International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 5, Issue 6, June 2016)

Control of Load Frequency of Power System by PID Controller using PSO

Shiva Ram Krishna[1], Prashant Singh[2], M. S. Das[3]

[1,2,3]*Dept. of Electrical & Electronics Engineering, T. I. T. & Science, Bhopal, India*

Abstract: **The objective of this work is to controlling the load frequency control of generator of power system by using PID controller. Parameters of PID controller such as proportional gain, integral gain and derivative gain can be controlled by new evolutionary technique called particle swarm optimization. By proper tuning of PID controller parameters by PSO, reduce the area control error and to minimize the frequency deviation of single area system as well as two area systems. These works establish a simulink Model by using Matlab for single area control and two area control system. In this work used a global search optimization technique PSO to find out optimum tuning of PID controller parameters. Results obtained by this method shows that the result is improved and get steady state very frequently.**

Keywords: **Particle Swarm Optimization (PSO), Generation frequency control, PID controller, single area and two area control system, tuning of parameters.**

I. INTRODUCTION

The main objective of power system operation and control is to maintain continuous supply of power with an acceptable quality, to all the consumers in the system. The system will be in equilibrium, when there is a balance between the power demand and the power generated[8]. As the power in AC form has real and reactive components: the real power balance; as well as the reactive power balance is to be achieved. 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).

Automatic generation control provides an effective mechanism for adjusting the generation to minimize frequency deviation and regulate tie-line power flows. The AGC system realizes generation changes by sending signals to the under-control generating units. The AGC performance is highly dependent on how those generating units respond to the commands. The generating unit response characteristics are dependent on many factors, such as type of unit, fuel, control strategy, and operating point.

Authors of [1] presented a real time simulation model to analyze the behavior of discrete controller for interconnected power system. This work two-area interconnected power system consisting of non-identical power plants with EHVAC transmission link as interconnection is considered for investigations. Hasan Bevrani et al. [2] described AGC as one of the important control problems in interconnected power system design and operation, and is becoming more significant today due to the increasing size, changing structure, emerging renewable energy sources and new uncertainties, environmental constraints, and complexity of power systems.

The potential applications of the SMES technology in electrical power and energy systems[4] described . A new method to determine the optimal tuning of the PID controller parameter of an AVR system using Modified particle swarm optimization (MPSO) algorithm [5]. S. P. Ghoshal et al. [6] described automatic generation control with interconnected two-area multiple-units hydro–hydro system is investigated. Such a hydro dominated system is dynamically unstable. A control strategy using controlling the phase angle of TCPS is proposed for provide active control facility of system frequency also, the optimum adjustment of PID controller's parameters in a robust way under bilateral contracted scenario following the large step load demands and disturbances with and without TCPS are investigated by Particle Swarm Optimization (PSO), that has a strong ability to find the most optimistic results [7].

II. GENERATOR VOLTAGE CONTROL SYSTEM

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. Therefore, the voltage control system is also called as excitation control system or automatic voltage regulator (AVR).For the alternators, the excitation are provided by a device (another machine or a static device) called exciter [9].

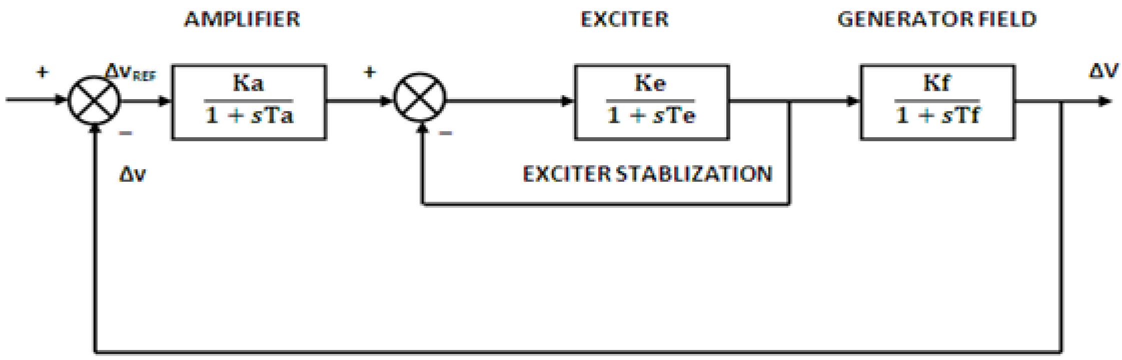

Fig.1. A simplified block diagram of Voltage (Excitation) Control System

2.1. Automatic Load frequency Control

The main functions of the ALFC are to: i) To maintain the steady frequency; ii) Control the tie-line flows; and iii) Distribute the load among the participating generating units.

