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Particle Swarm Optimization Based Automatic Generation Control of Two Area Interconnected Power System

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Abstract- Due to the continuous change in load, the frequency and tie-line power of control areas get disturbed from their scheduled value which is undesirable. Automatic Generation Control (AGC) is an essential mechanism in electric power systems which balance generated power and demand in each control area in order to maintain the system frequency at nominal value and tie-line power at its scheduled value. This necessitates an accurate and fast acting controller to maintain constant nominal frequency. The limitations of conventional controllers i.e. Integral (I), Proportional Integral (PI) are slow and lack of efficiency in handling system errors. This paper proposes Particle Swarm Optimization (PSO) technique for AGC of two-area interconnected power system. Firstly, the conventional controllers i.e. Integral (I), Proportional Integral (PI) are used for AGC of two-area interconnected power system. Then PSO based controllers are used and various responses due to various controllers have been compared. The responses of the proposed methods are demonstrated by MATLAB simulations.

Index Terms- automatic generation control (AGC), conventional integral (CI) and proportional integral (PI) controller, particle swarm optimization (PSO)

I. INTRODUCTION

Themain requirement in operation of interconnected power systems is the control of the frequency and the tie-line power flow. This can be achieved by the use of automatic generation control (AGC). The aim of the proposed controller is to restore the change in error to its nominal value in the smallest possible timewhenever there is any change in the loaddemand etc.This work presents the automatic generation control (AGC) of an interconnected two area system with the use of particle swarm optimization (PSO)technique. Here AGC for the two areas system is done by the use of conventional controllers andparticle swarm optimization (PSO)techniqueand change in overall error of the system is examined by using MATLAB SIMULINK.

II. PROBLEM FORMULATION

We have taking the concept of area control error which is produced by comparing the feedback and reference signal and provide to particular controller which we used in the model of interconnected power system. So the problem formulate in automatic generation control is that we have first calculate the area control error by integral square error or by integral time absolute error techniques and then taking the gain of particular controller at which the system error reduced and frequency is balanced according to load.

III. PLANT MODEL DESCRIPTION

(A) LINEARIZED MODEL

Study of automatic generation control (AGC) problem of a large interconnected power system is necessitated by the importance of maintenance of frequency and tie line flows at their scheduled values. A large widespread electric power system can be divided into a large number of control areas interconnected by means of several tie lines.

The control objective is to regulate the frequency of each area and tie line power contracts simultaneously. As in the case of frequency regulation, proportional plus integral controller will be installed so as to give zero steady error in tie line power flow.It is conveniently assumed that each control area can be represented by an equivalent turbine, generator and governor system. In an isolated control area case the incremental power ΔP_G-ΔP_D was accounted for by the rate of increase of stored kinetic energy and increase in area load caused by increase in frequency. Since a tie line transports power in or out of area, this fact must be accounted for the incremental power balance equation of each area.

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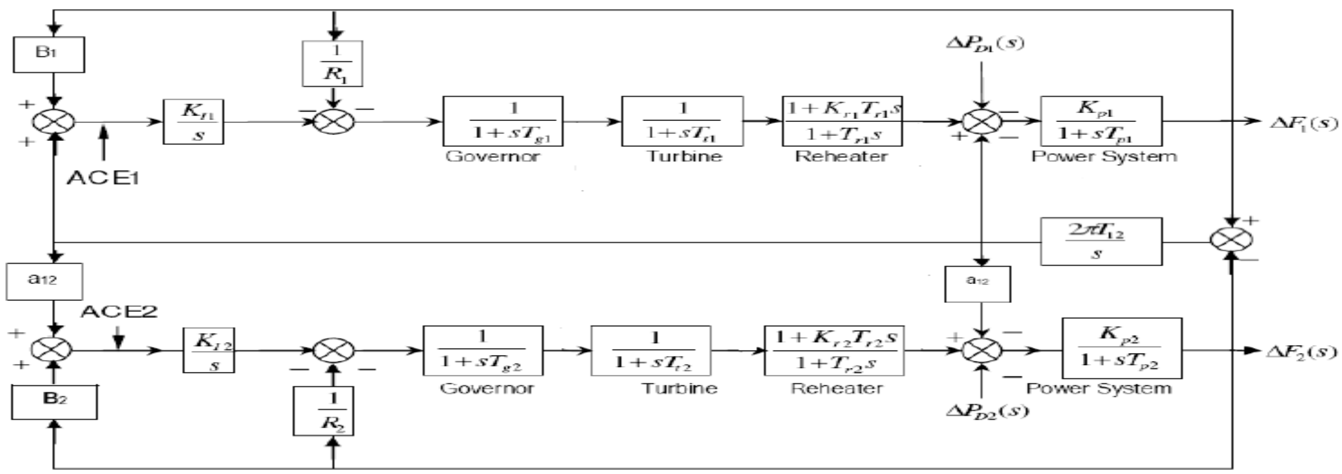

MODEL OF TWO AREA INTERCONNECTED POWER SYSTEM

ΔP_{D1}	Incremental load change in area 1
ΔP_{D2}	Incremental load change in area 2
R_i	Governor speed regulation parameter
T_{sg}	Governor Speed time constant
T_t	Turbine time constant
B_1	Frequency bias constant for area 1
B_2	Frequency bias constant for area 2
T_p	2H/ *f*D
K_p	1/D
D	Load damping constant
K_i	Integral gain
Δf_1	Change in frequency for area 1
Δf_2	Change in frequency for area 2

Let the step changes in loads $\Delta P_{D1}(s)$ and $\Delta P_{D2}(s)$ be simultaneously applied in control areas 1 and 2, respectively. When steady conditions are reached, the output signals of all integrating blocks will become constant and in order for this to be so, their input signals must become zero.

