Load Frequency Control Adaptation Using Artificial Intelligent Techniques for One and Two Different Areas Power System

Mohamed. M .Ismail M. A. Mustafa Hassan

Abstract- **The main objective of Load Frequency Control (LFC) is to regulate the power output of the electric generator within an area in response to changes in system frequency and tie-line loading .Thus the LFC helps in maintaining the scheduled system frequency and tie-line power interchange with the other areas within the prescribed limits. Most LFCs are primarily composed of an integral controller. The integrator gain is set to a level that the compromises between fast transient recovery and low overshoot in the dynamic response of the overall system. This type of controller is slow and does not allow the controller designer to take into account possible changes in operating condition and non-linearities in the generator unit. Moreover, it lacks robustness. This paper studies control of load frequency in two area power system with PID controller. In this study, PID parameters are tuned using different adaptation techniques. The overshoots and settling times with the proposed controllers are better than the outputs of the conventional PID controllers. The effectiveness of the proposed scheme is confirmed via extensive study using MATLAB/SIMULINK software. Simulation results are carried out by 1 to 10% system disturbances in both of one and two areas power system. Simulations are done by using the same PID parameters for the two different areas because it gives a better performance for the system frequency response than in case of using two different PID parameters for the two areas. Comparison of performance responses of conventional PID controller with PID controller using different intelligent techniques for the both cases show that the fuzzy tuned controller has better satisfactory generalization capability, feasibility and reliability, as well as accuracy than GA and the PSO algorithms. The qualitative and quantitative comparison has been carried out for the different controllers for one and two area power system.**

Index Terms*—Fuzzy Logic, Genetic Algorithm, Load Frequency Control, PID Controller, one and Two Area *Power System and Particle Swarm Optimization

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I. INTRODUCTION

Frequency is an explanation of stability criterion in power systems [1]. To provide the stability, active power balance and steady frequency are required. Frequency depends on active power balance. If any change occurs in active power demand/generation in power systems, frequency cannot be hold in its rated value. So oscillations increase in both power and frequency. Thus, system subjects to a serious instability problem. In electric power generation, system disturbances caused by load fluctuations result in changes to the desired frequency value. Load Frequency Control (LFC) is a very important issue in power system operation and control for supplying sufficient and both good quality and reliable power [3]. Power networks consist of a number of utilities interconnected together and power is exchanged between the utilities over the tie-lines by which they are connected. The net power flow on tie-lines is scheduled on a priori contract basis. It is therefore important to have some degree of control over the net power flow on the tie-lines. Load Frequency Control (LFC) allows individual utilities to interchange power to aid in overall security while allowing the power to be generated most economically. The variation in Load frequency is an index for ordinary operation of the power systems. When the load perturbation takes place, it will affect the frequency of other areas also. To improve the stability of the power networks, it is necessary to design Load Frequency Control (LFC) systems that control the power generation and active power. Because of the relationship between active power and frequency, three level automatic generation controls have been proposed by power system researchers [4]. Generally, ordinary LFC systems are designed with Proportional-Integral (PI) controllers [5]. However, since the "I" control parameters are usually tuned; it is incapable of obtaining good dynamic performance for various load and system changes. Many studies have been carried out in the past on this important issue in power systems, which is the load frequency control. As stated in some literature [6 - 10], some control strategies have been suggested based on the conventional linear control theory. These controllers may be improper in some operating conditions. This could be due to the complexity of the power systems such as nonlinear load characteristics and variable operating points. In this study, different intelligent techniques such that Fuzzy Logic, *Genetic Algorithm* (GA) and *Particle Swarm Optimization* (PSO) algorithms will be used to determine the parameters of a PID controller according to the system dynamics. In the integral controller, if the integral gain is very high, undesirable and unacceptable large overshoots will be occurred. However, adjusting the maximum and minimum values of proportional (kp), integral (ki) and integral (kd) gains respectively, the outputs of the system (voltage, frequency) could be improved. In this simulation study, two area power system with two different parameters are chosen and load frequency control of this system is made based on PID controller. This work is an improvement of [11] which assumes that the two areas of the power system have the same parameters which is not usually practical assumption for the real power system networks. This work is also an improvement of [12 - 14] by using the three different tuning techniques (Fuzzy Logic , GA and PSO) and by using saturation for the control valve while the previous work uses only one technique and don't take the saturation into consideration. This work is also an improvement of [15-17] that two power system areas connected are used instead of single power system area in the previous works. The overshoots and settling times with the proposed Genetic-PID controller are better than the outputs of the conventional PID controllers tuned by Ziegler-Nicholas technique, fuzzy technique and Particle Swarm Optimization.

II. PROBLEM FORMULATION

In order to keep the power system in normal operating state, a number of controllers are used in practice. As the demand deviates from its normal operating value the system state changes. Different types of controllers based on classical linear control theory have been developed in the past. Because of the inherent nonlinearities in system components and synchronous machines, most load frequency controllers are primarily composed of an integral controller. The integrator gain is set to a level that compromise between fast transient recovery and low overshoot in the dynamic response of the overall system. This type of controller is slow and does not allow the controller designer to take into account possible non-linearity in the generator unit so The PID controller will be used for the stabilization of the frequency in the load frequency control problems. The main objectives of LFC In order to regulate the power output of the electric generator within a prescribed area in response to changes in system frequency, tie line loading so as to maintain the scheduled system frequency and interchange with the other areas within the prescribed limits.