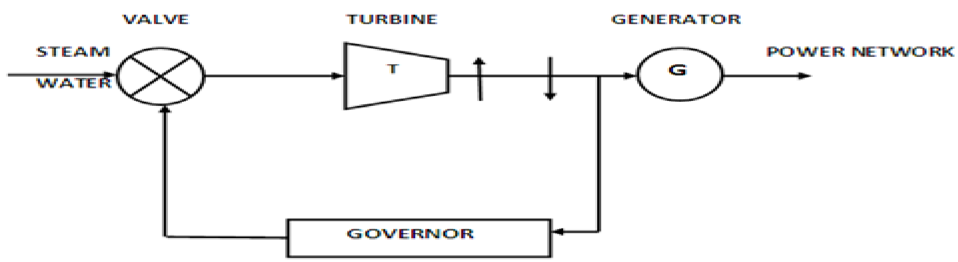

Fig.2: The Schematic representation of ALFC system

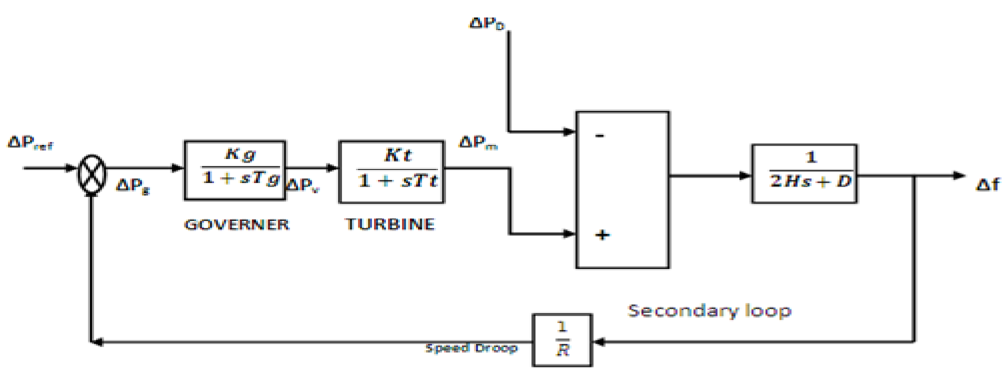

Fig.3. The block diagram representation of the ALFC

2.2. AGC in a Single Area System

In a single area system, there is no tie-line schedule to be maintained. Thus the function of the AGC is only to bring the frequency to the nominal value [9]. This will be achieved using the supplementary loop (as shown in Fig.4).

Which uses the integral controller to change the reference power setting so as to change the speed set point. The integral controller gain KI needs to be adjusted for satisfactory response (in terms of overshoot, settling time) of the system.

International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 5, Issue 6, June 2016)

