Particle Swarm Optimization based PID controller for two area Load Frequency Control System

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Abstract-- In this work PID controllers tuned with PSO are used in two area Control system. The two areas when interconnected could result in area control error. ACE is nothing but the frequency deviation and tie line power deviation occurred in the tie line. In such a complex situation, proper tuning of individual area's PID controller became indispensable. So the load frequency control is very important issue in the interconnected power system .This ensures the zero steady state error in frequency dynamics and proper sharing of load by generators of interconnected areas. The controller transfer function is then used to simulate the overall system response of two areas Load Frequency Control. The proposed system is PSO optimized PID controller based two area load frequency control system enhances smooth and efficient control of area control error (ACE). The PSO is having good converging rate than genetic algorithm for all the types of control system. The experimental result shows the frequency response and tie line power response of PID controller, Fuzzy-PID, and PSO-PID controller. Finally the PSO based PID controller based optimization technique is giving good response than other mentioned existing system**.**

Index Terms—Load frequency control(LFC) PID Controller, Two-area control, Particle swarm optimization.

I. INTRODUCTION

Reliable and good quality power transfer is maintained in interconnected power system under deregulated environment through proper choice of automatic generation control components. Sudden change in load introduces frequency fluctuations and tie-line power exchange. Suitable load frequency control with the consideration of bilateral contracts between participating areas nowadays became mandatory. Optimal output feedback, linear feedback, Kalman estimator are such few control strategies adopted elsewhere to accomplish the same. Several optimization techniques like Genetic algorithm, Particle Swarm Optimization, Bacterial Foraging are currently being applied for the automatic generation control in multi-area system under deregulation.

Such optimization techniques have also been used for automatic generation control of interconnected power system without deregulation. These techniques are used either to tune the different types of controllers or to set the parameters for power system stabilizers. These action sensable operators to improve the control of the frequency deviation situation and restoration of the tie line power fluctuations quickly. In deregulated environment participation contract between two or more areas are regulated by an independent system operator. Contract violation and its effects are also important in these situations.

In this paper, two area automatic generation control has been studied in a deregulated environment to observe the effect of load change in system dynamics. One GENCO and one DISCO are considered in each area under study. GENCOS share load of its own area as well as that of the other area as demanded by the DISCO. This participation is based on the contract made between the two systems as per the corresponding DISCO Participation Matrix (DPM) matrix. It is generally developed in restructured environment. The PID controller is used here to nullify the effect of frequency and tie-line power deviations in both the areas. MATLAB code has been developed to achieve PID controller tuning based on genetic algorithm. PID controller tuning ensures the improvements in the system response in terms of settling time, rise time, overshoot and steady state value. Studies are made for different contract conditions. The results are compared with step response of similar system having a PID controller tuned with PSO in conventional interconnected power system without deregulation.

II. LOAD FREQUENCY CONTROL

Load frequency control (LFC) of an interconnected power system is concerned with two main objectives i) matching the electrical power generation to the load, ii) adjusting the frequency and iii) tie line power loading to their scheduled values. It is technically feasible to operate the power system in an interconnected manner. Frequency deviation and tie line power deviation are the two prime parameters with respect to LFC. In interconnected power system, load variations in any areas disturb the frequency and tie-line power of other interconnected areas. The primary objective of LFC is to maintain zero steady state errors in interconnected areas, with the condition to fulfill the requested dispatch conditions. The operating point of a power system changes continuously, however, because of the inherent characteristics of the changing loads. It is also desirable that a well designed and operated interconnected power system should cope with changes in the load and it should provide acceptable level of power quality while maintaining frequency and voltage within the stipulated tolerance.

Power systems are used to convert natural energy into electric power. They transport electricity to factories and houses to satisfy all kinds of power needs. To optimize the performance of electrical equipment, it is important to ensure the quality of the electric power. It is well known that three-phase alternating current (AC) is generally used to transport the electricity. During the transportation, both the active power balance and the reactive power balance must be maintained between generating and utilizing the AC power. Those two balances correspond to two equilibrium points: frequency and voltage.

When either of the two balances is broken and reset at a new level, the equilibrium points will float. A good quality of the electric power system requires both the frequency and voltage to remain at standard values during operation.

