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Optimal Design & Analysis of Load Frequency Control for two Interconnected Area, Using PSO as Smart Tool to Tune PID

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***ABSTRACT*- This paper consist optimal design and analysis of Automatic Load Frequency Control (ALFC) of two interconnected area using PID controller. The suitable inter-connectivity effect has been considered to realize the system as real time system. Both areas are considered with reheat and governor dead band which make the system non-linear. The different parameter of PID controlled automatic generation control (AGC) is tuned by particle swarm optimization (PSO) method. Step load perturbation (SLP) of 1% is applied to both Area-1 and Area-2. The optimal system stability and performance is checked by changing the different parameter of the system member like governor, SLP, turbine, controller etc. The analysis is made on the basis of response, table obtained and steady state behaviour by comparing its performance with other tuned method. For this MATLAB- Simulink is used.**

Keywords: Automatic load frequency control, PSO, PID, Two interconnected area, Automatic generation control.

I. INTRODUCTION

The stability of power system is required for continuous supply of power with an acceptable quality, to all the consumers in the system. There must be optimal relation between the power demand and the power generated. The generated power system quality is defined by three factors: Consistent frequency, Consistent voltage and reliability level [1]. Iinterconnected electric power generation systems utilize tie- lines to transmit power from one area to another, either scheduled via a contract or in support during a system Disturbance [2]. As we adopted the power in AC generation and transmission system which having two form as real and reactive components and among the both the balance has to be maintained. There are two basic control mechanisms used to achieve reactive power balance (acceptable voltage profile) and real power balance (acceptable frequency values). The former is called the automatic voltage regulator (AVR) and the latter is called the automatic load frequency control (ALFC) or automatic generation control (AGC). AGC tries to achieve this balance by maintaining the system frequency and the tie line flows at their scheduled values. The AGC action is guided by the Area Control Error (ACE), which is a function of system frequency and tie line flows. The ACE represents a mismatch between area load and generation taking into account any interchange agreement with the neighboring areas [1], [2] A simulation model for AGC studies of such a system has been proposed here. The AGC performance of a two area test system has been studied with a Particle Swarm Optimization (PSO).All generators are supposed to constitute a coherent group in each control area. From the experiments on the power system, it can be seen that each area needs its system frequency to be controlled [6].The simulation results indicate that better control performance in terms of overshoot and settling time can be obtained by the PSO. Literature survey shows that, early works on AGC was initiated by Cohn [2]. After that a modern optimal control concept for interconnected systems of AGC design was introduced by Elgerd and Fosha for the first time [3]. They suggested a proportional controller and different feedback form to develop the optimal controller. The first gain scheduling control method for AGC of an interconnected power system was proposed by Lee and Coworkers in1991 [4]. Later on frequency-domain analysis further validates the strong robustness of the controller against parameter variations and external disturbances suggested by Yao Zhang, & Lili Dong in their early works [9]. For this the work of S. K. Sinha, R. Prasad suggested that the ccomputer simulation on the two area thermal system shows better control performance in terms of peak overshoot and settling time by tuned controller as compared to the untuned controller[10]. Over the past decades, many control strategies have been proposed for AGC viz. Proportional and integral (PI), Proportional, Integral and Derivative (PID) and Optimal controllers, optimal control [7] and variable structure control [8]

II. MODELING OF SYSTEM AND LOAD FREQUENCY CONTROL

The voltage of the generator is proportional to the speed and excitation (flux) of the generator. The speed being constant, the excitation is used to control the voltage. The voltage control system is also called as excitation control system or automatic voltage regulator (AVR). The objectives of the LFC are to maintain reasonably uniform frequency, to divide the load between generators, and to control the tie-line interchange schedules. The main functions of the ALFC are to:

A. To maintain the steady frequency;
B. Control the tie-line flows; and

C. Distribute the load among the participating generating units.

In an interconnected power system, a sudden load perturbation in any of the interconnected areas causes the deviation of frequencies of all the areas and also of the tie-line powers. The imbalance between real power generation and load demand (plus losses) throughout the daily load cycle causes kinetic energy of rotation to be either added to or taken from the on-line generating units, and frequency throughout the Interconnected system varies as a result. If the amount of the generated power is less than the amount of power demand, then the frequency of the system decreases and vice-versa. For satisfactory operation of power units running in parallel it is most desirable to have the frequency and tie-line power fixed on their nominal and scheduled values even when the load alters and, therefore to remove area control error (ACE = 0).