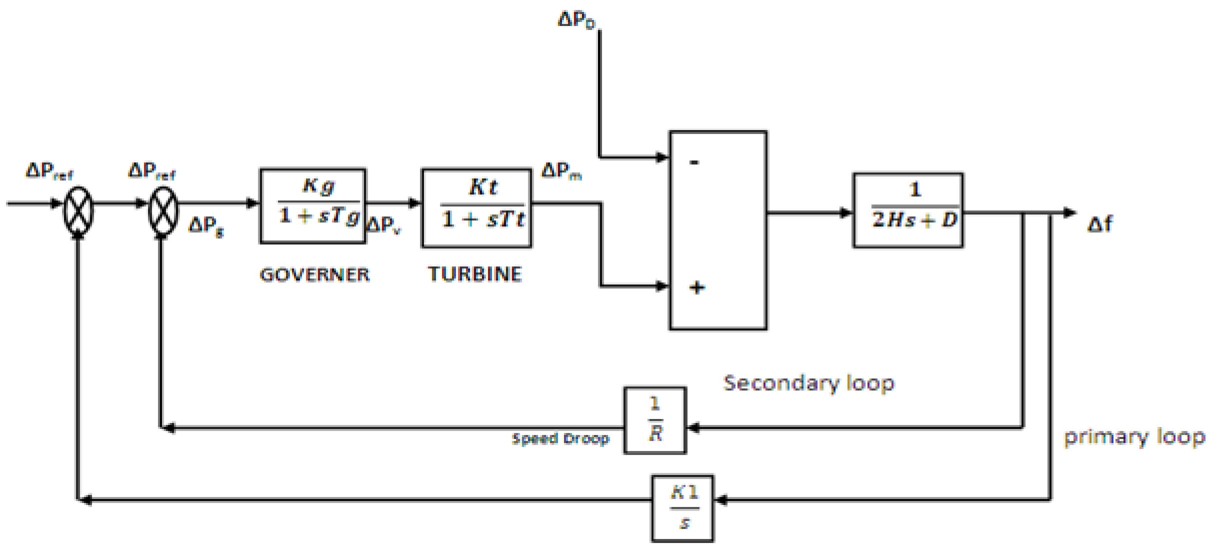

Fig.4: The block diagram representations of the AGC for single area control

2.3. AGC in a Multi Area System

In an multi area control system, there will be one ALFC loop for each control area as shown in fig. 5.

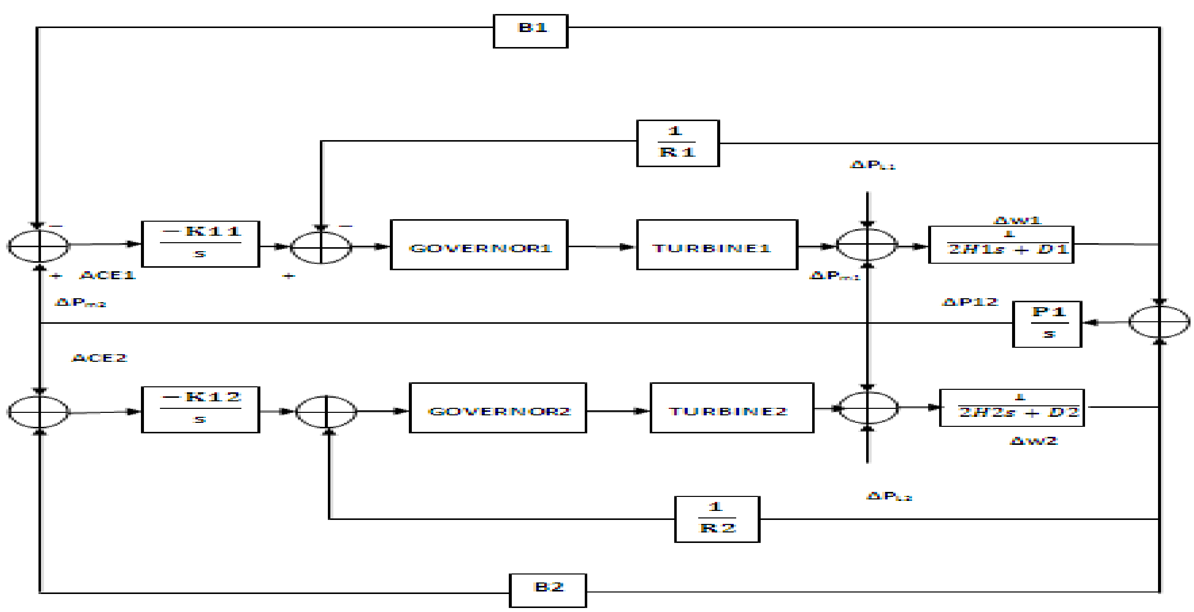

Fig.5. AGC for a multi-area operation

III. Problem Formulation

Tie-Line Bias Control: In this control strategy each area of an interconnected system tries to regulate its area control error (**ACE**) to zero, where:

$$ACE=(T_a - T_s) - 10\beta(f_a - f_s) \qquad (1)$$

Where $(T_a - T_s)$ = Difference between the actual and the scheduled net interchange on the Tie lines,

International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 5, Issue 6, June 2016)

$(f_a - f_s)$ = Frequency Error and

$\beta = 1/R + D$

The control error for each area is a linear combination of tie-line power and frequency errors and can be expressed as shown

$$ACE1 = \Delta P1\text{-}2 + B1\Delta f1 \quad (2)$$

$$ACE2 = \Delta P2\text{-}1 + B2\Delta f2 \quad (3)$$

The signals to the respective speed changers will, therefore, be of the following type

$$\Delta Pref_1 = -KI_1 \int (\Delta P_{1-2} + B_1 \Delta f_1)\, dt \quad (4)$$

$$\Delta Pref_2 = -KI_2 \int (\Delta P_{1-2} + B_2 \Delta f_2)\, dt \quad (5)$$

Where B_1 and B_2 represent tie line bias parameters; and KI_1 and KI_2 are integrator gains.

