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Performance Analysis of Load Frequency Control in Single area Power System Using GA and PSO Based PID Controller

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ABSTRACT: This Paper presents a comparative study of Genetic Algorithm method (GA) and Particle swarm optimization (PSO) method to determine the optimal proportional-integral-derivative (PID) controller parameters, for load frequency control in a single area power system. Comparing with conventional Proportional–Integral (PI) method and the proposed PSO the performance of the controller is improved for the step input in Load frequency control. This paper presents a comparative study of Genetic Algorithm (GA) and Particle Swarm Optimization (PSO) method to determine the optimal parameter of proportional integral-derivative (PID) controller parameters, for load frequency control in single area power system. For this application, MATLAB –Simulink software is used.

Keywords: Load frequency control, A single area power system, Particle swarm optimization, Genetic Algorithm.

I. INTRODUCTION

The modern power systems with industrial and commercial loads need to operate at constant frequency with reliable power. Load Frequency Control (LFC) is a very important issue in power system operation and control for supplying su cient and reliable electric power with good quality. The main goal of the LFC is to maintain zero steady state errors for frequency deviation and good tracking load demands in a multi-area restructured power system [1]. However, since the "I" control parameters are usually tuned, it is incapable of obtaining good dynamic performance for various load and system change scenarios. Many studies have been carried out in the past about the load frequency control. In literature, some control strategies have been suggested based on the conventional linear control theory [2]. These controllers may be unsuitable in some operating conditions due to the complexity of the power systems such as nonlinear load characteristics and variable operating points. According to [3], conventional PID control schemes will not reach a high degree of control performances.

The popularity of PID controllers is due to their functional simplicity and reliability. They provide robust and reliable performance for most systems and the PID parameters are tuned to ensure a satisfactory closed loop performance [4]. A PID controller improves the transient response of a system by reducing the overshoot, and by shortening the settling time of a system [5]. The PID control algorithm is used to control almost all loops in process industries and is also the cornerstone for many advance control algorithms and strategies. For this control loop to function properly, the PID loop must be properly tuned. Standard methods for tuning include Ziegler-Nichols Ultimate-cycle tuning [6], Cohen- Coon's [7], Astrom and Hagglund [8] and many other traditional techniques. Although new methods are proposed for tuning the PID controller, their usage is limited due to complexities arising at the time of implementation. Since, Particle Swarm Optimization algorithm and Genetic Algorithm is an optimization method that finds the best parameters for controller in the uncertainty area of controller parameters and obtained controller is an optimal controller, it has been used in almost all sectors of industry and science. One of them is the load frequency control [9]. In this study, they both are used to determine the parameters of a PID controller according to the system dynamics. Both GA and PSO are similar in the sense that these two techniques are population based heuristic search methods and they approach for the optimal solution by updating generations. Since the two approaches are supposed to find a solution to a given objective function but employ different strategies and computation effort, it is appropriate to compare their performance. In this study, GA and PSO are used to determine the parameters of a PID controller according to the system dynamics changing with daily period. The error criteria for both the methods are set to improve transient error and steady state error. Hence the fitness function is taken here are Integral Square Error (ISE) [11]. The Performance of both optimization techniques in terms of convergence rate, error minimization and time complexity are compared.

II. LOAD FREQUENCY CONTROL

Basically, Single area power system consists of a governor, a turbine and a generator with feedback of regulation constant. System also includes step load change input to the generator. This work mainly related with the controller unit of a single area power system. The objectives of the LFC are to maintain reasonably uniform frequency, to divide the load between generator and to control the tie line interchange schedules. Simple block diagram of a single area power system with the controller is shown in figure 1. ZZ So far, PID controllers have widely been used in process control. With simple structure, they yet can effectively control various large industrial processes. There are many tuning approaches for these controllers, but each has own disadvantages or limitations. As a result, the design of PID controllers still remains a remarkable challenge for researchers. In simple words, the PID controller is used to improve the dynamic response as well as reduce or eliminate the steady-state error. The derivative term normally adds a finite zero to the open loop plant transfer function and can improve the transient response in most cases. The integral term adds a pole at origin resulting in increasing the system type and therefore reducing the steady-state error. Furthermore, this controller is often regarded as an almost robust controller. As a result, they may also control uncertain processes. The well-known PID controller transfer function is as follows :