III. MODELING OF SINGLE AREA AND MULTI AREA POWER SYSTEMS

Non-reheat type single area thermal generating system is represented by block diagram of closed loop controlled system model. As shown in Figure 1, f is the system frequency (Hz), R is regulation constant (Hz/unit), Th is speed governor time constant (sec), Tt is turbine time constant (sec), H is Inertia Constant (s) and D is area parameter (Mw/Hz).

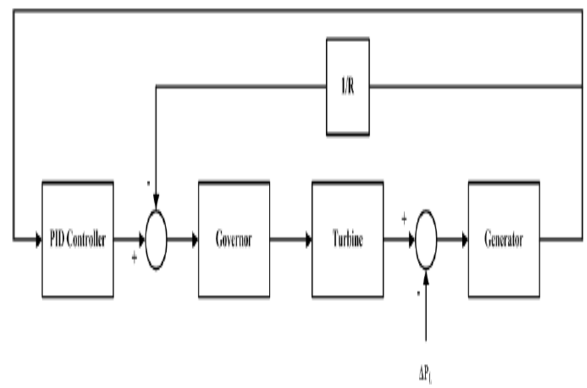

Figure 1 One Area Power Generation Model

A single rotating machine is assumed to have a steady speed of ω and phase angle δ0. Due to various electrical or mechanical disturbances, the machine will be subjected to differences in mechanical and electrical torque, causing it to accelerate or decelerate. We are mainly interested in the deviations of speed, Δω, & and deviations in phase angle Δδ, from nominal. This can be expressed in Laplace transform operator notation as:

$$\Delta Pmech - \Delta Pelec = M\ s\ \Delta\omega \quad (1)$$

The load on a power system comprises of a variety of electrical devices. Some of them are purely resistive. Some are motor loads with variable power frequency characteristics, and others exhibit quite different characteristics. Since motor loads are a dominant part of the electrical load, there is a need to model the effect of a change in frequency on the net load drawn by the system. The relationship between the change in load due to the change in frequency is given by:

$\Delta PL\ (freq) = D\ \Delta\omega$ (or)

$D = \Delta PL\ (freq) / \Delta\omega$ (2)

The net change in Pelec in Figure (1) is

$\Delta P_{elec} = \Delta P_L + D\ \Delta\omega$

No frequency Sensitive load Change — frequency sensitive load change

The basic control input to a generating unit as far as generation control is concerned is the load reference set point. By adjusting this set point on each unit a desired unit dispatch can be maintained while holding system frequency close to the desired nominal value. R is equal to pu change in frequency, divided by pu change in unit output. That is R= Δω / Δp pu
The combined block diagram of single area system with, governor prime mover – rotating Mass/load model is shown in Figures 2 and 3.

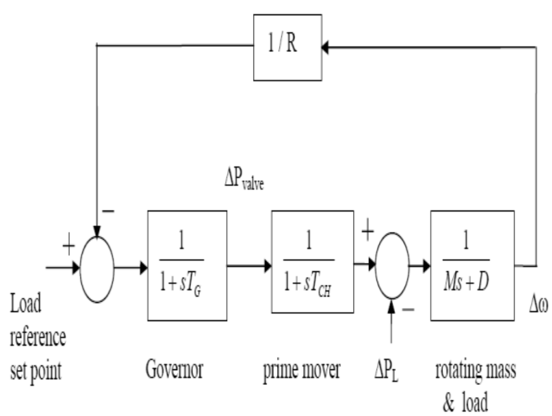

Figure 2. Block Diagram of Primary LFC Loop for Single Area System

Suppose that this generator experiences a step increase in load , ΔPL(s)= ΔPL/s

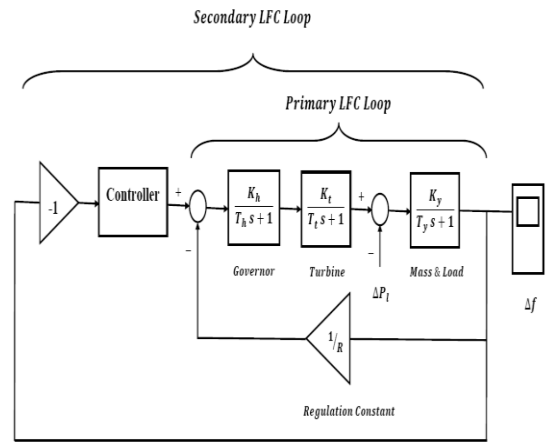

Figure 3. Block diagram of single area system with a controller

The transfer function relating the load change ΔPL, to the frequency change Δω is

$$\Delta\omega(s) = \Delta P_L(s)\left[\frac{\frac{-1}{Ms+D}}{1+\frac{1}{R}\left(\frac{1}{1+sT_G}\right)\left(\frac{1}{1+sT_{CH}}\right)\left(\frac{1}{Ms+D}\right)}\right] \quad (3)$$

The steady state value of Δω(s) may be found by:

$$\Delta\omega\ \text{steady state} = \lim_{s \to 0} [\, s\ \Delta\omega(s)]$$

$$\Delta\omega\ \text{steady state} = \frac{-\Delta P_L}{\frac{1}{R} + D} \quad (4)$$

In two-area system, two single area systems are interconnected via the tie line. Interconnection established increases the overall system reliability. Even if some generating units in one area fail, the generating units in the other area can compensate to meet the load demand. The power flowing across a transmission line can be modeled using the DC load flow method as:

$$P_{tieflow} = \frac{1}{X_{tie}}(\beta_1 - \beta_2) \quad (5)$$

This tie flow is a steady-state quantity. For purposes of analysis here, we will perturb the above equation to obtain deviations from nominal flow as a function of deviations in phase angle from nominal.

$$P_{tieflow} + \Delta P_{tieflow} = \frac{1}{X_{tie}}[(\beta_1 + \Delta\beta_1) - (\beta_2 + \Delta\beta_2)]$$
$$= \frac{1}{X_{tie}}(\beta_1 - \beta_2) + \frac{1}{X_{tie}}(\Delta\beta_1 - \Delta\beta_2) \quad (6)$$

Then

$$\Delta P_{tieflow} = \frac{1}{X_{tie}}(\Delta\beta_1 - \Delta\beta_2) \quad (7)$$

Where Δβ1 and Δβ2 are equivalent to Δδ1 and Δδ2.

