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Analysis of Load Frequency Control of Interconnected Power System Using Soft Computing Technique

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ABSTRACT: In this paper, an evolutionary computing approach for determining the optimal values for the proportional-integral derivative (PID) controller parameters of load frequency control (LFC) of two area power system using the particle swarm optimization technique is presented. In order to improvise the performance of supplying power of a power system, error function is minimised. The choice of this algorithm over other recent well known algorithms such as Bacteria Foraging Optimisation Algorithm (BFOA) andGenetic Algorithm (GA) is explained for the same interconnected system.This necessitates designing of an accurate and fast controller to maintain the system parameters at nominal value. The main purpose of system generation control is to balance the system generation against the load and losses so that the desired frequency and power interchange between neighbouring systems are maintained.Genetic Algorithm (GA) and Particle Swarm Optimization (PSO) are used to tune the parameters of the PID controller through performance optimization of the system. System performance characteristics were compared to another controller designed.The effectiveness and robustness of the proposed schemes were verified by the numerical simulation inMATLAB environment under different scenariossuch as load and parameters variations.

KEYWORDS: Load frequency control (LFC),Particle Swarm Optimization (PSO),Two area power system,PID Controller;

I. INTRODUCTION

Load frequency control (LFC) is used to regulate the power output of the electric generator within an area as the response of changes in system frequency and tie-line loading. Thus, LFC helps in maintaining the scheduled system frequency and tie-line power interchange with the other areas within the prescribed limits.In power system, both active and reactive power demands are never steady they continuously change with the rising orfalling trend. Steam input to turbo generators(or water input tohydro generators) must therefore, be continuously regulated tomatch the active power demand, failing which the machinespeed will vary with consequent change in frequency, whichmay be highly undesirable.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 [3]. A PID controller improves the transient response of a system by reducing the overshoot, and by shortening the settling time of a system [4]. 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.Many studies have been carried out in the past about the load frequency control. Inliterature, some control strategies have beensuggested based on the conventional linear control theory [1]. 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 some authors, variable structure control [2] maintains stability of system frequency.The frequency is closely related to the real power balance whereas voltage is related to reactive power. The real power and frequency control is referred to as load frequency control (LFC) [1]. If in a system there are changes in load then those changes will affect both frequency and bus voltages. LFC as the name signifies adjusts the power flow between different areas while holding the frequency constant. LFC is actually a loop that regulates output in the range of megawatt and frequency of the generator [9]. This consists of two loops i.e. primary loop and secondary loop. Nowadays power systems are connected to neighbouring areas. But interconnection of the power systems leads to high increment in the order of the system. This connection is madepossible by tie-lines.

