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AUTOMATIC GENERATION MANAGEMENT & CONTROL BY USING PARTICLE SWARM OPTIMIZATION

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ABSTRACT:

The previous is named the automated transformer and therefore the latter is called the automatic load frequency control or automatic generation control. AGC provides an efficient mechanism for adjusting the generation to reduce frequency deviation and regulate the tie line power flows. The system is going to be in equilibrium, once there's a balance between the power demand and therefore the power generated. Because the power in AC kind has real and reactive components: the real power stability; also because the reactive power balance is to be achieved. There are two basic control mechanisms wont to reach reactive power balance and real power balance.

The objective of this work is to reduce the area control error and to minimize the frequency deviation of single area system and two area systems. Matlab simulink Model are formatted for single and two area control system. In this work PID controller and a global search technique PSO is used to find optimum solution. PSO is an optimization technique based on the social behavior like fish schooling, can provide global solution of the nonlinear problem.

KEYWORDS:

PARTICLE SWARM OPTIMIZATION, AGC SYSTEM, EMS, SCADA.

I. INTRODUCTION

The most objective of providing associate degree Automatic Generation Control (AGC) has been to keep up the system frequency at par value and also the power interchange between completely different areas at their scheduled values. The main objective of grid operation and management is to keep up continuous provider of power with a suitable quality, to all or any the customers within the system. The system is going to be in equilibrium, once there's a balance between the ability demand and also the power generated. Because the power in AC kind has real and reactive components: the important power balance; also because the reactive power balance is to be achieved. There are two basic management mechanisms wont to attain reactive power stability (acceptable voltage outline) and real power balance (acceptable frequency values). The previous is named the automated transformer (AVR) and also the latter is named the automated load frequency management (ALFC) or automatic generation management (AGC).

1.1 Introduction to Automatic Generation Control

AGC provides a good mechanism for adjusting the generation to attenuate frequency deviation and regulate tie-line power flows. The AGC system realizes generation changes by causing signals to the under-control generating units. The AGC performance is extremely captivated with however those generating units answer the commands. The generating unit response characteristics area unit captivated with several factors, like form of unit, fuel, management strategy, and operational purpose. The AGC, security management, Supervisory Control and Data Acquisition (SCADA), and cargo management area unit the key units within the application layer of a contemporary energy management system (EMS). The AGC method is performed in a very center remote from generating plants, whereas the facility production is controlled by turbine-governors at the generation web site.

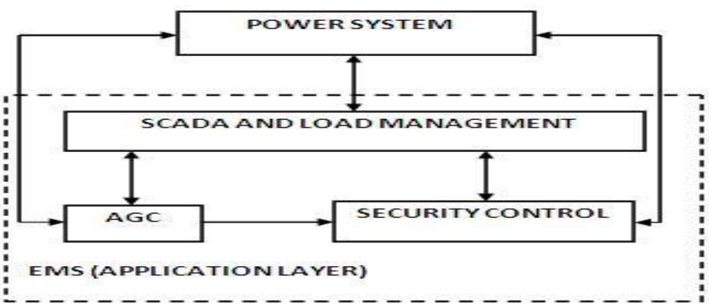

Fig 1. Application layer of a modern EMS

AGC communicates with SCADA, the load management unit, and therefore the security centre within the EMS,

1.2 Generator Voltage Control System

The voltage of the generator is comparative to the velocity and excitation of the generator. The speed being constant, the excitation is employed to regulate the voltage. Therefore, the voltage system is additionally referred to as excitation system or automatic transformer (AVR). For the alternators, the excitation are provided by a tool (another machine or a static device) referred to as exciter. For giant an out sized an oversized generator the exciter could also be needed to provide a field current of as giant as 6500A at 500V and thus the exciter could be a fairly large machine. betting on the means the dc offer is given to the sphere winding of the generator (which is on the rotor), the exciters are classified as: i) DC Exciters; ii) AC Exciters; and iii) Static Exciters.