The area control error (ACE) is indicative of the total interchange of power for multi area control is given as the follows;

$$ACEk = \Sigma(\Delta P_{ij} + B_k \Delta f_k) \quad (6)$$

3.1. Super Conducting Magnetic Energy Storage System (SMES)

The real power as well as the reactive power can be absorbed by or released from the SMES coil according to system power requirements. The one major advantage of the SMES coil is that it can discharge large amounts of power for a small period of time. Also, unlimited number of charging and discharging cycles can be carried out.

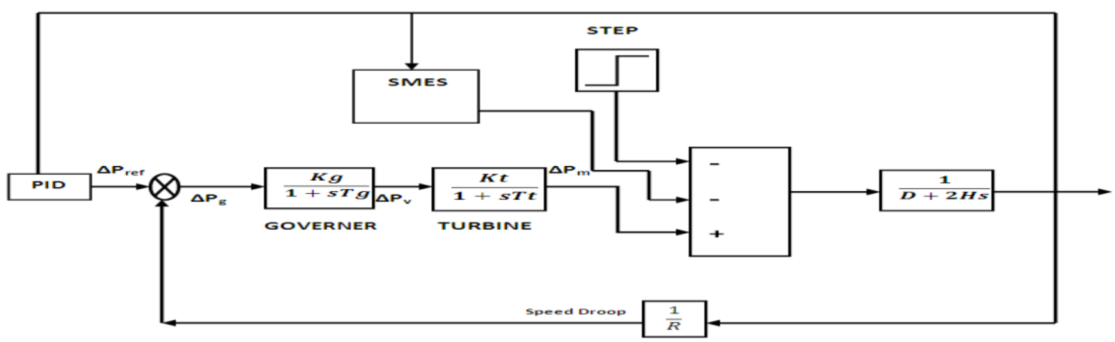

Fig. 6. Single area system with SMES unit

IV. Particle Swarm Optimization

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 [5], 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); and the field of evolutionary computation.

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.

1. Evaluate the fitness of each particle
2. Update individual and global best fitness's and positions
3. Update velocity and position of each particle

The velocity of each particle in the swarm is updated using the following equation:

$$v_i(t+1) = wv_i(t) + c_1 r_1 [x_i(t) - x_i(t)] + c_2 r_2 [g(t) - x_i(t)] \quad (7)$$

Once the velocity for each particle is calculated, each particle's position is updated by applying the new velocity to the particle's previous position:

$$x_i(t+1) = x_i(t) + v_i(t+1) \quad (8)$$

International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 5, Issue 6, June 2016)

V. SIMULATION MODEL AND THEIR RESULTS

5.1. Case Study 1: Single Area Test System

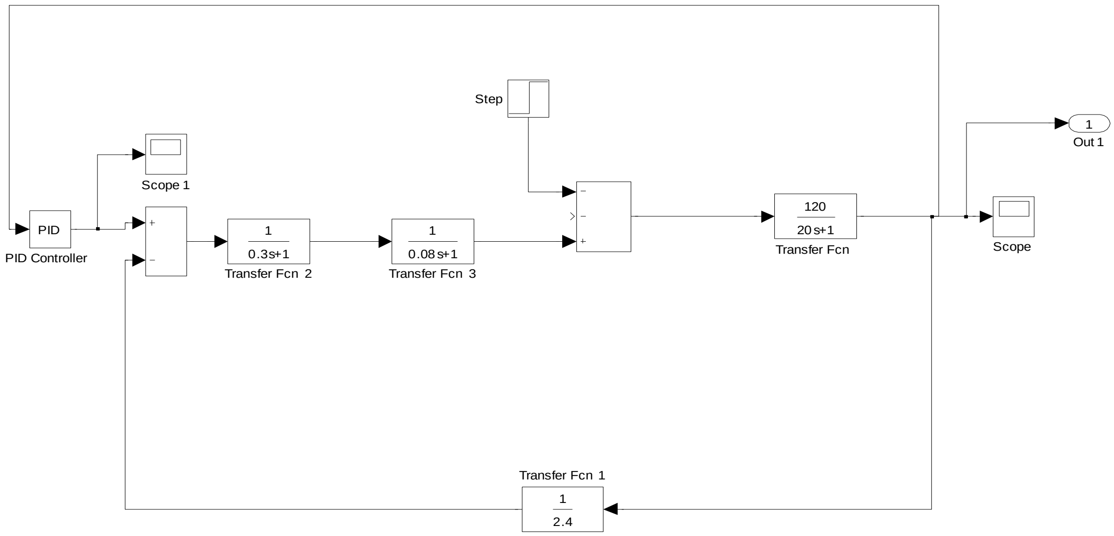

Fig. 7 Simulink model of single area control

For the considered single area test system the PID controller parameters are optimized using PSO technique.