$$K_p + \frac{K_i}{s} + K_d \times s \qquad \dots (1)$$

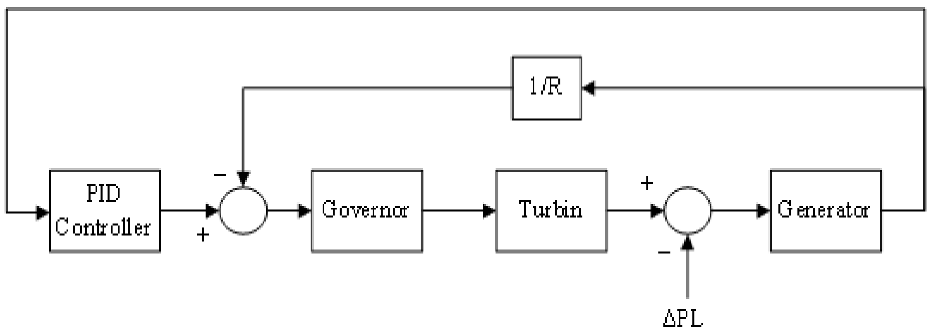

Fig. 1. A single Area Power System with the controller ($\Delta PL = 0.01$).

III. THEORITICAL BASICS

A. Genetic Algorithm

Genetic Algorithm The GA has been used for optimizing the parameters of control system that are complex and difficult to solve by conventional optimization methods. GA maintains a set of candidate solutions called population and repeatedly modifies them. At each step, the GA selects individuals from the current population to be parents and uses them produce the children for the next generation. Candidate solutions are usually represented as strings of fixed length, called chromosomes. A fitness or objective function is used to reflect the goodness of each member of population. Given a random initial population GA operates in cycles called generations.

• Each member of the population is evaluated using a fitness function

•The population undergoes reproduction in a number of iterations. One or more parents are chosen stochastically, but strings with higher fitness values have higher probability of contributing an offspring.

• Genetic operators, such as crossover and mutation are applied to parents to produce offspring.

• The offspring are inserted into the population and the process is repeated.

B. Particle Swarm Optimization

Particle swarm optimization (PSO) is an evolutionary computation technique developed by Dr. Eberhart and Dr. Kennedy in 1995, inspired by social behavior of bird flocking or fish schooling. PSO is a population based optimization tool. The system is initialized with a population of random solutions and searches for optima by updating generations. All the particles have fitness values, which are evaluated by the fitness function to be optimized, and have velocities, which direct the flying of the particles. The particles are “flown” through the problem space by following the current optimum particles.

PSO is basically developed through simulation of bird flocking in two-dimension space. The position of each agent is represented by XY axis position and also the velocity is expressed by Vx (the velocity of X axis) and Vy (the velocity of Y axis). Modification of the agent position is realized by the position and velocity information. Bird flocking optimizes a certain objective function. Each agent knows its best value so far (pbest) and its XY position. This information is analogy of personal experiences of each agent. Moreover, each agent knows the best value so far in the group (gbest) among pbest. This information is analogy of knowledge of how the other agents around them have performed. Namely, each agent tries to modify its position using the following information:

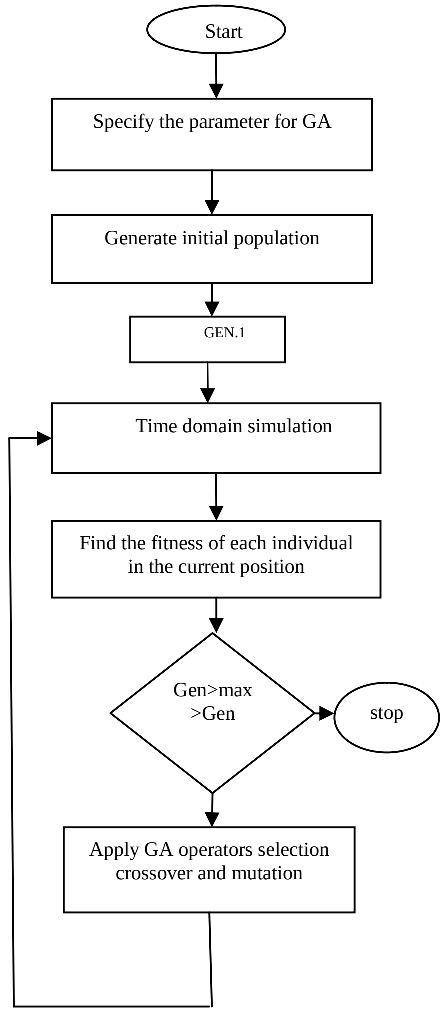

Fig. 2. The computational flow chart of GA.