A simplified diagram of the generator voltage system is shown in Fig.2.The generator terminal voltage Green Mountain State is compared with a voltage reference Vref to get a voltage error signal -V. This signal is applied to the transformer shown as a block with transfer operate Ka/(1+sTa). The output of the regulator is then applied to exciter shown with a block of transfer operate Ke/(1+sTe). The output of the exciter E_{fd} is then applied to the sector winding that adjusts the generator terminal voltage. The generator field are often drawn by a block with a transfer operate Kf/(1+sTf). The stabilizing compensator shown within the diagram is employed to boost the dynamic response of the exciter. The input to the present block is that the exciter voltage and therefore the output could be a stabilizing feedback signal to scale back the excessive overshoot.

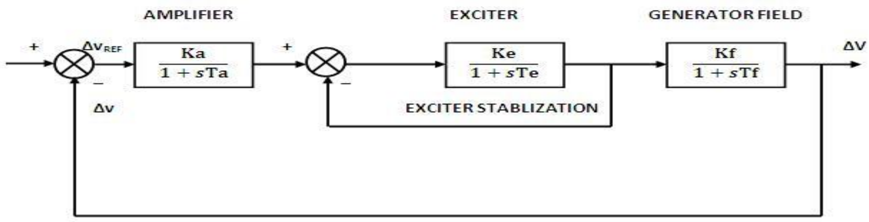

Fig.2 : A simplified block diagram of Voltage (Excitation) Control System

1.3 Concept of AGC (Supplementary ALFC Loop)

The ALFC loop shown in Fig.3 is called the primary ALFC loop. It achieves the primary goal of real power balance by adjusting the turbine output delP_m to match the change in load demand delP_d. All the collaborating generating units contribute to the modification in generation. However a modification in load leads to a gradual state frequency deviation excavation. The restoration of the frequency to the value needs a further management loop known as the supplementary loop. This objective is met by mistreatment integral controller that makes the frequency deviation zero. The ALFC with the supplementary loop is usually known as the AGC.

The diagram of associate AGC is shown in Fig 3 . The main objectives of AGC square measure

i) to control the frequency (using each primary and supplementary controls) to keep up the scheduled tie-line flows. A secondary objective of the AGC is to share out the compulsory modify in generation between the connected generating units economically (to obtain least operating costs).

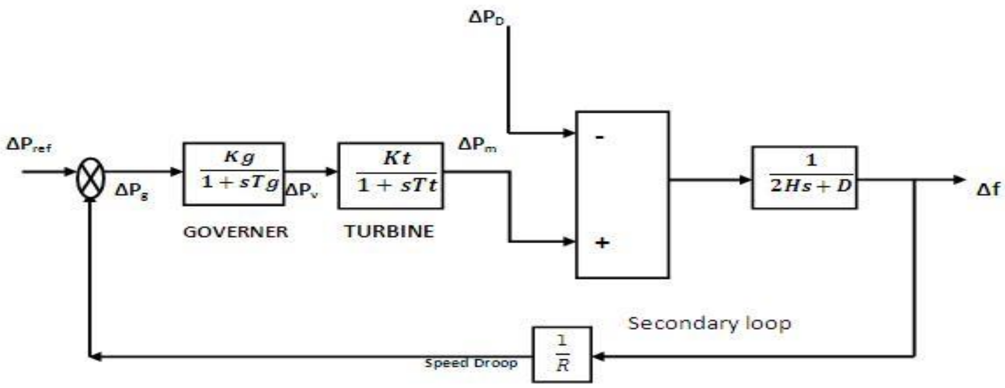

Fig 3: the ALFC block diagram

II. PROBLEM FORMULATION

For the proposed test system the main aim is to minimize the area control error of the test system. Automatic generation control is used to regulate the frequency and maintain it to its nominal value. For a two area system Automatic Generation Control is also to minimize tie-line power flow oscillation between the two areas. In order to obtain the above requirements the parameters of PID Controller (Kp, Ki, Kd) and parameters of SMES (Ksmes, Tsmes, T1, T2, T3, T4) are optimized using Particle Swarm Optimization. The main objectives of the test system which are to be formulated and the system modeling of the test system have been discussed below:

2.1 Tie line bias control of multi area system

In order to write a mathematical expression for the tie line bias control, consider a control area designated as k and the net interchange f power is equal to the sum of power over all the j interconnecting tie-lines. The area control error (ACE) is indicative of the total interchange of power. Therefore, it is expressed in the following form:

$$ACEk = \Sigma(\Delta P_{ij} + B_k \Delta f_k) \quad (3f)$$

All the area generators which constitute the secondary LFC receive the ACE and initiate corrective action for restoring the tie-line power to its power interchange and frequency to its normal value.

III. SYSTEM MODELLING

For obtaining better transient response and for dynamic stability of the test system an SMES unit is incorporated in the both single as well as two area system. SMES unit is added in the terminal of area1 of the two area system. For better performance, SMES parameters have been optimized using PSO technique. The system modeling of single as well as two area system with SMES unit is been discussed below:

3.1 Linearized model of single area system

In this we have considered a single area system with SMES unit. The PID controller used in this system is being optimized using PSO, even the control variables of SMES (Ksmes,Tsmes,T1,T2,T3,T4) structure is optimized by means of PSO. For the dynamic presentation of the test system 10% load change is considered. The block figure representations of single system with SMES unit are shown in the Figure. Here the SMES units behave as a frequency stabilizer used to bring the system frequency to its nominal value and also to reduce frequency deviation of the system.

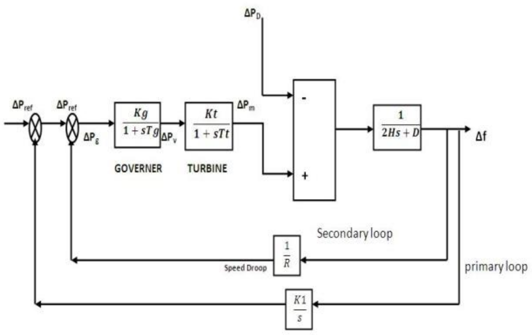

Fig 4: System modeling of the Single area system with SMES unit

3.2 Mathematical modeling of SMES

The structure of frequency stabilizer for SMES is shapely because the second order lead-lag compensator and is shown in Fig. the target of AGC is to change primary frequency regulation, restore the frequency to its par value as quickly as potential and minimize the tie-line power flows. so as to satisfy higher than needs, the parameters of SMES square measure have to be compelled to be optimized, that is completed by mistreatment PSO.