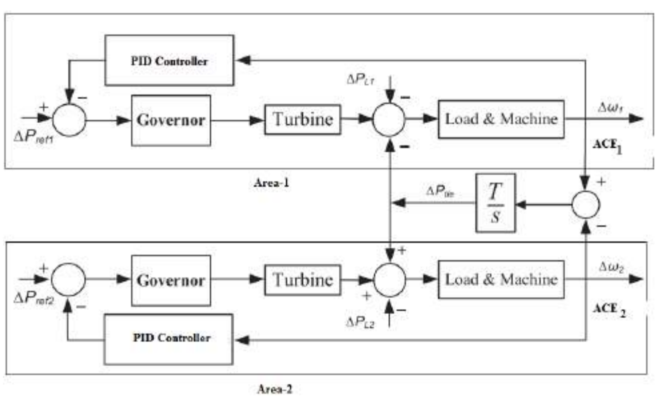

Fig. 1: Two Area Control Scheme Using PID

The addition of governor dead band makes the system non-linear where the governor dead band refers to the amount of continuous speed change during which position of the valve does not change substantially. Thus, before there is a change in position of the valve due to governor dead band can change the turbine speed. Due to the presence of the dead band, the system is affected by a sinusoidal oscillation of 0.5 Hz which is a more realistic approach in designing an interconnected system. Thus, in this work it is tried to linearize the dead band effect of the governor in the terms of change and in rate of change of speed. The main aim of tuning the system is minimizing the value of Area Control Error (ACE).

$$ACE_i = \sum_j \Delta P_{tie,ij} + B_i \Delta f_i$$

The function of the AGC is only to bring the frequency to the nominal value. This will be achieved using the supplementary loop (as shown in Fig. 1).Which uses the integral controller to change the reference power setting so as to change the speed set point. The integral controller gain Kp, Ki & Kd needs to be adjusted for satisfactory response (in terms of overshoot, settling time) of the system.

III. PARTICLE SWARM OPTIMIZATION (PSO)

Particle Swarm Optimization (PSO) is a technique used To explore the search space of a given problem To find the settings or parameters required to maximize a particular objective. This technique, first described by James Kennedy and Russell C. Eberhart in 1995, originates from two separate concepts: The idea of swarm intelligence based off the observation of swarming habits by certain kinds of animals (such as birds and fish); The field of evolutionary computation. PSO is a population-based algorithm that exploits a population of individuals to probe promising regions of the search space. In this context, the population is called a swarm and the individuals are called particles. Each particle moves with an adaptable velocity within the search space, and retains in its memory the best position it ever encountered.