Then Equation (6) can be expressed as:

$$\Delta P_{tieflow} = \frac{T}{s}(\Delta\omega_1 - \Delta\omega_2) \quad (8)$$

Where T is "tie-line stiffness" coefficient .

A block diagram representing this interconnection can be drawn as in Figure 4 , by adding a saturation element to the steam or hydro control valve in the power system model, the simulink model is indicated in Figure 5.

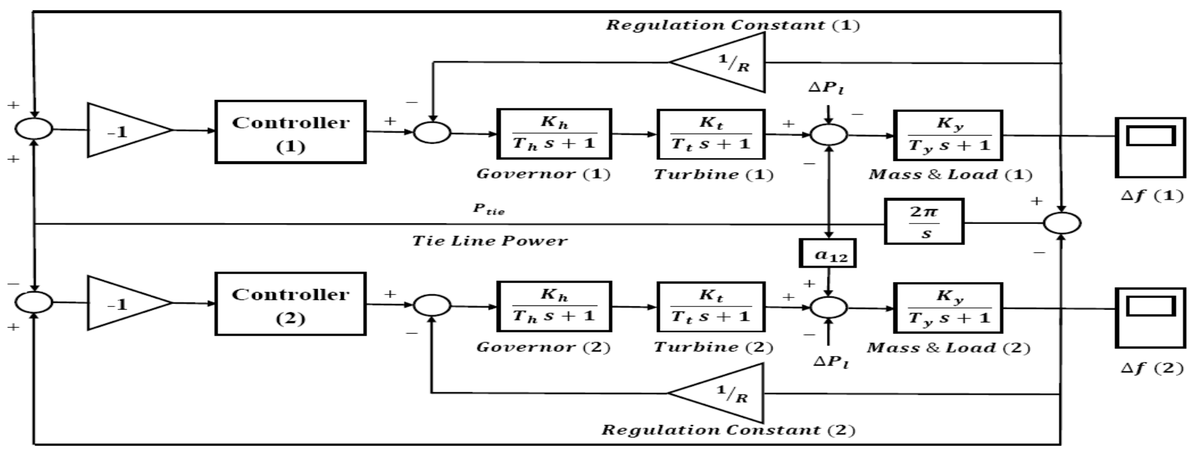

Figure (4). Block Diagram Of Interconnected Areas

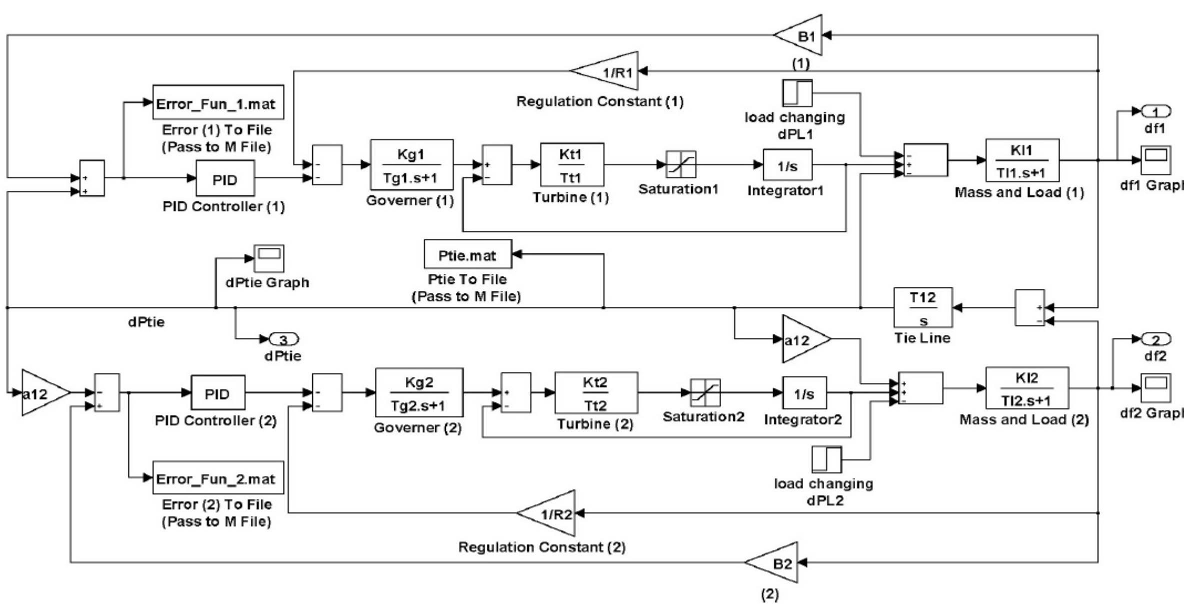

Figure (5): The Non-Linearized Two-Area Power System Simulink Model with Genetic Algorithm-Tuned PID Controller