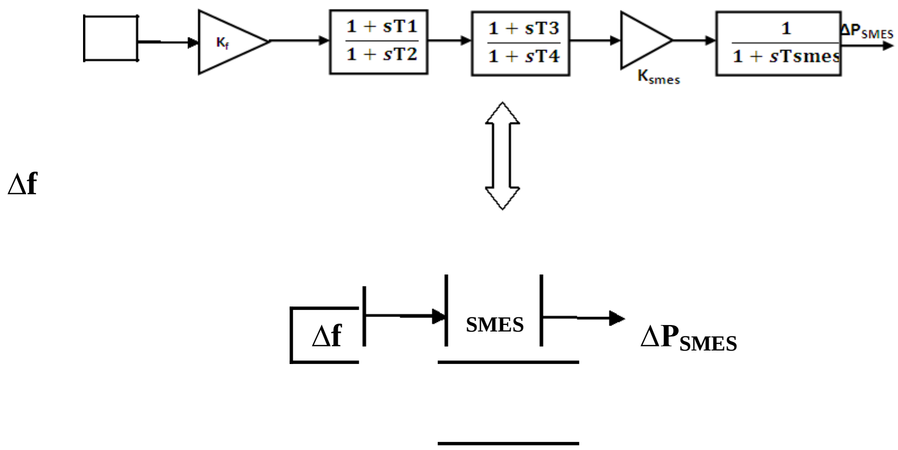

Fig.5 SMES Block Diagram

IV. EXISTING METHODOLOGY

4.1 Genetic Algorithm

Genetic rule could be a part of organic process computing, that could be a apace growing space of computing. GAs is impressed by Darwin's theory concerning evolution. Merely aforesaid, answer to a tangle resolved by GAs is evolved. GAs were initial prompt by John Netherlands and developed by him and his students and colleagues within the seventies of last century. This result in Holland's book “Adoption in Natural and Artificial Systems" printed in 1975 .Over the last twenty years of the last century, it's been wont to solve a good vary of search, optimization and machine learning issues. Thus, the GA is AN iteration procedure that maintains a relentless size population of candidate answer. In 1992 John Koza has used GA to evolve programs to perform sure tasks. He referred to as his methodology “genetic programming” (GP).

4.2 Genetic algorithms and ancient ways of optimization

Genetic rule relies on the principles of natural genetic science and selection. the fundamental components of natural genetics: replica, crossover ,mutation, area unit utilized in the genetic search procedure .Genetic rule dissent from ancient methodology in following way:

1.) A population of purpose is employed for beginning the procedure rather than single style purpose. If the amount of style variables is n, typically the scale of the population is taken as 2n to 4n .since many points area unit used as candidate solutions, Genetic rule is a smaller amount possible to urge unfree at an area minima.

2.) Genetic rule uses solely the values of objective operate. The derivatives don't seem to be utilized in the search procedures.

3.) In GAs the planning variables area unit diagrammatical as strings of binary variables that correspond to the body in natural genetic science.

4.) The search methodology is of course applicable for finding natural and number programming issues.

5.) The target operates worth reminiscent of style vector plays the role of fitness in natural genetic science.

4.3 GA Mechanism

The GA mechanism is galvanized by the mechanism of survival, wherever stronger people would possible be the winners in an exceedingly competitive surroundings. Unremarkably in an exceedingly GA. The parameters to be optimized square measure diagrammatic in an exceedingly binary string. A simplified flow diagram for GA is shown in Figure 6. the value perform, that determines the optimisation downside, represents the most link between the matter at hand (system) and GA. And additionally provides the elemental supply to produce the mechanism for analysis of algorithmic rule steps.

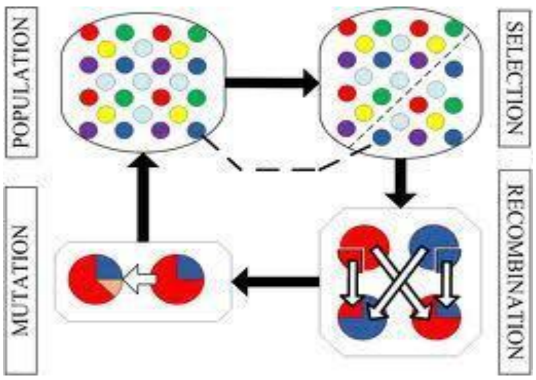

Fig 6. GA Mechanism

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To start the optimization, GA uses every which way created initial solutions created by a random variety generator. This technique is most popular once a priori data regarding the matter isn't out there. There square measure essentially 3 genetic operators wont to manufacture a brand new generation: choice, crossover, and mutation. The GA employs these operators to converge at the world optimum. Once every which way generating the initial population (as random solutions).

V. PROPOSED TECHNIQUE AND METHODOLGY

5.1 Particle Swarm Optimization: An Introduction

Particle Swarm Optimization (PSO) may be a technique accustomed explore the search house of a given downside to seek out the settings or parameters needed to maximize a specific objective. this method, initial delineated by James Kennedy and Russell C. Eberhart in 1995 [1], originates from two separate concepts: the concept of swarm intelligence primarily based off the observation of swarming habits by bound forms of animals (such as birds and fish); and therefore the field of organic process computation.