Thus a control system is essential to cancel the effects of the random load changes and to keep the frequency and voltage at the standard values. although the active power and reactive power have combined effects on the frequency and voltage, the control problem of the frequency and voltage can be decoupled. The frequency is highly dependent on the active power while the voltage is highly dependent on the reactive power. Thus the control issue in power systems can be decoupled into two independent problems. One is about the active power and frequency control while the other is about the reactive power and voltage control. The active power and frequency control is referred to as load frequency control (LFC)

The foremost task of LFC is to keep the frequency constant against the randomly varying active power loads, which are also referred to as unknown external disturbance. Another task of the LFC is to regulate the tie-line power exchange error. A typical large-scale power system is composed of several areas of generating units. In order to enhance the fault tolerance of the entire power system, these generating units are connected via tie-lines. The usage of tie-line power imports a new error into the control problem, i.e., tie-line power exchange error.

Otherwise there would be economic conflicts between the areas. Hence each area requires a separate load frequency controller to regulate the tie-line power exchange error so that all the areas in an interconnected power system can set their set points differently. Another problem is that the interconnection of the power systems results in huge increases in both the order of the system and the number of the tuning controller parameters. As a result, when modeling such complex high-order power systems, the model and parameter approximations cannot be avoided .Therefore the requirement of the LFC is to be robust against the uncertainties of the system model and the variations of system parameters in reality.

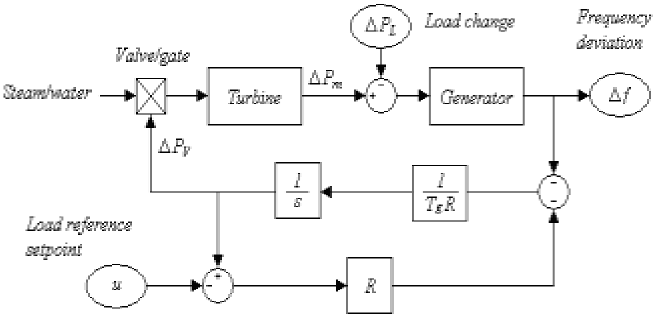

Fig.1 Block diagram of load frequency control

In summary, the LFC has two major assignments, which are to maintain the standard value of frequency and to keep the tie-line power exchange under schedule in the presences of any load changes. In addition, the LFC has to be robust against unknown external disturbances and system model and parameter uncertainties. The high-order interconnected power system could also increase the complexity of the controller design of the LFC.

The Interconnected Power Systems: Power systems are interconnected for economy and continuity of power supply. For the interconnected operation fuel costs, generation limits, tie line capacitors, spinning reserve allocation and area commitments are important considerations. Compared to stand alone power system, interconnected networks have special features that need to be addressed such as load sharing, frequency error minimized and reliable power supply.

While interconnecting two or more stand alone power system, it should be noted that,

- Generators in two areas have same power rating.
- All areas are connected through tie-line.
- Each area regulates its own load variations.

Area Control Error: The goals of LFC are not only to cancel frequency error in each area, but also to drive the tie-line power exchange according to schedule .Since the tie-line power error is the integral of the frequency difference between each pair of areas, if we control frequency error back to zero, any steady state errors in the frequency of the system would result in tie-line power errors. Therefore we need to include the information of the tie-line power deviation into our control input.

III. PSO CONTROLLER FOR THE INTERCONNECTED POWER SYSTEM

PSO is a robust stochastic optimization technique based on the movement and intelligence of swarms. PSO applies the concept of social interaction to problem solving. It was developed in 1995 by James Kennedy (social-psychologist) and Russell Eberhart (electrical engineer). It uses a number of agents (particles) that constitute a swarm moving around in the search space looking for the best solution. Each particle is treated as a point in a N-dimensional space which adjusts its “flying” according to its own flying experience as well as the flying experience of other particles. Each particle keeps track of its coordinates in the solution space which are associated with the best solution (fitness) that has achieved so far by that particle. This value is called personal best , ***pbest***. Another best value that is tracked by the PSO is the best value obtained so far by any particle in the neighborhood of that particle. This value is called ***gbest***. Unlike in genetic algorithms,evolutionary programming and evolutionary strategies, in PSO, there is no selection operation. All particles in PSO are kept as members of the population through the course of the run PSO is the only algorithm that does not implement the survival of the fittest. No crossover operation in PSO. In EP balance between the global and local search can be adjusted through the strategy parameter while in PSO the balance is achieved through the inertial weight factor (w) of eq. 1(a)

Steps of PSO**:** Steps of PSO as implemented for optimization :

Step 1: Initialize an array of particles with random positions and their associated velocities to satisfy the inequality constraints.