IV. PID CONTROLLER

Basically, electric power system components are non-linear; therefore a linearization around a nominal operating point is usually performed to get a linear system model which is used in the controller design process. The operating conditions of power systems are continuously varying. Accordingly, the real plant usually differs from the assumed one. Therefore, classical algorithms to design a Load Frequency Control using an assumed plant may not ensure the stability of the overall real system. For the single area non-reheat thermal system considered in this study, the conventional Proportional integral (PI) controller was replaced by a PID controller. PID controller consists of Proportional Action, Integral Action and Derivative Action. It usually refers to Ziegler-Nichols PID tuning parameters. It is by far the most common control algorithm [18]. In this paper, the basic concept of the PID controls will be explained. PID controller's algorithm is mostly used in feedback loops, especially in the new industries. PID controllers can be implemented in many forms. It can be implemented as a stand-alone controller or as part of Direct Digital Control (DDC) package or even Distributed Control System (DCS). The latter is a hierarchical distributed process control system which is widely used in process plants such as pharceumatical or oil refining industries.

It is interesting to note that more than half of the industrial controllers in use today utilize PID or modified PID control schemes. Below in Figure 6 is a simple diagram illustrating the schematic of the PID controller. Such set up is known as non- interacting form or parallel form.

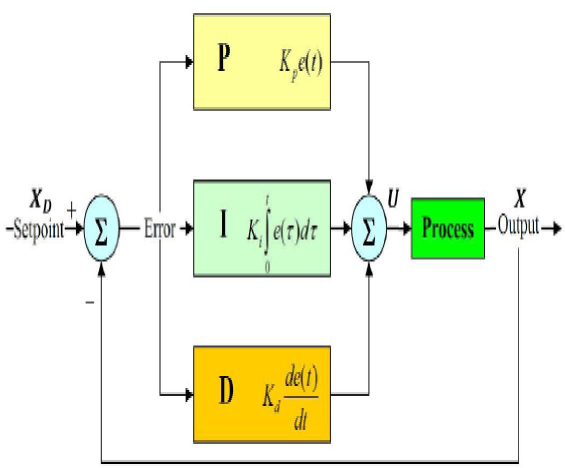

Figure 6 Schematic of the PID Controller – Non Interacting Form

The PID controller has the following structure

$$G_c(s) = K_p + \frac{K_i}{s} + K_d s \quad (9)$$

Where: kp is proportional gain, ki and kd are integral and derivative time constants, respectively. In this simulation, the objective is to minimize the cost function. For this reason the objective function is chosen as the Integral Square Error (ISE). The ISE squares the error to remove negative error components.

$$ISE = \sum_{K=1}^{q} e^2(K) \quad (10)$$

The minimization fitness function becomes

$$f = \frac{1}{ISE} \quad (11)$$

The control signal for the conventional PID controller can be given in the following equations.

$$U_i(s) = -\,G_c(s) \times \frac{1}{ISE} \quad (12)$$

$$U_i(s) = \left(K_p + \frac{K_i}{s} + K_d s\right)\left(\frac{1}{\left(\sum_{K=1}^{q} e^2(K)\right)}\right) \quad (13)$$

Based on this performance index (ISE), optimization problem can be stated as:

Minimize f subject to :

$$K_p^{min} \le K_p \le K_p^{max}$$
$$K_i^{min} \le K_i \le K_i^{max}$$
$$K_d^{min} \le K_d \le K_d^{max}$$

V. ADAPTATION OF PID CONTROLLER USING FUZZY ALGORITHM

The fuzzy logic programming have been become widely used in industry. Extensive number of researches were developed using fuzzy logic technique [18-22]. This paper proposed two inputs-three outputs self tuning of a PID controller. The controller design used the error and change of error as inputs to the self tuning, and the gains (KP1, KI1, KD1) as outputs. The FLC is adding to the conventional PID controller to adjust the parameters of the PID controller on-line according to the change of the signals error and change of the error. The proposed controller also contains a scaling gains inputs (Ke, KΔe) as shown in Figure 7. The fuzzy logic model using simulink in MATLAB is shown in Figure 8 and 9, to satisfy the operational ranges (the universe of discourse) making them more general.

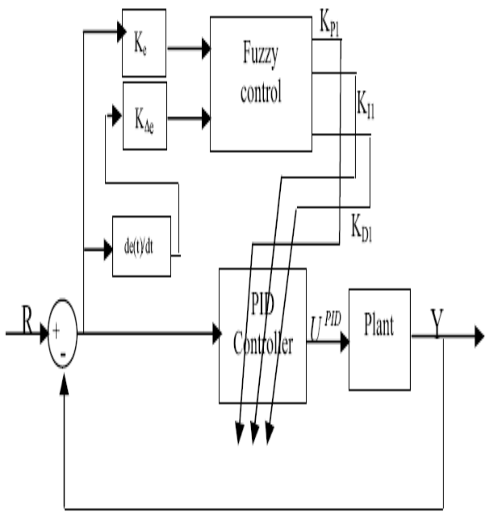

Figure 7Fuzzy Self Tuning Proposed.