PSO belongs to the broad category of random improvement algorithms. The concepts that underlie PSO area unit galvanized not by the organic process mechanisms encountered in natural process, however rather by the social behavior of flocking organisms, like swarms of birds and fish faculties. it's been determined that the behavior of the people that comprise a flock adheres to elementary rules like nearest-neighbor speed matching and acceleration by distance. During this respect, it's been claimed that PSO performs mutation with a conscience. PSO may be a population-based formula that exploits a population of people to probe promising regions of the search house. During this context, the population known as a swarm and therefore the people area unit called particles. Every particle moves with Associate in labile speed among the search house, and retains in its memory the simplest position it ever encountered. Within the international variant of PSO the simplest position ever earned by all people of the swarm is communicated to any or all the particles.

5.2 PSO: Fundamentals & Concept

5.2.1 Optimization

The domain Rn of f is cited because the search house (or parameter space). Every component of Rn is named a candidate answer within the search house, with ˆx being the best answer. The worth n denotes the amount of dimensions of the search house, and so the amount of parameters concerned within the improvement downside. The perform f is named the target perform, that maps the search house to the perform house. Since a perform has only 1 output, this perform house is typically one-dimensional. The perform house is then mapped to the one-dimensional fitness house, providing one fitness price for every set of parameters. This single fitness price determines the optimality of the set of parameters for the required task. In most cases, as well as all the cases mentioned during this paper, the perform house may be directly mapped to the fitness house. However, the excellence between perform house and fitness house is very important in cases like multi objective improvement tasks, that embody many objective functions drawing input from constant parameter house.

5.2.2 PSO Parameter Selection

The choice of PSO parameters will have an oversized impact on improvement performance. Choosing PSO parameters that yield smart performance has so been the topic of abundant analysis. Basically, it may be fanciful that the perform that is to be reduced forms a hyper-surface of spatiality same as that of the parameters to be optimized (search variables). It's then obvious that the 'ruggedness' of this hyper-surface depends on the actual downside.

Now, however smart the search is depends on however intensive it's, that is set by the parameters. Whereas a 'lesser rugged' answer hyper-surface would want fewer particles and lesser iterations, a 'more rugged' one would need a additional thorough search- victimization additional people and iterations.

This is analogous to a different realistic state of affairs of flocks sorting out an honest 'food' traversing a really tough piece of land containing gardens everywhere, some higher than others wherever a massively inhabited flock would be inevitable so as to succeed in the simplest (read international optimum) 'food' supply, compared to Associate in a different piece of land wherever there are a unit only a few gardens on an otherwise non-vegetated land, wherever it becomes straightforward to go looking for 'food' and lesser range of people and iterations can satisfy.

5.2.3 PSO Algorithms

The PSO formula works by at the same time maintaining many candidate solutions within the search house. Throughout every iteration of the formula, every candidate answer is evaluated by the target perform being optimized, decisive the fitness of that answer. Every candidate answer may be thought of as a particle "flying" through the fitness landscape finding the utmost or minimum of the target perform. Initially, the PSO formula chooses candidate solutions willy-nilly among the search house. Figure 7 shows the initial state of a four-particle PSO formula seeking the worldwide most during a one-dimensional search house.

The search house consists of all the potential solutions on the x-axis; the curve denotes the target performs. It ought to be noted that the PSO formula has no data of the underlying objective perform, and so has no means of knowing if any of the candidate solutions area unit with regards to or remote from a neighborhood or international most. The PSO formula merely uses the target perform to judge its candidate solutions, and operates upon the resultant fitness values.