Step 2: Check for the satisfaction of the equality constraints and modify the solution if required.

Step 3: Evaluate the fitness function of each particle.

Step 4: Compare the current value of the fitness function with the particles previous best value (pbest). If the current fitness value is less, then assign the current fitness value to pbest and assign the current coordinates (positions) to pbest.

Step 5: Determine the current global minimum fitness value among the current positions.

Step 6: Compare the current global minimum with the previous global minimum (gbest). If the current global minimum is better than gbest, then assign the current global. minimum to gbest and assign the current coordinates (positions) to gbest.

Step 7: Change the velocities.

Step 8: Move each particle to the new position and return to step 2.

Step 9: Repeat step 2-8 until a stop criterion is satisfied or the maximum number of iterations is reached.

This computational technique is developed inspired by social behaviour of bird flocking or fish schooling. In this technique, a group of random particles (solutions) are generated. According to fitness value the best solution is determined in the current iteration and also the best fitness value is stored. The best solution is known as pbest. Another best fitness value is also tracked in the iterations obtained so far. This best fitness value is a global best and its corresponding particle (solution) is called gbest. In every iteration all the particles will be updated by following the best previous position (pbest) and best particle among all the particles (gbest) in the swarm.

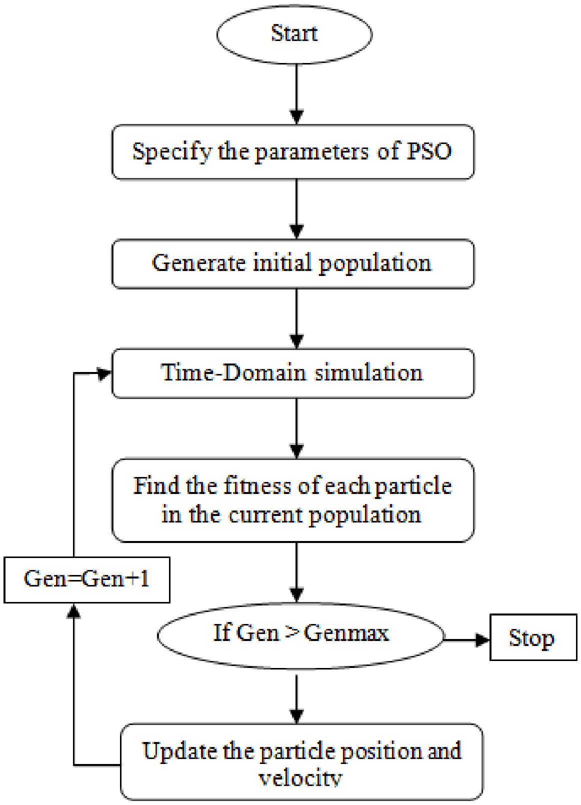

Fig 2. Flow chart for PSO technique

FUZZY-PID:

When the control problem is to regulate the process output around a set point, it is natural to consider error as an input, even to a fuzzy controller, and it follows that the integral of the error and the derivative of the error may be useful inputs as well. In a fuzzified PID controller, however, it is difficult to tell the effect of each gain factor on the rise time, overshoot.

Steps involved in the fuzzy-PID controller:

- Fuzzification block, transforming input physical values into corresponding linguistic variables
- Knowledge base, containing rules table for logic output block;
- Logic output block, transforming input linguistic variables into output with some belonging functions Con;
- Defuzzification block, transforming output linguistic variables into physical control influence.

Membership functions for the output parameter are here, NB means Negative Big, NS means Negative Small, ZE means Zero and PB means Positive Big & PS means Positive Small.The error, e and change in error, de are inputs of FLC. Two input signals are converted to fuzzy numbers first in fuzzified using five membership functions: Positive Big (PB), Positive Small (PS), Zero (ZZ), Negative Small (NS), Negative Big (NB), Small (S), Medium (M), Big (B), Very Big (VB) and Very Very Big (VVB). The conventional controller for LFC scheme is replaced by a fuzzy PID type controller. The gains KPi, KIi and Kdi in Equation are tuned on-line in terms of the knowledge base and fuzzy inference, and then, the conventional PID controller generates the control signal.

The motivation of using the fuzzy logic for tuning gains of PID controllers is to take large parametric uncertainties, system nonlinearities and minimizing of area load disturbances.