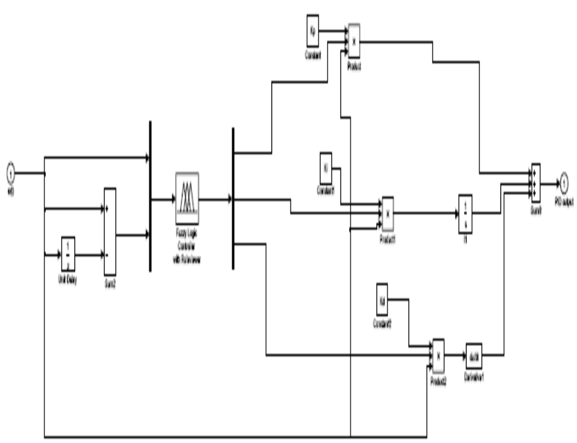

Figure 8 Fuzzy Logic Model Using MATLAB Simulink

Now the control action of the PID controller after self tuning can be describing as:

$$U_{PID} = K_{P2} * e(t) + K_{I2} \int edt + K_{d2} \frac{de(t)}{dt} \quad (14)$$

Where KP2, KI2, and KD2 are the new gains of PID controller and are equals to:

KP2=KP1 * KP, KI2=KI1 * KI, and KD2=KD1 * KD (15)

Where KP1, KI1, and KD1 are the gains outputs of fuzzy control, that are varying online with the output of the system under control. Where KP, KI, and KD are the initial values of the conventional PID.

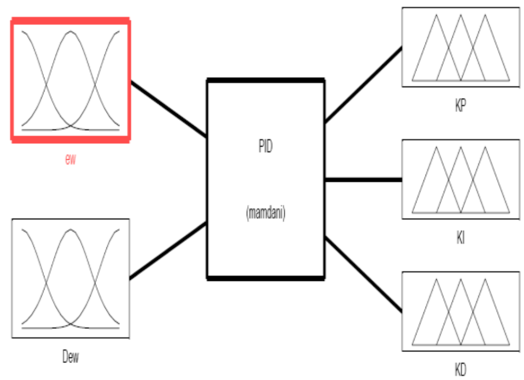

Figure 9 Fuzzy Logic Model Input - Outputs

The general structure of fuzzy logic control is represented in Fig.10 and comprises three principal components :

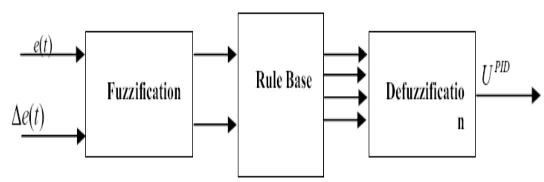

Figure 10 Fuzzy Logic Control Structure

1- **Fuzzification** This converts input data into suitable linguistic values. As shown in Fig 11 and 12, there are two inputs to the controller: error and rate change of the error signals. The error is defined as e(*t*) = *r*(*t*) - *y*(*t*) , Rate of error is defined as Δe(t)=de(t)/dt , Where r (t) is the reference input, y (t) is the output, e (t) is the error signal, and Δe(t) is the rate of error. The seventh triangular input and output member ship functions of the fuzzy self tuning are shown in the Figures (8,9). For the system under study the universe of discourse for both e(t) and Δe(t) may be normalized from [-1,1], and the linguistic labels are {Negative Big, , Negative , medium, Negative small, Zero, ,Positive small, Positive medium, Positive Big }, and are referred to in the rules bases as {NB,NM,NS,ZE,PS,PM,PB },and the linguistic labels of the outputs are {Zero, Medium small, Small, Medium, Big, Medium big, very big} and refereed to in the rules bases as {Z,.MS, S, M, B, MB, VB}.

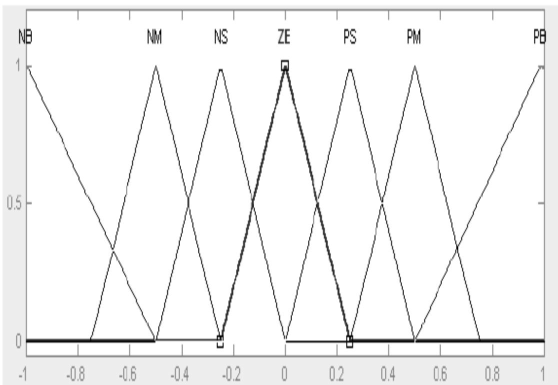

Figure 11 Memberships Function Of Inputs (e, Δe).

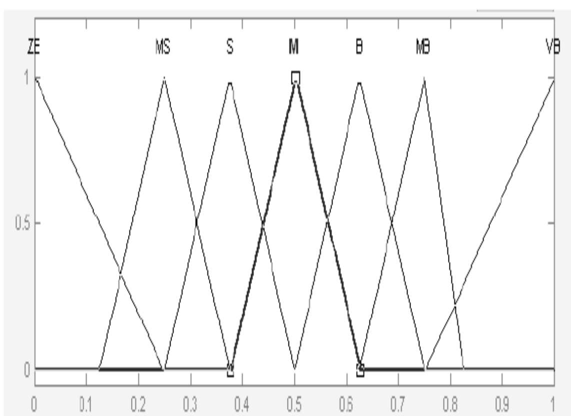

Figure 12 Memberships Functions of Outputs (KP1, KI1, and KD1).

2- Rule base: A decision making logic which is, simulating a human decision process, fuzzy control action from the knowledge of the control rules and linguistic variable definitions. Where Ei and Ej are the linguistic label input, UP, UI, and UD are the linguistic label output. Tables (1), (2), and (3) show the control rules that used for fuzzy self tuning of PID controller.

Table 1: Rule bases for determining the gain K_{P1}.

ė/e	NB	NS	ZE	PS	PB
NB	VB	VB	VB	VB	VB
NS	B	B	B	MB	VB
ZE	ZE	ZE	MS	S	S
PS	B	B	B	MB	VB
PB	VB	VB	VB	VB	VB

Table 2: Rule bases for determining the gain K_{I1}.