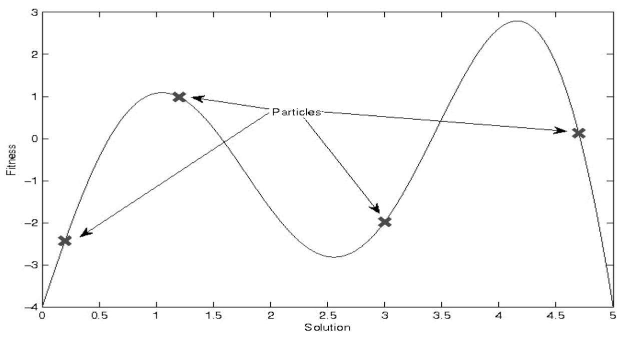

Fig 7 Initial PSO State

VI. SIMULATION RESULTS AND DISCUSSION

- For both single area system and two area system a comparison is made between **PARTICLE SWARM OPTIMIZATION** based PID controller and **GENETIC ALGORITHM** based PID controller.
- For further improvement of the result an SMES unit is also incorporated in the test system both for single as well as two area system.
- The parameters of SMES unit have been optimized using PSO method.
- A comparison is also made between PSO tuned SMES unit and an unturned SMES unit.

6.1 Case study 1: single area test system

Firstly a Single area test system is considered. Its PID control parameters (Kp, Ki, Kd) are optimized using Particle Swarm Optimization and Genetic Algorithm. And the two techniques have been compared on the basis of result so obtained. In the above Test system an SMES unit is incorporated for obtaining better result. And for further improvement of the result the parameters of SMES (Ksmes,Tsmes,T1,T2,T3 & T4) are optimized using Particle Swarm Optimization Technique.

6.1.1 Single area system with PSO based PID controler without SMES

For the considered single area test system the PID controller parameters are optimized using PSO technique. After optimization results obtained are-

Single Area Test System

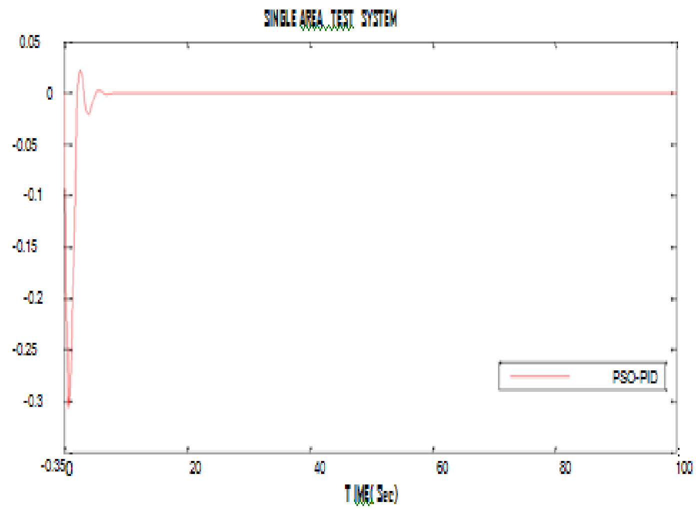

Fig 8: Frequency Deviation of Single Area System with PSO based PID controller.

Figure 8 shows the plot of Change in frequency with respect to time in a Single Area System with PSO based PID Controller. From the plot it can be seen that the error for the system with PSO based PID controller is nearly about -0.3 & its Settling time is up to 8 Sec.

6.2 Single area system with GA based PID controler without SMES

Here the PID controller of the given single area test system is optimized using Genetic algorithm and the following results are obtained-