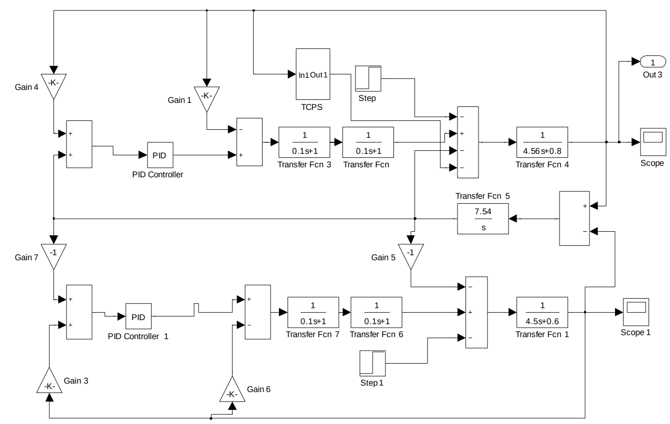

Fig. 2: Purposed Model of Two Interconnected Area ALFC

In the global variant of PSO the best position ever attained by all individuals of the swarm is communicated to all the particles. In the local variant, each particle is assigned to a neighbourhood consisting of a pre specified number of particles. In this case, the best position ever attained by the particles that comprise the neighbourhood is communicated among them. The PSO algorithm works by simultaneously maintaining several candidate solutions in the search space. During each iteration of the algorithm, each candidate solution is evaluated by the objective function being optimized, determining the fitness of that solution. Each candidate solution can be thought of as a particle "flying" through the fitness landscape finding the maximum or minimum of the objective function. Initially, the PSO algorithm chooses candidate solutions randomly within the search space. The PSO algorithm consists of just three steps, which are repeated until some stopping condition is met. Evaluate the fitness of each particle Update individual and global best fitness's and positions Update velocity and position of each particle Algorithm of PSO: Create a 'population' of agents (particles) uniformly distributed over X. Evaluate each particle's position according to the objective function. If a particle's current position is better than its previous best position, update it

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Determine the best particle (according to the particle's previous best positions) Update particles' velocities: Vik+1 = wVik +c1 rand1 (…) x (pbesti-sik) + c2 rand2 (…) x (gbest-sik) Move particles to their new positions: sik+1 = sik + Vik+1 Go to step previous until stopping criteria are satisfied Particle's velocity: Vik+1 = wVik +c1 rand1 (…) x (pbesti-sik) + c2 rand2 (…) x (gbest-sik). Makes the particle move in the same direction and with the same velocity Improves the individual makes the particle return to a previous position, better than the current Conservative Makes the particle follow the best neighbour's direction the following weighting function is usually utilized in

$$w = w_{Max}-[(w_{Max}-w_{Min}) \times iter]/Max\ Iter$$

Where w_{Max}= initial weight,

w_{Min} = final weight,

Max iter = maximum iteration number,

iter = current iteration number.

sik+1 = sik + Vik+1 displacement equation

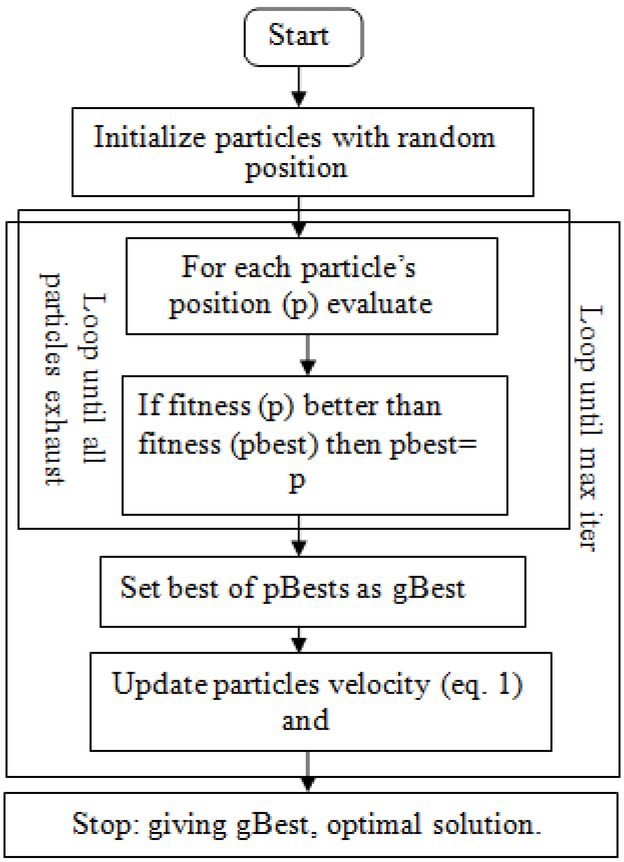

Figure 3 proposed model flow chart

PID controllers are used to improve the dynamic performance of AGC of a two area power system. The main aim of this work is the application of PSO algorithm to tune the parameters of the PID controllers in an interconnected system. In view of the above, the present work investigates the following aspects: (a) To optimize the parameters of the conventional PID controllers using PSO algorithm. (b) To determine settling time and the performance of PSO optimized PID controlled AGC for a two area interconnected power system. In order to represent a basic simple model of an interconnected power system, a two area power system of rating 1000 MW each with reheat and governor with dead band is considered. The transfer function model of the proposed system is shown in model. A step load perturbation of 1% is applied in both area-1 and area-2, to study the transient response of change in frequency of both the areas and the tie line power deviation.