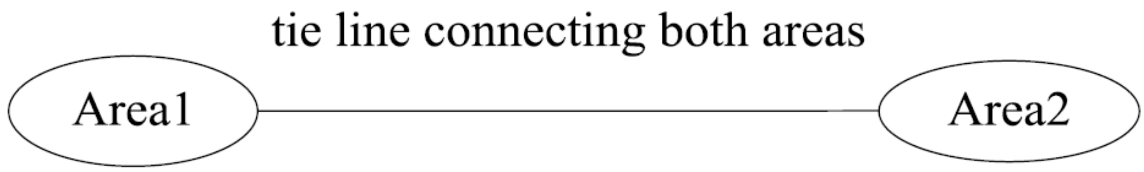

Fig.1 Figure showing two areas connected by tie-line

Tie-line allows the flow of electric power between areas. Introduction of tie-line power leads to introduction of an error called tie-line power exchange error. When there is load change in an area, that area will get energy with the help of tie-lines from other areas.Recently, a lot of artificial intelligence based robust controllers such as genetic algorithm,tabu search algorithm; fuzzy logic and neuralnetworks are used for PID controller parameterstuning in LFC by authors [4, 5, 6, 7]. Since, ParticleSwarm Optimization algorithm is an optimizationmethod that finds the best parameters for controllerin the uncertainty area of controller parameters andobtained controller is an optimal controller, it hasbeen used in almost all sectors of industry andscience. One of those areas is the load frequencycontrol as shown in [8].The objective of this study is to investigate the load frequency control and inter area tie-power control problem for a multi-area power system taking into consideration the uncertainties in the parameters of system.. An optimal control scheme based particle swarm optimization (PSO)Algorithm method is used for tuning the parameters of this PID controller. The proposed controller is simulated for a two-area power system. To show effectiveness of proposed method and also compare the performance of these two controllers, several changes in demand of first area, demand of second area and demand of two areas simultaneously are applied. Simulation results indicate that PSO controllers guarantee the good performance under various load conditions.

II. PARTICLE SWARMOPTIMIZATION

The PSO method is a member of wide category of Swarm Intelligence methods for solving the optimization problems. It is a population based search algorithm where each individual is referred to as particle and represents a candidate solution. Each particle in PSO flies through the search space with an adaptable velocity that is dynamically modified according to its own flying experience and also the flying experience of the other particles.The particle swarm optimization (PSO) is a heuristic optimization method based on swarm intelligence. It comesfrom research on the bird and fish flock movement behaviour [10]. PSO is a population-based optimization method isdeveloped in 1995 by Dr. Kennedy and Dr.Eberhart [12, 13].In the search space each particle acts individually and accelerates toward the bestpersonal location (pbest) while checking the fitness value of itscurrent position. Fitness value of a position is obtained byevaluating the so-called fitness function at that location. If aparticles' current location has a better fitness value than that of its current p_{best}, then the p_{best} is replaced by the currentlocation. [17- 18]Each particle in the swarm has knowledge of thelocation with best fitness value of the entire swarm which iscalled the global best or g_{best}. At each point along their path,each particle also compares the fitness value of their pbest tothat of g_{best}. If any particle has a p_{best} with better fitness valuethan that of current g_{best}, then the current g_{best} is replaced bythat particle's p_{best}. The movement of particles is stopped onceall particles reach sufficiently close to the position with bestfitness value of the swarm.Steps of PSO as implemented for optimization are[11-14]:

1. Create a population of agents (called particles) uniformlydistributed over *X*.
2. Evaluate each particle's position according to the objectivefunction.
3. If a particle's current position is better than its previous bestposition, update it.
4. Determine the best particle (the particle's previous bestpositions).
5. Update particles velocities according to:

$$V_i^{t+1} = V_i^t + C_1 rand_1\left(Pbest - X_i^t\right) + C_2 rand_2\left(gbest - X_i^t\right)$$

6. Move particles to their new positions according to:

$$X_i^{t+1} = X_i^t + V_i^{t+1}$$

7. Go to step 2 until stopping criteria are satisfied.

In everyiteration, all particles will be updated by following the best previous position (pbest) and best particleamong all the particles (g_{best}) in the swarm. Here, the fitness function is taken to minimize the sumsquared error of frequency of Area 1, Area 2, and tie power.The flowchart of the main steps of PSO is presented in Figure below:-