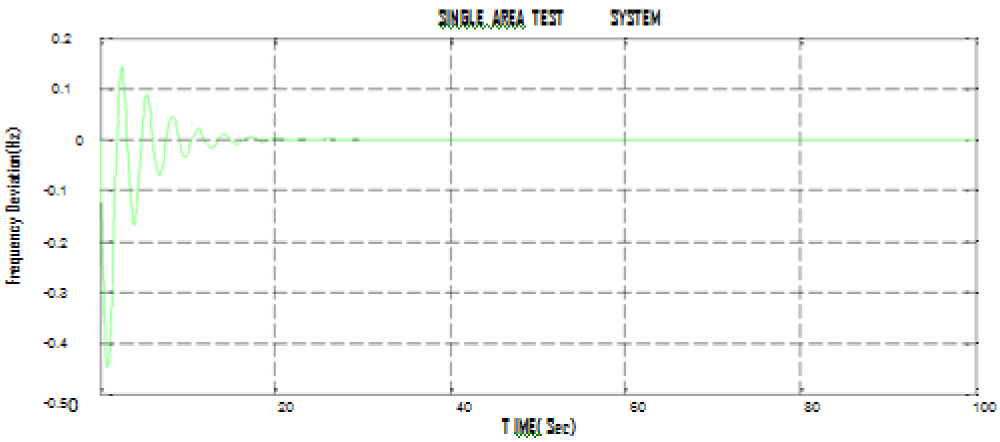

Fig. 9: Change in Frequency of single area test system with GA based PID

6.3 Comparision of GA and PSO based PID controler

On the basis of the results so obtained a comparison can be made between Genetic Algorithm based PID controller and Particle Swarm Optimization based PID controller. For the two techniques peak overshoot, error and the settling time are the parameter which has been compared.

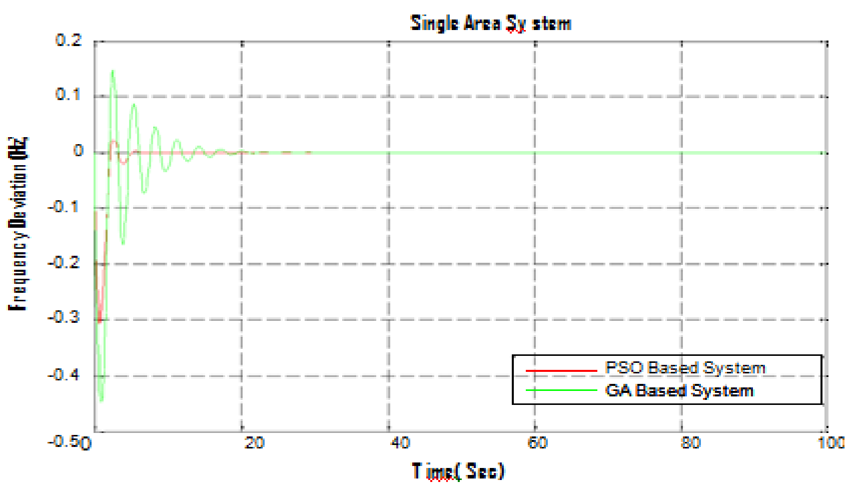

Fig 10 Comparison of frequency deviation in GA and PSO based Single Area System

Figure 10 shows the plot of change in frequency with respect to time for Single Area System with GA and PSO based PID controller. The description of the result obtained from the single area System is detailed in the Table 1 (Comparison of Frequency Deviation of single area system).

Table 1 Comparison of Frequency Deviation of single area system

SINGLE AREA SYSTEM			
Optimization Technique	ERROR	OVER SHOOT	SETTLING TIME
PSO BASED PID	-0.301	0.020	8secs
GA BASED PID	-0.450	0.150	20secs

6.4 Observations

From the above Table & Fig 10 it can be observed that, for a single area system PSO based PID controller gives less error as compared to GA based PID controller. And also the settling time & peak overshoot for the PSO based PID controller is better as compared to GA based PID controller.

VII. CONCLUSIONS

Significant conclusions of this paper are as follows:

(a)This paper presents design method for determining the PID controller parameters using the PSO method.

(b) A comparative study is made between PSO based PID controller and GA based 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 genetic algorithm (GA), the proposed method was indeed more efficient and robust in improving the step response of an AGC system.

(d)Incorporation of tuned SMES system in the above test system is able to stabilize the test system. SMES can yield dynamic stability and effectively suppress the frequency oscillations

(e)PSO based optimization technique have yielded good results.

(f) SMES coordination can yield dynamic stability and effectively suppress the frequency oscillations.

(g) PSO technique for the optimization of the parameters of PID controller, SMES yields better result as compared to the traditional optimization technique.

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