ė/e	NB	NS	ZE	PS	PB
NB	M	M	M	M	M
NS	S	S	S	S	S
ZE	MS	MS	ZE	MS	MS
PS	S	S	S	S	S
PB	M	M	M	M	M

3- Defuzzification: This yields a non fuzzy control action from inferred fuzzy control action. The most popular method, center of gravity or center of area is used for defuzzification

Table 3: Rule bases for determining the gain K_{D1}.

ė/e	NB	NS	ZE	PS	PB
NB	ZE	S	M	MB	VB
NS	S	B	MB	VB	VB
ZE	M	MB	MB	VB	VB
PS	B	VB	VB	VB	VB
PB	VB	VB	VB	VB	VB

VI. ADAPTATION OF PID CONTROLLER USING GENETIC ALGORITHM

Genetic Algorithms (GA.s) are a stochastic global search method [19, 20] that mimics the process of natural evolution. It is one of the methods used for optimization. John Holland formally introduced this method in the United States in the 1970 at the University of Michigan. The continuing performance improvement of computational systems has made them attractive for some types of optimization. The genetic algorithm starts with no knowledge of the correct solution and depends entirely on responses from its environment and evolution operators such as reproduction, crossover and mutation to arrive at the best solution. By starting at several independent points and searching in parallel, the algorithm avoids local minima and converging to sub optimal solutions. In this way, GAs have been shown to be capable of locating high performance areas in complex domains without experiencing the difficulties associated with high dimensionality, as may occur with gradient decent techniques or methods that rely on derivative information. The steps involved in creating and implementing a genetic algorithm:

a) Generate an initial, random population of individuals for a fixed size.
b) Evaluate their fitness.
c) Select the fittest members of the population.
d) Reproduce using a probabilistic method (e.g., roulette wheel).
e) Implement crossover operation on the reproduced chromosomes
f) (choosing probabilistically both the crossover site and the .mates.).
g) Execute mutation operation with low probability.
h) Repeat step 2 until a predefined convergence criterion is met.

The convergence criterion of a genetic algorithm is a user-specified condition for example the maximum number of generations or when the string fitness value exceeds a certain threshold. In this paper the no of variables is three (Kp , KI ,KD) , the population type is double vector , population size is 20 , the initial range of variable is [0.2– 1]. For the reproduction , the elite count is 2 and the crossover friction is 0.8 , the mutation function is Gaussian, the crossover function is scattered , the stopping rules is the no of generation is 100 , and the stall time limit is 200 sec. Genetic Algorithm Process Flow chart is indicated in Figure 13.

I. ADAPTATION OF PID CONTROLLER USING PSO

Optimization techniques using analogy of swarming principle have been adopted to solve a variety of engineering problems in the past decade. Swarm Intelligence (SI) is an innovative distributed intelligent paradigm for solving optimization problems that originally took its inspiration from the biological examples by swarming, In the earlier PSO algorithms, each particle of the swarm is accelerated by its best previous position and towards the best particle in the entire swarm. Here, the underlying assumption is that each particle in the swarm remembers the best position already visited and also it is informed about the best particle position. After letting the particles to search adequate number of times in the solution space independently for the best possible positions, they are attracted to the basin containing the best particle by establishing proper communication among them about the search environment as explained in [21- 24].

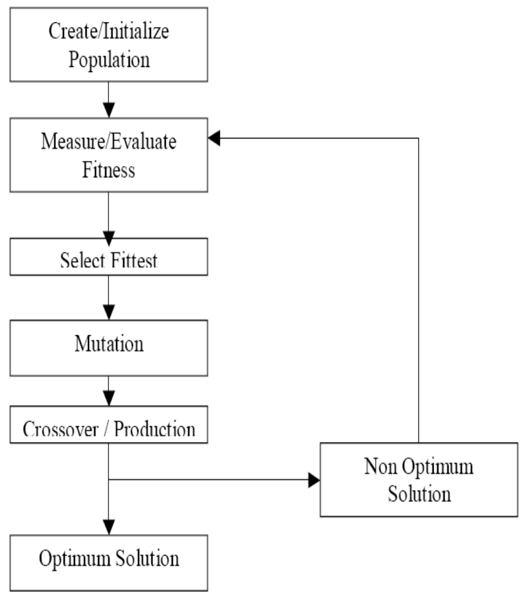

Figure 13 Genetic Algorithm Process Flow chart

Let the i^{th} particle of the swarm is represented by the D–dimensional vector:

$$x_i = (x_{i1}, x_{i2}, ..., x_{iD})$$

and the best particle in the swarm, i.e. the particle with the smallest function value, is denoted by the index g. The best previous position (the position giving the best function value) of the i^{th} particle is recorded and represented as:

$$p_i = (p_{i1}, p_{i2}, ..., p_{iD}),$$

and the position change (velocity)

$v_i = (v_{i1}, v_{i2}, ..., v_{iD})$ of the i^{th} particle.