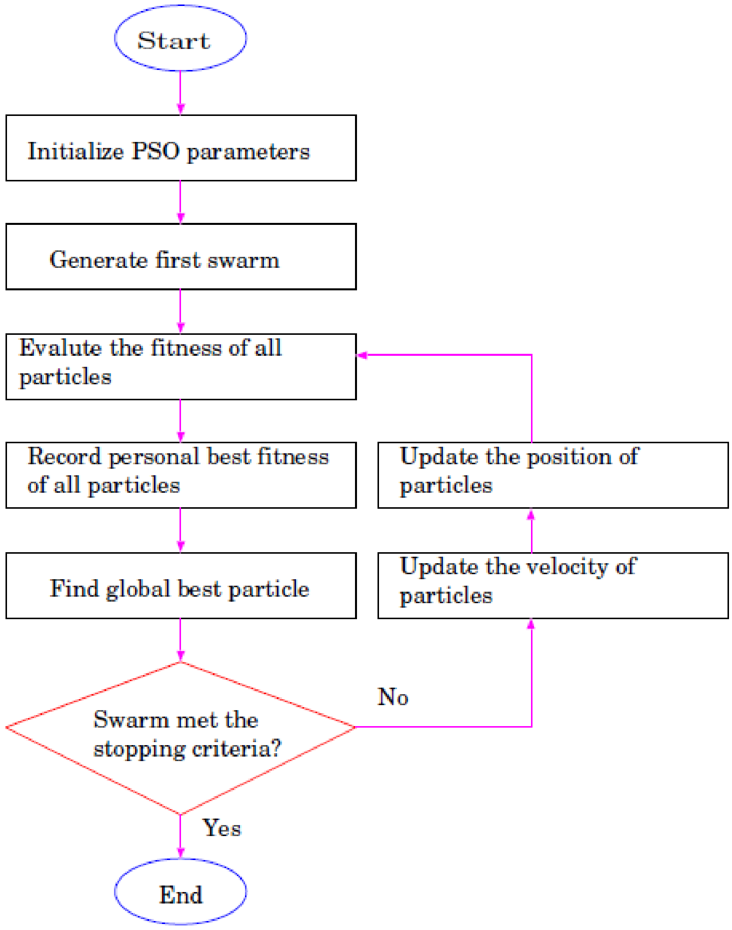

Fig. 2. Standard flowchart of PSO.

III. MODEL OF TWO –AREA INTERCONNECTED POWER SYSTEM

Basically, two area power systemsconsist 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 two area power system.The two area interconnected power system is shown in fig.3, where and are thefrequency deviations in area 1 and area 2respectively Δf_1andΔf_2 in Hz. and$\Delta P_{d1}$and ΔP_{d2} are the loaddemand increments. A two area system consists oftwo single area systems, connected through apower line called tie-line, is shown in the Figure.each area feeds its user pool, and the tie line allows electric power to flow between the areas.Information about the local area is found in the tieline power fluctuations. Therefore, the tie-linepower is sensed, and the resulting tie-line powersignal is fed back into both areas. It is convenientlyassumed that each control area can be representedby and equivalent turbine, generator and governorsystem.The framework of PSO based self-tuning PID controller is depicted as Figure 4. To find the optimum parameters (Kp, Ki, Kd) of PIDcontroller, PSO program should search in 3- dimensional search space. With the optimized parameters based on PSO algorithm, the proposed PID controller of the LFC can achieve optimal properties. The block diagram of a two area power system with this controller is shown in Figure 2. The two area power system parameters are given in Table 1.