The current positions (x,y),
The current velocities (vx, vy),
The distance between the current position and pbest
The distance between the current position and gbest

This modification can be represented by the concept of velocity. Velocity of each agent can be modified by the following

$$V_i^{k+1} = \omega V_i^k + c_1 r_1 \times (P_{best_i^k} - S_i^k) + c_2 r_2 \times (G_{best_i^k} - S_i^k) \quad \ldots(2)$$

Where

V_i^k = velocity of individual i at iteration k.

ω = inertia weight parameter

c_1, c_2 = acceleration coefficients.

r_1, r_2 = random no between 0 and 1

S_i^k = position of individual i at iteration k,

$P_{best_i^k}$ = best position of individual i until iteration k.

$G_{best_i^k}$ = best position of the group until iteration k.

The following weighting function is usually utilized .

$$\omega = \frac{\omega_{max} - (\omega_{max} - \omega_{min}) \times iter}{iter_{max}} \quad \ldots(3)$$

Where

$\omega_{max}, \omega_{min}$ = initial and final weight

$iter_{max}$ = maximum iteration number,

iter = current iteration number

Each individual moves from the current position to the next one by the modified velocity in (2) using the following equation.

$$S_i^{k+1} = S_i^k + V_i^{k+1} \quad \ldots(4)$$

Where

S^k = Current searching point

S^{k+1} = modified searching point

V^k = current velocity

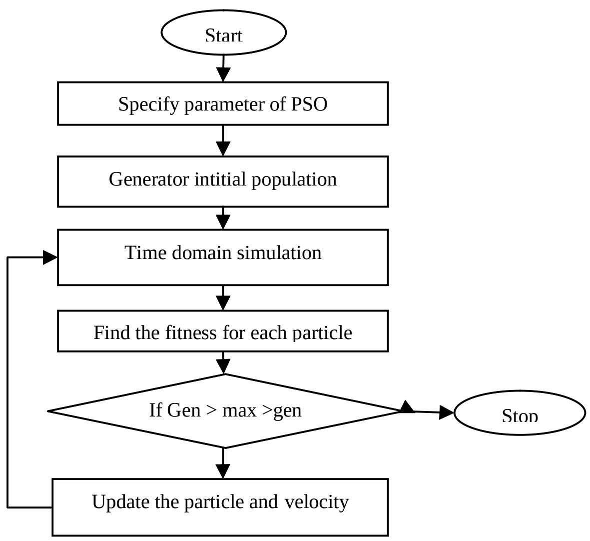

Fig. 3. Computational flow chart of PSO.

Computational flow chart of PSO shoen in fig 3.

IV MODEL WITH PROPOSED PID CONTROLLER

PID controller [5] are being extensively used by industries today owing to their simplicity. Its main focus here is elimination of steady state error as well as an improvement in the dynamic response. The derivative controller adds a finite zero to the open loop plant 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.

In this paper the performance of PID controller designed using the integral of squared-error (ISE), the ISE performance criterion formulas as follow:

$$\text{ISE} = \int_0^{\tau} e^2(t)\, dt$$

A set of good controller parameters Kp,Ki and Kd can yield a good step response. Incorporating the LFC with PID controller the result will be in Fig. 4.

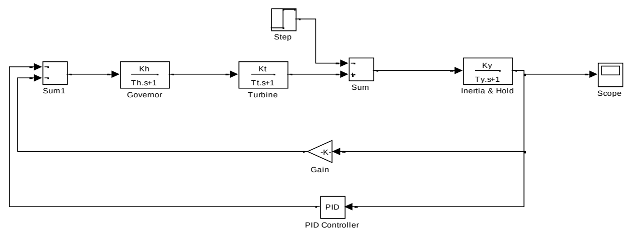

Fig. 4. Single area power system with proposed PSO and GA based PID controller.

V. SIMULATION RESULTS

The simulation has been conducted in MATLAB Simulink package for single area power system with PID controller. The ordinary power system parameters consisting of the speed governor, turbine and generator are given in Table 1.Here the governor free operation is assumed and load demand (ΔPL = 0.01). The value of PID parameters as obtained by PSO optimization.

Kp = 4.2155

Ki =4.5999

Kd = 0.57889

Simulation results for the single area power system are shown in Table 2. The results of optimization (Fig 5, Fig 6) gives almost same results but computational time by PSO was found much less than by GA. Therefore, the proposed PSO-PID controller provides better performance than GA based PID controller for the single area power system.