After optimization results obtained are-

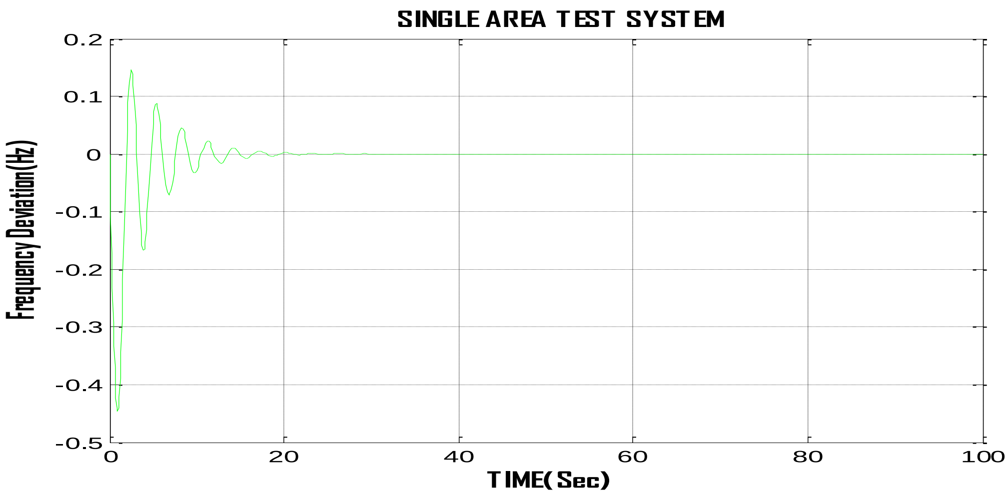

Fig. 8 Frequency Deviation of Single Area System with PSO based PID controller.

5.2 Case Study 2: Two Area Test System

For obtaining better transient response an SMES whose parameters are optimized using PSO has been incorporated in the Single area test system with PSO based PID controller. The structure of frequency stabilizer for SMES is modeled as the second order lead-lag compensator [4].

The objective of AGC is to reestablish primary frequency regulation, restore the frequency to its nominal value as quickly as possible and minimize the tie-line power flows. In order to satisfy above requirements, the parameters of SMES are needed to be optimized, which is done by using PSO. The simulation results of PSO based two area system with optimized SMES is shown in fig.10