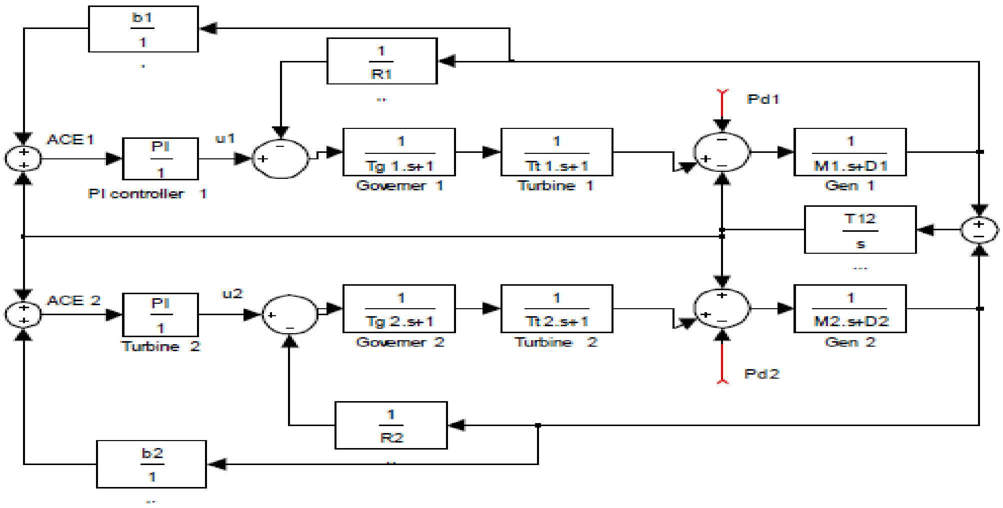

Fig.3 block diagram of a two area power system with the controller

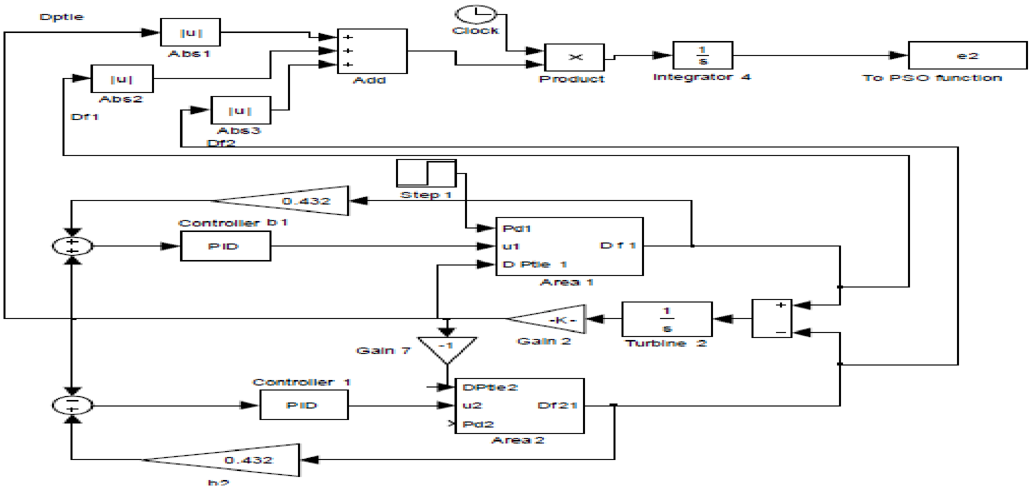

Fig.4 block diagram of a two area power system with the optimal controller and PSO function

IV. RESULTS AND COMPARISION

The Two area power system parameter is shown in table 1 and the value of regulation constant is also optimized by PSO. Simulation result for Two area power system are shown in table 2. During the simulation study, error signals Δf_1andΔf_2, and tie line power which is required for the controller is transferred to PSO software. All positions of particles on each dimension are clamped in limits which are specified by the user, and the velocities are clamped to the range [v_{min}.,v_{max}.] given as [12]: a step load increase in demand of 0.01 p.u is applied to area 1 and area 2 simultaneously.

Table 1:Parameters of the two area power system

Description	Area 1	Area 2
Governor Gain	1	1
Governor Time Constant	80e-03	80e-03
Turbine Gain	1	1
Turbine Tine Constant	0.3	0.3
Load Model Gain	120	120
Load Time Constant	20	20
Ptiemax	200Mw	200Mw
Load change for Frequency	0.01	0.01

Simulation results show performance improvement in time domain specifications for a step load of 0.01 p.u.Using the PSO approach, global and local solutions could be simultaneously found for better tuning of the controller parameters. The PID value which was obtained by the PSO algorithm is compared with Conventional and fuzzy logic control method in various perspectives, namely robustness and stability Performances. All the simulations were implemented using MATLAB

