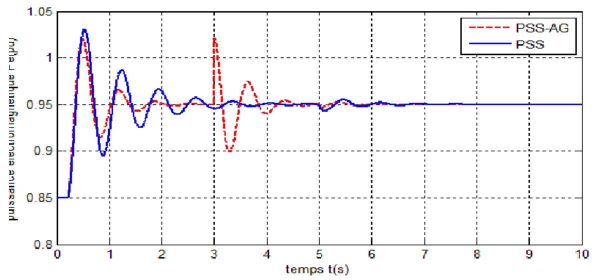
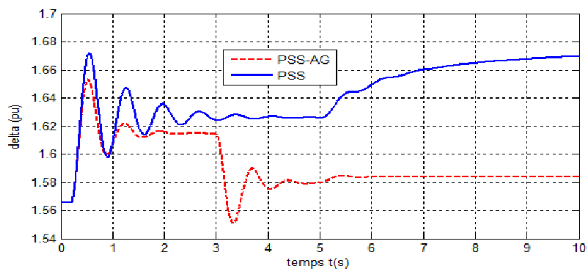


Fig.4 functioning system in the nominal régime used of TBB-500 connected to a long line with, H∞ -PSS,PSSPID(robustness tests) (Ug, Pe ,glissement ,delta)







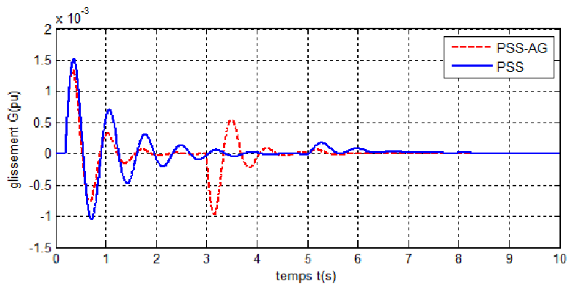


Fig.5. functioning system in the under-excited used of TBB-500 connectedto a long line with, H∞ -

PSS,PSSPID(robustness tests) (Ug, Pe ,glissement ,delta)

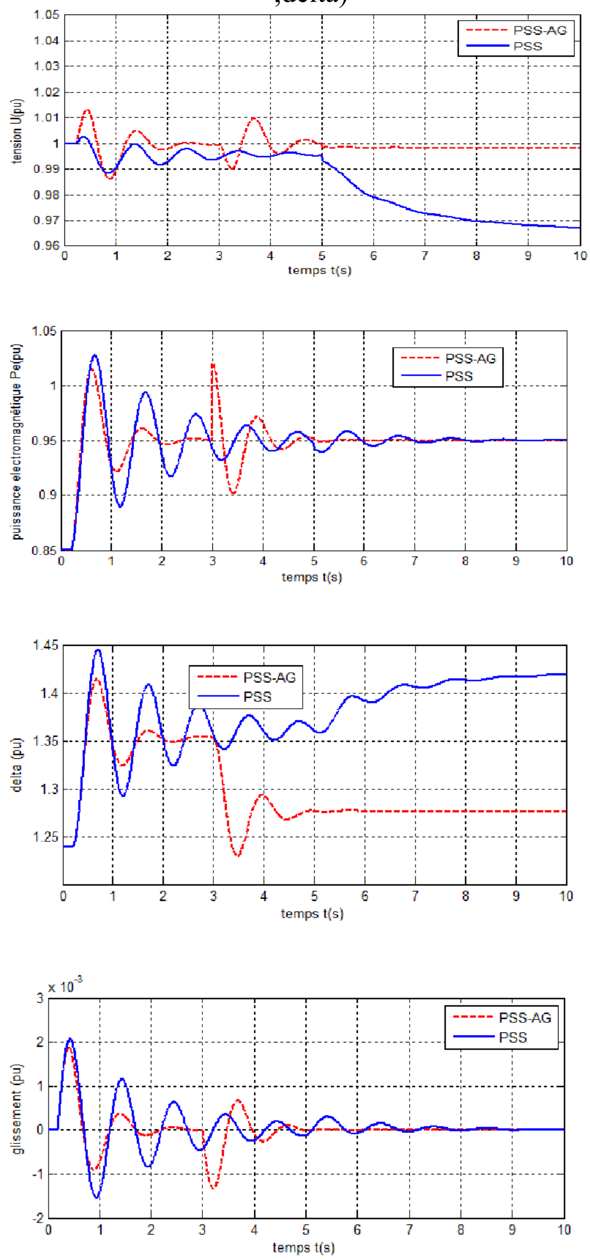


Fig.6 functioning system in the over-excited used of TBB-500 connected to a long line with, H∞ -PSS,PSSPID(robustness tests) (Ug, Pe ,glissement ,delta)