IV. SIMULATION RESULTS AND COMPARISION

PSO-PID FITNESS FUNCTION:

The pso is used to the find best Kp Ki Kd values for the PID controller. 100 particles are assumed for each particle to give 1 best fitness value. Number of group is set by 30, the single population have 3 members such as Kp Ki Kd.

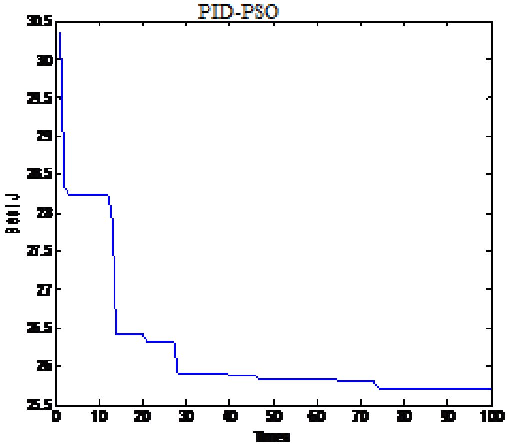

Fig.3. PSO-PID Fitness function

Fitness function is reduced to 25.5 which is constant from 52 to 100. So the best fitness function is 25.5.fitness function is nothing but is a particular type of objective function that is used to summaries single figure of merit, which is to close a given design solution for achieving the set items.

PID RESPONSE:

PSO-PID best fitness function’s set of kp ki kd values are applied to the PID controller. The PID waveform gives better response, it reduces the overshoot occurred in a system.

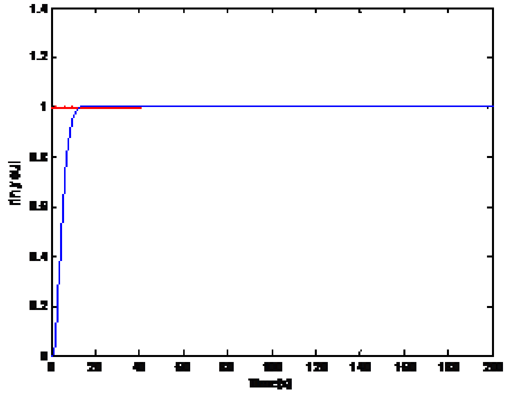

Fig.4. PID Response

FREQUENCY DEVIATION OF INTERCONNECTED AREA:

Frequency deviation in interconnected power system is cleared by using the fuzzy-PID, PID, and PSO-PID. Here output response is compared. Fuzzy-PID is better response compared to the PID controller. PSO-PID is best response compared to the fuzzy-PID. Settling time of the PSO-PID is minimum compared to the other 2 methods.

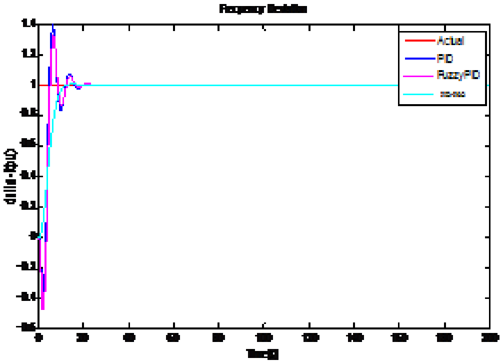

Fig.5. Frequency Deviation of Interconnected Area

TIE LINE POWER DEVIATION OF INTERCONNECTED AREA:

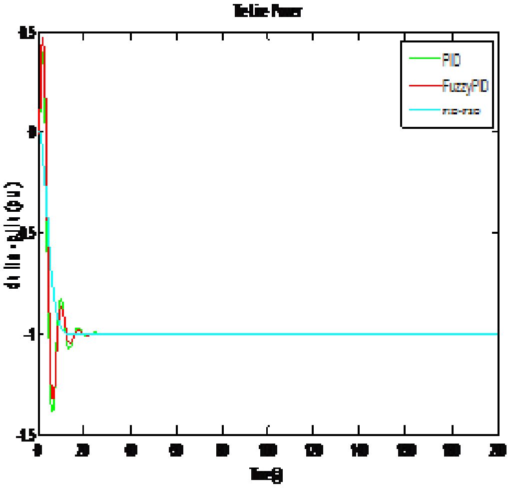

Fig.6.Tie line power deviation of Interconnected Area

Tie line power deviation in interconnected power system is cleared by using the fuzzy-PID,PID, and PSO-PID. Here output response is compared. Fuzzy-PID is better response compared to the PID controller. PSO-PID is best response compared to the fuzzy-PID. Settling time of the PSO-PID is minimum compared to the other 2 methods.