The particles are manipulated according to the equations:

$$v_{id} = w.v_{id} + c_1.r_1.(p_{id} - x_{id}) + c_2.r_2.(p_{gd} - x_{id}) \quad (14)$$

$$x_{id} = x_{id} + v_{id} \quad (15)$$

where d = 1, 2, . . . , D; i = 1, 2, . . . , N and N is the size of population; *w* is the inertia weight; c_1 and c_2 are two positive constants; r_1 and r_2 are two random values in the range {0,1}. The first equation is used to calculate i^{th} particle's new velocity by taking into consideration three terms: the particle's previous velocity, the distance between the particle's best previous and current position, and, finally, the distance between swarm's best experience (the position of the best particle in the swarm) and i^{th} particle's current position. Then, following the second equation, the i^{th} particle flies toward a new position. The main steps of the PSO algorithm are shown below:

```
Initialize Swarm
repeat
    forall particles do
        Calculate fitness f
    end
    for all particles do
 v_id = w.v_id + c1.r1.(p_id - x_id) + c2.r2.(p_gd - x_id)

 x_id = x_id + v_id
   end
until stopping criteria
```

In this paper, PSO Algorithms is used to find the optimal parameters of the PID controller. The structure of the PID controller with PSO algorithms is shown in Fig. 14. A complete summary of the steps used for PSO algorithm is indicated in Figure 15. In this paper the no of variables is three (Kp , KI ,KD) , the number of birds is 50; Maximum number of "birds steps are 50 , number of dimensions are 3 , c3 =1 , c2 =1.2 and c1 = 0.4 and the weight factor w =0.9

I. Simulations

Simulations are done by using MATLAB simulink for the case of one and two power system areas connected with each other's by tie transmission lines.

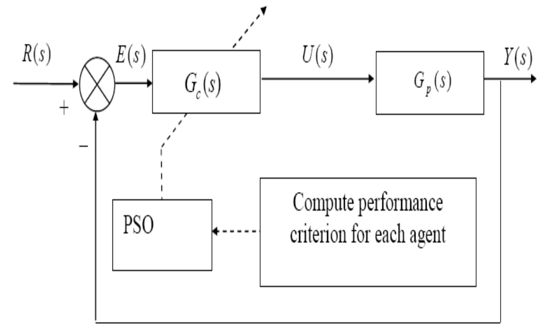

Figure 15 PID tuning using PSO algorithm

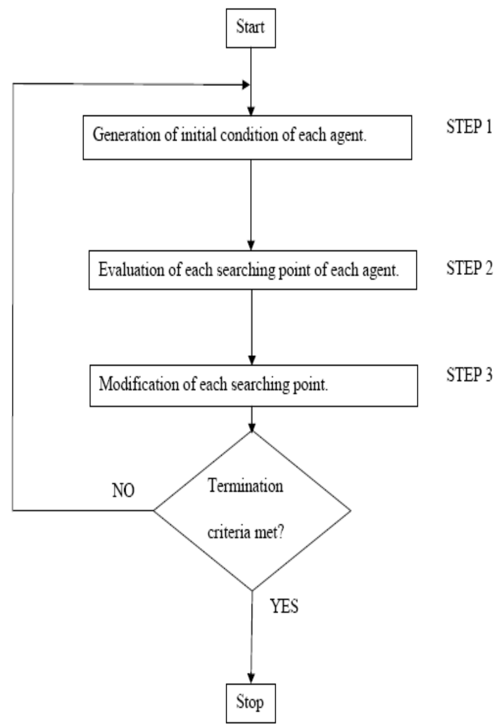

Figure 15 PSO Process Flow chart

In case of one area power system, the parameters will be as following:

Kg1=1; Kt1=1; Tg1=0.08; Tt1=0.3; R1=2.4; Kl1=120; Tl1=20; B1=0.425

By using fuzzy logic controller, the gains of the PID controller are changed online during the simulation as shown in Figure 16 but by using GA and PSO, the following optimal PID parameters are shown in Table 4.

The performance of the PID controller was compared in case of the three intelligent techniques (fuzzy , GA and PSO algorithms) with step change in the load disturbance of 0.07 p.u in the first area and 0.05 p.u in the second area .

Table 4 PID optimal parameters using GA and PSO

PID parameters	Kp	Ki	Kd
GA	4.9	5.2	2.867
PSO	18.5	7.8	5.897

From the Figure 17, the results can be concluded as illustrated in Table (5).

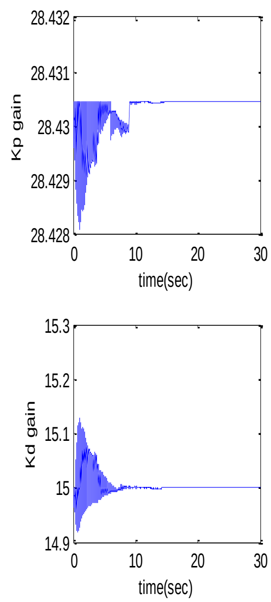

Figure (16): Gains of PID Tuned Using Fuzzy Algorithm for single area power system

Table 5 Performance of the Different Tuning Algorithms for PID Controller For one power system area

Controller	Settling time (Sec)	Peak overshoot
Fuzzy PID tuned	10	0.00003
GA PID tuned	12	0.00254
PSO PID tuned	16	0.0005

For the two area power system, the parameters will be for transmission line 1 parameters:
Kg1=1; Kt1=1; Tg1=0.08; Tt1=0.3; R1=2.4; l1=120; Tl1=20; B1=0.425
Transmission line 2 parameters:
Kg2=1; Kt2=1; Tg2=0.072; Tt2=0.33; R2=2.7; Kl2=112.5; Tl2=25; B2=0.425
By using fuzzy logic controller, the gains of the PID controller are changed online during the simulation as shown in Figure 18 but by using GA and PSO, the following optimal PID parameters are shown in Table 6 .