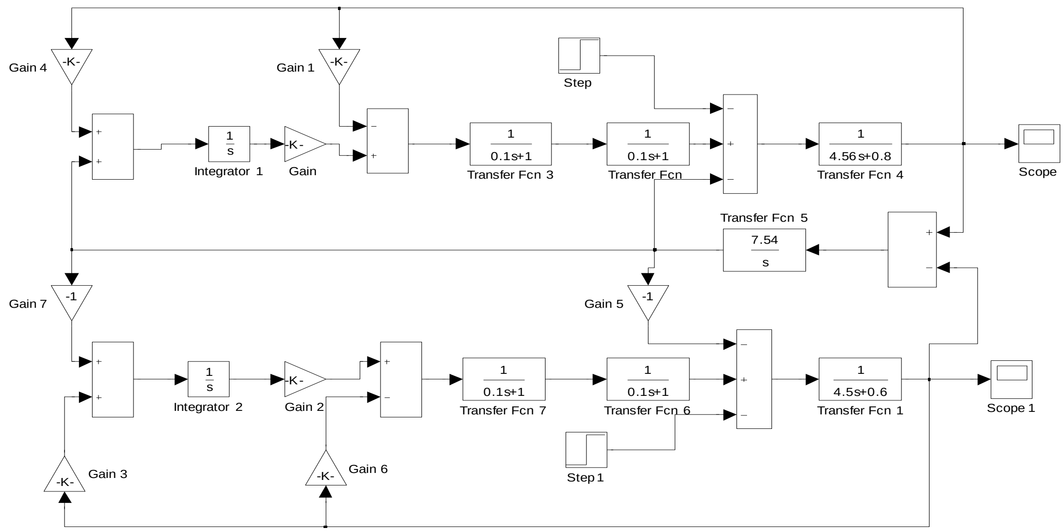

Fig. 9 Simulink model of double area control

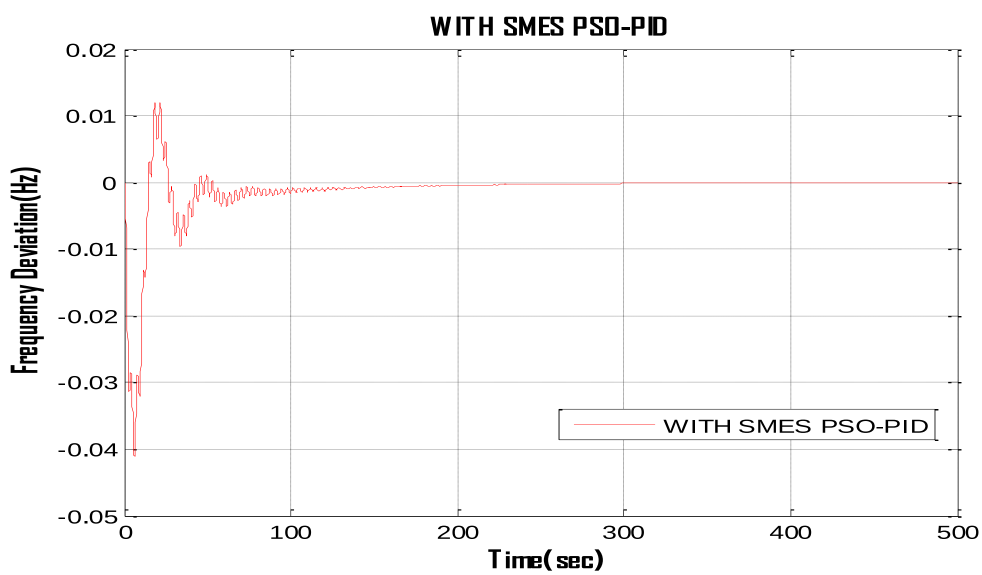

Fig. 10 Frequency Deviation of Double Area System with PSO based PID controller.

Table 1
Comparison of frequency deviation for PSO & PID controller in two area test system

TWO AREA SYSTEM			
Optimization Technique	ERROR	OVER SHOOT	SETTLING TIME
PSO BASED PID	-0.045	0.009	150secs
GA BASED PID	-0.052	0.012	350secs

International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 5, Issue 6, June 2016)

VI. Conclusion

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.

REFERENCES

[1] Naimul Hasan, Ibraheem, Shuaib Farooq," Real Time Simulation of Automatic Generation Control For Interconnected Power System". International Journal on Electrical Engineering and Informatics - Volume 4, Number 1, March 2012.

[2] HasanBevrani&TakashiHiyama,japan "Intelligent Automatic Generation Control". Taylor & francis gp. publishing co. -2011.

[3] SandeepBhongade, H.O.Gupta,B.Tyagi."Performance of SMES unit on Artificial Neural Network based multi area AGC scheme". Journal of power electronics & power system.Vol-1.Issue no.4March-2011.

[4] Mohd.Hassan Ali "An overview of SMES application in energy & power system", IEEE Transaction on Sustainable Energy. Vol. No.1, 2010.

[5] G.Shabib, Mesalam Abdel Gayed, And A.M. Rashwan." Optimal Tuning of PID Controller for AVR System using Modified Particle Swarm Optimization". 14th International Middle East Power Systems Conference (MEPCON'10), Cairo University, Egypt, December 19-21, 2010.

[6] S.P.Ghoshal, Pragnesh Bhatt & Ranjit Roy "Optimized AGC by SSSC & TCPS in coordination with SMES for two area Hydro power system". International Conference on advances in computing, control & telecommunication technologies-pages-476.2009.

[7] H. Shayeghi , H.A. Shayanfar, A. Jalili. "LFC Design of a Deregulated Power System with TCPS Using PSO". World Academy of Science, Engineering and Technology, pp. 671-680, 2009.

[8] Hassan W. Qazi, "Development of Sensitivity Based Indices for Optimal Placement of UPFC to Minimize Load Curtailment Requirements", Master Thesis, Electrical Power System, Royal Institute of Technology-KTH, Stockholm, Sweden, Jun 2009.

[9] Shayeghi H. "A robust mixed H2/H∞ based LFC of a deregulated power system including SMES" Energy Conversion and Management. 49.pp: 2656–2668. 2008