V.CONCLUSION

In this work, two area load frequency control is established by using the PSO tuned PID controller .Inter connection of the two area is very important issue in the power system because of the frequency deviation and tie line power deviation. Compare this result by using the PID and Fuzzy-PID controlling methods. Fuzzy PID give the better response compare to the PID controller. The PID controller which is used to bring the system dynamics within comfortable limits is tuned with the help of genetic algorithm. This PSO tuned PID controller gives best response compare to the Fuzzy PID controller. The frequency deviation, tie line power deviation are settled with the minimum duration and the overshoot of the waveforms will be reduced.
Future work of this project will be developed by using another optimization method.

REFERENCES:

[1] Sahbi Marrouchi and Souad Ben Saber, "A Comparative Study of Fuzzy Logic, genetic algorithm, and Gradient-Genetic Algorithm Optimization Methods for Solving the Unit Commitment Problem", 20 June 2014; Published 16 July 2014.

[2] Sateesh Kumar Vavilala ,RS Srinivas, Machavarapu Suman, "Load Frequency Control of Two Area Interconnected Power System Using Conventional and Intelligent Controllers", ISSN : 2248-9622, Vol. 4, Issue

1, January 2014, pp.156-160

[3] Dr. S.K.Bhagat, Binod Rai2 and Amresh Kumar," GA based Internal Model Controller Design for Load Frequency Control in Power System via Reduced Order Model", www.ijesi.org Volume 3 , March 2014 PP 17-26.

[4] Atul Ikhe and Anant Kulkarni, "Load Frequency Control For Two Area Power System Using Different Controllers", International Journal of Advances in Engineering, Sept. 2013.

[5] A.Harsha Vardhan, A. Sai Bharadwaj, S. Srinivasulu RajuN.Archana, "Implementation of Fuzzy PID Controller And Performance Comparison With PID For Position Control Of Dc Motor", Volume 7, Issue 9 (July 2013), PP. 78-84.

[6] Rajesh Narayan Deo, Shiva Pujan Jaiswal, M. Venkateswarlu Naik, "Fuzzy Logic Based Automatic Load Frequency Control of Multi-Area Power Systems", 2013 IJEDR1301002

[7] A.M. Jadhav and K. Vadirajacharya, "Performance verification of PID Controller In An Interconnected Power System Using Particle Swarm optimization", Energy Procedia, vol.14, pp. 2075- 2080,2012

[8] Nitish Katal, Sanjay Kr. Singh,"Optimization of PID Controller for Quarter-Car Suspension System using GeneticAlgorithm",(IJARCET)Volume1, Issue 7, September 2012.

[9] A. Jalili H. Shayeghi N.M. Tabatabaei," Fuzzy PID Controller Based on LFC in The Deregulated Power System Including SMES", International Journal on Technical and Physical Problems of Engineering (IJTPE), Is.8,Vol. 3, No. 3, Sep. 2012

[10] Armin Ebrahimi Milani, Babak Mozafari, "Genetic Algorithm Based Optimal Load Frequency Control In Two-Area Interconnected Power Systems", ISSN: 2229-8711 Online Publication, June 2011.

[11] K.S.S. Ramakrishna, Pawan Sharma, T. S. Bhatti, "Automatic Generation Control of Interconnected Power System With Diverse Sources of Power Generation International Journal of Engineering, Science an Technology" Vol. 2, No. 5, 2010, pp. 51-65.

[12] J.Sadeh and E. Rakhshani, "Multi-Area load frequency control in a deregulated power system using optimal output feedback control", 5th Int. Conf. on European Electricity Market, May, 2008, pp.1-6

[13] Nidul Sinha1, Loi Lei Lai, "GA Optimized PID Controllers For Automatic
Systems Under Generation Control of Two Area Reheat Thermal Deregulated Environment", DRPT2008,6-9 April 2008

[14] B. Venkata Prasanth1, Dr. S. V. Jayaram Kumar, "Load Frequency Control For a Two Area Interconnected Power System Using Robust Genetic Algorithm controller", Journal of Theoretical and Applied Information Technology, 2005 – 2008.

[15] Lusika Roy , Bikash Dey, Load Frequency Control in Interconnected Power System by Using Classical Controller, International Journal of Electronics and Computer Science Engineering, ISSN- 2277-1956