From the simulation results ,The effect of the controller can be realized from decrement of dynamic performances (static errors negligible so better precision, and very short setting time so very fast system., and we found that after few oscillations, the system returns to its equilibrium state even in critical situations (specially the under-excited regime) and granted the stability and the robustness of the studied system.

8 CONCLUSION

This paper has presented an intelligent controller (Genetic–PSS-PID),compared with a classical PSS-PID controller.

The optimum values of the PSS are globally search by GA. The dynamic performance of the GPSS is superior than the conventionally tuned PSS under small as well large perturbation. Simulation of the response of the proposed PSS to various disturbances changes in network configuration and system loading have demonstrated the effectiveness of the GPSS.

References:

[1] .Sadiq K. Ahmed ,Magid E.Dubakh Ayam M.Abbas.« Design of Electronic PID Controller Using Genetic Algorithms»,Al-Mansour Journal/ Issue (15) 2011.

[2] .F ad hel Abbass Jumaa.« Design An Intelligent Controller Based On Genetic-PID Algorithm For DC Motor Control», Journal of Engineering and Development, Vol. 18, No.3, May 2014,ISSN 1813- 7822.

[3] .GHOURAF Djamel Eddine, NACERI Abdellatif, DERRAR Amina .« Optimization by genetic algorithm for synthesize a robust stabilizer PSS applied to power system (application under GUI/MATLAB)», Proceedings of the 2014 International Conference on Circuits, Systems and Control

[4] .Demello F.P. and Concordia C., « Concepts of synchronous machine stability as affected by excitation control », IEEE Trans. on PAS, vol. PAS-88, pp. 316–329, 1969.

[5] .P. KUNDUR, "Definition and Classification of power System Stability", Draft 2, 14 January,2002

[6] .Hasan ALKHATIB ''etude de la stabilite aux petites perturbations dans les grands reseaux electriques : optimisation de la regulation par une methode metaheuristique'' Thèse doctorat d'état, UNIVERSITE PAUL CEZANNE D'AIX-MARSEILLE, 2008

[7] .Ang, K. H. G. Chong, and Li Y." PID Control system analysis , Design and

technology " IEEE transaction on control sytems technology , Vol.13 No. 4 July, 2005.

[8] .Mitchell M. "An Introduction to Genetic Algorithms ",1st MIT press paperback edition, Cambridge, Mass,1998.

[9]. Ogata K., "Modern Control Engineering", Third edition, Prentice Hall Inc 1997.

[10] . Porter B. and Jones A.H. “Genetic Tuning of Digital PID Controller ", electronic letter, 1992.

APPENDIX

1 Parameters of the used Turbo –Alternators

parameters	TBB-500	Units of measure
power nominal	500	MW
Factor of Power nominal	0.85	p.u.
Xd	1.869	p.u.
Xq	1.5	p.u.
Xs	0.194	p.u.
Xf	1.79	p.u.
Xsf	0.115	p.u.
Xsfd	0.063	p.u.
Xsf1q	0.0487	p.u.
Xsf2q	0.0487	p.u.
Ra	0.0055	p.u.
Rf	0.000844	p.u.
R1d	0.0481	p.u.
R1q	0.061	p.u.
R2q	0.115	p.u.

2 Parameters of the Regulator AVR

Parameter	*SG: TBB-500*
T1u	*0.039*
Te	*0.04*
K1ua	*-7*
K0ua	*-50*

3 Parameters of the used conventional PID-PSS

Parameter	*SG: TBB-500*
T1u	*0.039*
Te	*0.04*
K1ua	*-8*
K0ua	*-15*
Tfc	*0.07*
T1ω	*0.026*
T0ω	*1*
K1ω	*1*
K0ω	*2*
Tif	*0.03*
Kif	*-1*
Tuf	*0.05*
Kuf	*1*