III. RESULT AND ANALYSIS

The Kp, Ki and Kc is obtained from PSO as: Initialization of PSO parameters wmax=0.9; wmin=0.4; Maximum iteration number itmax=10; Pmax=[-.06 .2 -.03]; Pmin=[.06 -.2 .03]; V(i, j) = m(j) + (n (j) - m(j))*rand; vmax = [.12 -.4 .06]; The gBest value obtained through PSO is listed as: gBest =

Kd	Ki	Kc
0.0548	-0.2265	0.0029
0.0487	-0.1969	0.0227
0.0193	-0.2613	0.018
0.0396	-0.2882	0.0293
0.0081	-0.2612	0.0157
0.0093	-0.1775	0.0269
0.0085	-0.2216	0.0279
0.0551	-0.2116	0.0125
0.0513	-0.1531	0.028
0.0221	-0.2325	0.0286

gbest Value = 0

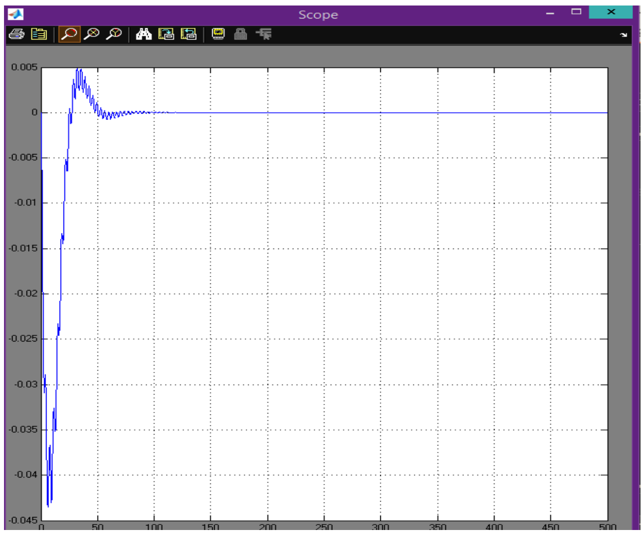

Figure4 Frequency Deviation of Double Area System with PSO based PID controller of Area- 1

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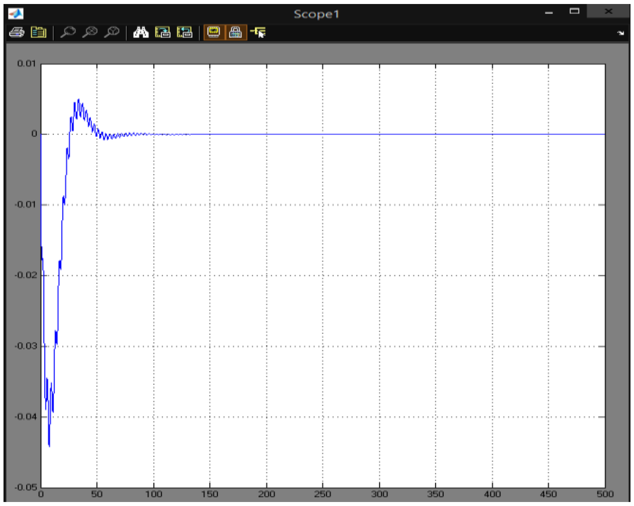

Figure 5 Frequency Deviation of Double Area System with PSO based PID controller of Area- 2

CONCLUSION

Significant conclusions of this work are as follows: a) this work presents design method for determining the PID controller parameters using the PSO method. b) An efficient analysis is made of PSO based PID controller and un-tuned PID controller. The results show that the proposed approach had superior features, including easy implementation, stable convergence characteristic, and good computational efficiency. Fast tuning of optimum PID controller parameters yields high-quality solution. c) Compared with the other conventional method, the proposed method was indeed more efficient and robust in improving the step response of an AGC system.

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