Table 1.

Description	Parameters	Value
Governor Gain	K_h	1
Governor Time Constant	T_h	80e-3
Turbine Gain	K_t	1
Turbine Time Constant	T_t	0.3
Load Model Gain	K_y	120
Load Time constant	T_y	20

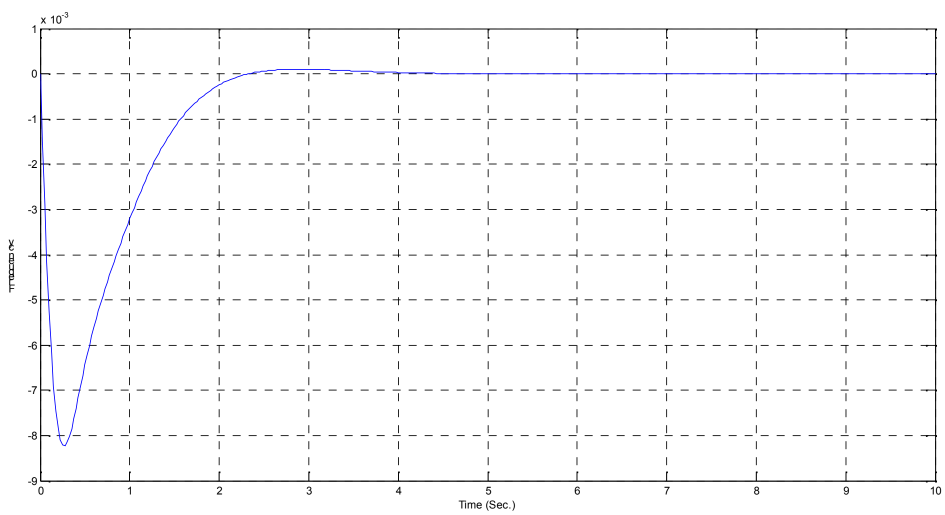

Fig. 5. Deviation of frequency of single area power system with GA based PID controller.

Table 2. System performance for PSO and GA based Controller.

Sr No	POP SIZE	CONTROLLER	SETTLING TIME	MAX OVERSHOOT
1		Conventional PI	13.5	0.01966
2	10	PSO-PID	1.00e-04	1.9794
		GA-PID	1.01e-04	2.0791

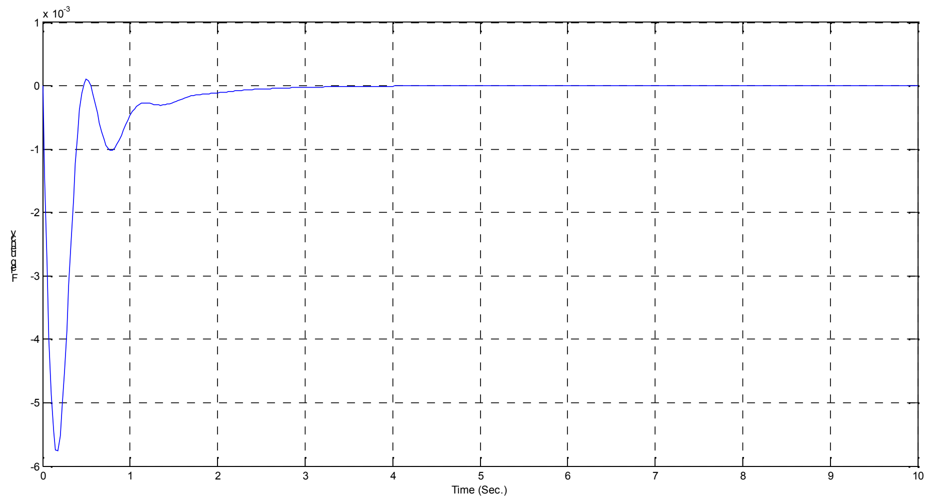

Fig. 6. Deviation of frequency of the single area power system with PSO based PID controller.

VI. CONCLUSION

In this study, a Genetic algorithm and Particle swarm optimization tuned proportional integral derivative controller has been investigated for load frequency control of single area power system. The simulink package for single area power system with PID controller is developed in MATLAB as in fig 4.The simulation result shown that ,the evolutionary algorithm provide much better response than that of conventional PI controller method among them PSO works with much better efficiency as computational time minimizes, simple and has stable convergence characteristics than GA. Two area power system operations will be investigated in next time.

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