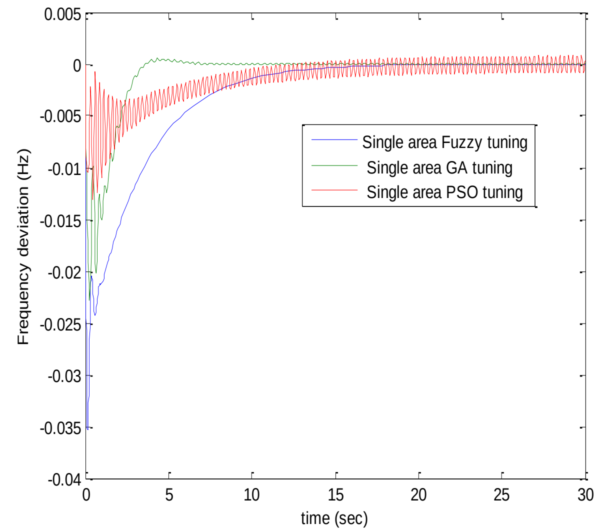

Figure (17): Frequency Deviation Responses Of single area Power System In Case of GA , PSO and Fuzzy PID Tuning

Table 6 PID optimal parameters using GA and PSO

PID parameters	Kp1	Kp2	Ki1	Ki2	Kd1	Kd2
GA	4.535	4.53	4.51	4.5179	2.31	2.31
PSO	23.43	23.43	7.23	7.2393	6.30	6.306

The performance of the PID controller was compared in case of the three intelligent techniques (fuzzy , GA and PSO algorithms) for the two power system areas with step change in the load disturbance of 0.07 p.u in the first area and 0.05 p.u in the second area. From the Figure 19, the results can be concluded as illustrated in Table (7).

Table 7 Performance of the Different Tuning Algorithms for PID Controller For Two Different Area

Controller	Settling time (Sec)	Peak overshoot
Fuzzy PID tuned	7	0.0004
GA PID tuned	11.0	0.002083
PSO PID tuned	16	0.0005

The result indicates that the settling time in case of PSO is nearly double value of the settling time in case of using Fuzzy Logic and GA algorithms. The peak overshoot in case of the fuzzy logic tuning technique is smaller than in case of GA technique in the two simulations, which indicates that using fuzzy logic controller leads to the best frequency deviation results than the two other techniques.

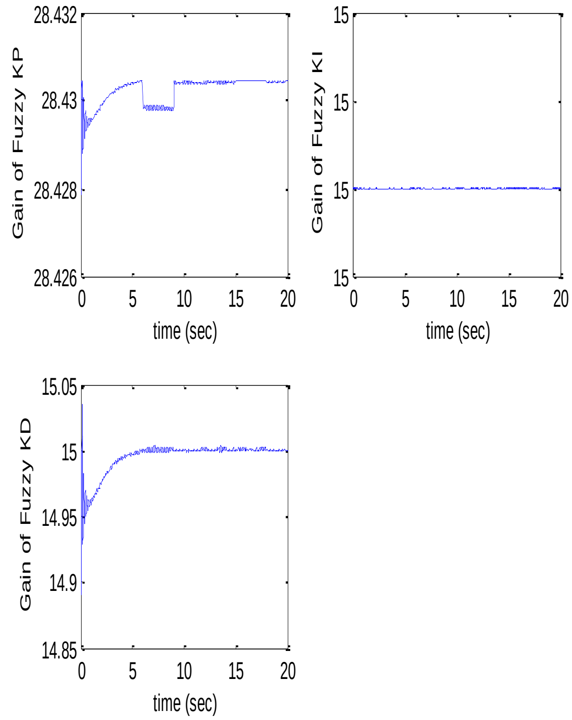

Figure (18): Gains of PID Tuned Using Fuzzy Algorithm for two different area power system

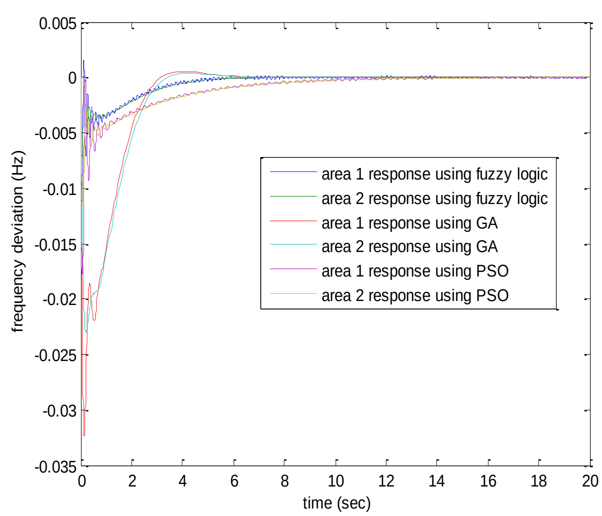

Figure (19): Frequency Deviation Responses Of Two Power System Areas In Case of GA , PSO and Fuzzy PID Tuning

II. Conclusion

In this proposed study, a new GA, PSO and fuzzy Algorithm based PID has been introduced for automatic load frequency control of a multi area power system. For this purpose, first, more adaptive tuning mechanism for the PID controller parameters is obtained. It has been shown that the proposed control algorithms are effective and provides significant improvement in system performance. Therefore, the proposed PID controllers are recommended to generate good quality and reliable electric energy. In addition, the proposed controllers are very simple and easy to implement since it does not require many information about system parameters. Simulations are done by using the same PID parameters for the two different areas because it gives a better performance for the system frequency response than in case of using two different PID parameters for the two areas. This research is the starting of applying the AI algorithms on the four different area power system which will be future work. Comparison study of the proposed PID controllers with each other's was presented.

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