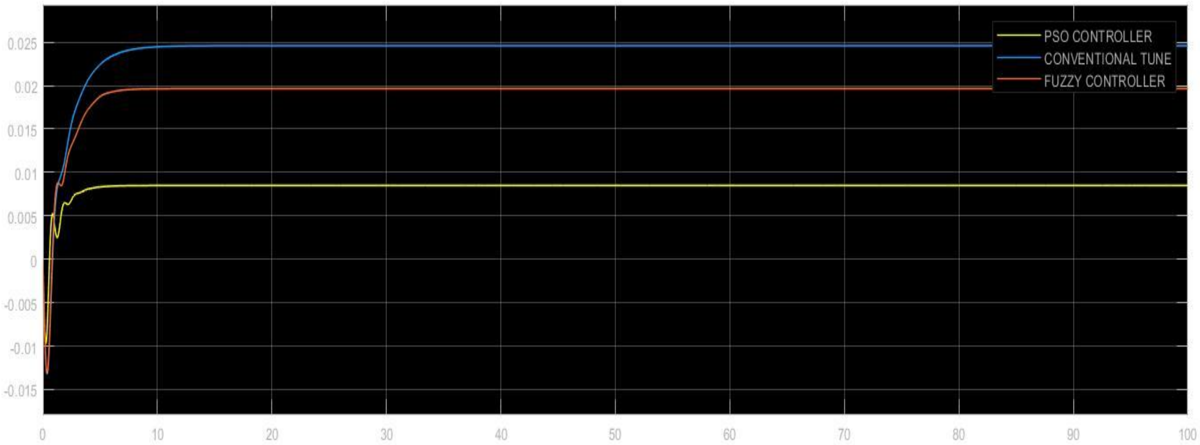

Fig.5.Change in frequency in area 1 for a step load of 1% at area 1

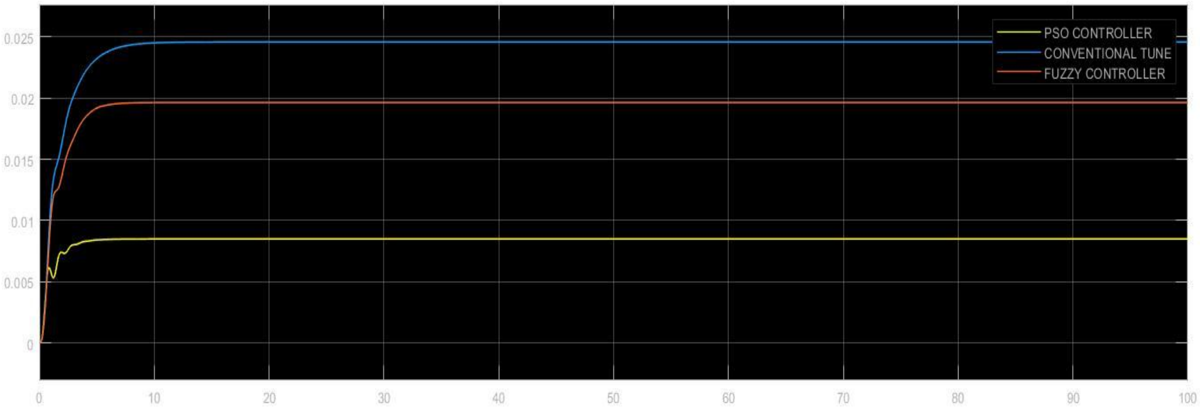

Fig 6. Change in frequency in area 2 for a step load of 1% at area 1

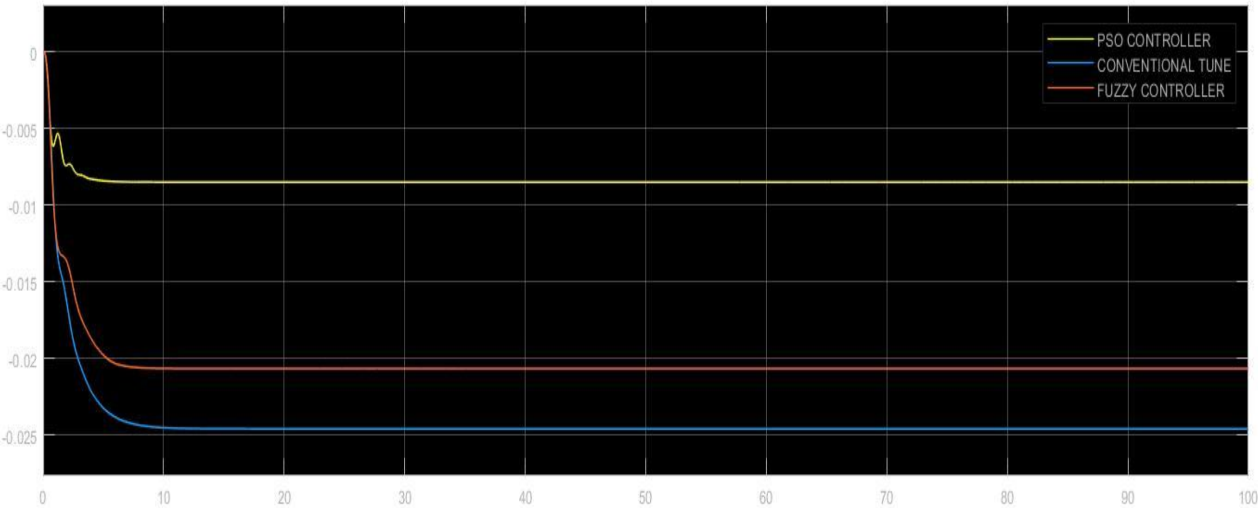

Fig 7. Change in frequency in area 1 for a step load of 1% at area 2

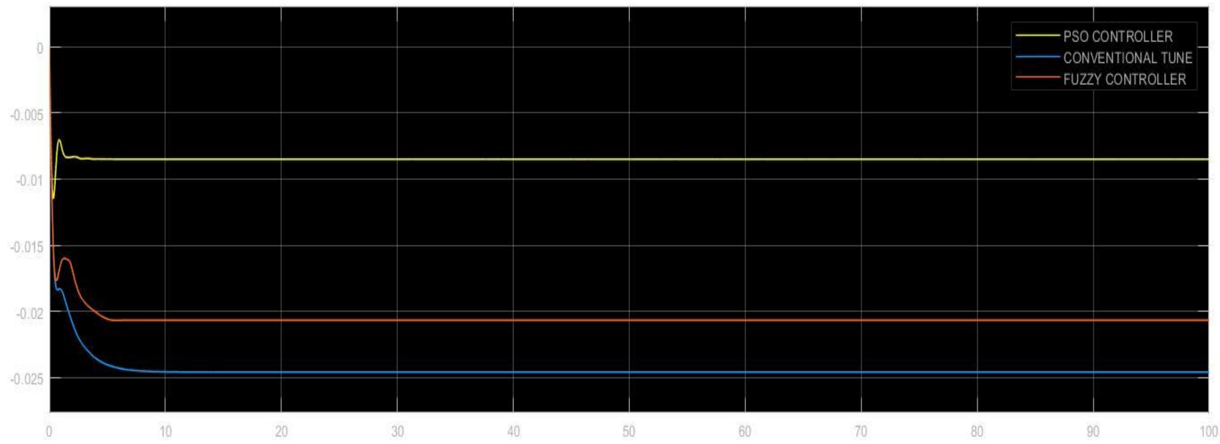

Fig 8. Change in frequency in area 2 for a step load of 1% at area 2

V. CONCLUSION

In this study, a new particle swarm optimized LFC has been investigated for load frequency control of a Two area power systems. For this purpose, first, to obtain more adaptive tuning mechanism for the PID controller parameters and sensitivity of the system is increased. It has been shown that the proposed control algorithm is effective and provides significant improvement in system performance. Therefore, the proposed PSO-PID controller is recommended to generate good quality and reliable electric energy. In addition, the proposed controller is very simple and easy to implement since it does not require many information about system parameters. As a further study, the proposed method can be applied to multi area power system load frequency control and also optimum values can be obtained by Particle Swarm optimization and compare with Conventional and fuzzy logic control method.

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