(B) CONVENTIONAL AGC SYSTEM

Automatic control system of close loop system means minimizing the area control error (ACE) to maintain system frequency and tie-line deviation are set at nominal value. Block diagram of two area system is shown in fig above. The ACE of each area is linear combination of biased frequency and tie-line error.

$ACE_i = \Delta p_{tie,ijnj=1} + \beta_i \Delta f_i$ (1)

Where, ACE_i is the area control error of the i_{th} area

Δf_i = frequency error of i_{th} area

$\Delta p_{tie,}$ = tie- line power flow error between i_{th} and j_{th} area

B_i= frequency bias coefficient of i_{th} area.

IV. OPTIMIZATION OF CANTROLLER PARAMETERS, FRQUANCY BIAS FACTOR& SPEED REGULATION CONSTANT

In this study we have considered all pi controller gains ie Ki1=Ki2=Ki,Kp1=Kp2=Kp,and frequency bias factors B1=B2=B and speed regulation constants R1=R2=R.we need to optimizeKi,Kp,B,R in order to obtain good dynamic response of the agc system. In this study Ki,Kp,B,R values are optimized using the particle swarm optimization technique by minimizing the quadratic performance index (PI) for 0.01 p.u. step load change in area-1 .where w1and w2 are the weight factor .

V. OVERVIEW OF PARICLE SWARM OPTIMIZATION

PSO is a population based optimization technique based on intelligent scheme developed by Kennedy and Eberhart (1995) (Kennedy et al., 2007). PSO has emerged as one of the most assuring optimizing schemes for effectively dealing near to global optimization tests. The inspiration of the mechanism is established by the social and cooperative nature represented by flying birds. The algorithm simulates a simplified social milieu in capable solutions of a swarm which means that a single particle bases its search on its own experience and information given by its neighbors in the specified region. Particles are flown in the solution region with their

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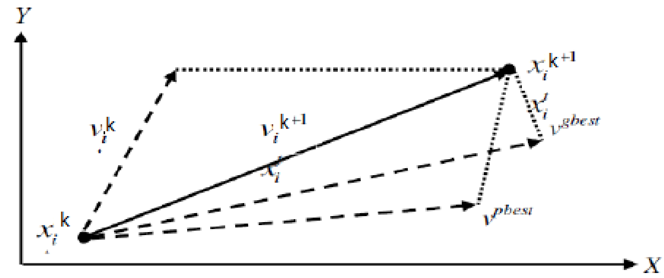
randomized assigned velocity. Among these particles, each particle keeps track of its coordinates in the solution region which are associated with the best fitness it has achieved so far. This value is known as „pbest". Another „best" value that is tracked by the particle is the best value, obtained so far by any particle in the group of the particles. This best value is also known as a global best„gbest" and the pattern is forwards to successful solutions. PSO technique using equation (5) is known as the *gbest* structure. PSO is a population based EA that has many primitive benefits over other optimization techniques. A most attractive quality of the PSO approach is itssimplicity as it involves only two main reference equations. Each particle coordinates represent a possiblesolution assisted with two real vectors.



Each particle coordinates represent a possible solution assisted with two real vectors .And vi =[vi1, vi2, vi3...viN] are the two vectors assisted with each particle „i" in N-dimensional search space .Number of particles or possible solutions of a swarm can go forward through the feasible solution place to explore optimal solutions. Each particle modifies its position based on its own best exploration, and overall experience of best particles (Beielstein et al., 2003). This particle also considers its previous velocity vector according to the following reference equations,

Velocity modifications

Each particle velocity can be modified by the following equation:

V_i^{k+1}=C* (W*V_1^k + C_1rand x (pbest$_i$ – S_i^k) + C_2rand x (gbest$_i$ - S_i^k)) (2)

Position modifications

Positions of the particles are modified at each interval of the flying time. The position of the particle may bechange or not change, depending on the solution value.

$S_i^{k+1} = S_i^k + V_i^{k+1}$(3)

Where, v_i is velocity of particle „i" at iteration *k*.

V_i^{k+1}= (W*V_1^k + C_1rand x (pbest$_i$ – S_i^k) + C_2rand x (gbest$_i$ - S_i^k)) (4)

Typical values for the inertia parameter are in the range [0, 2]. On the other side several different approaches using a construction factor *s*, which increase the algorithm's capability to converge to a better solution and the equation used to modify the particle's velocity

V_i^{k+1}= s*(V_i^k+ C_1rand x (pbest$_i$ – S_i^k) + C_2rand x (gbest$_i$ - S_i^k))(5)

VI. PSO BASED CONTROLLER DESIGN

Step1. The minimum and maximum gain limits of PI controllers are specified from the conventional PI controller. The initial Particle matrix of(N X 8)is generated by selecting a value with a uniform probability over the search space (K_{min}=0, K_{max}=2).

Step2. Set the population size and the initial Particle velocities are set to zero.

Step3.Assume the initial value of K and enter the maximum no. Of iterations/generations required.

Step4.Evaluate the initial population by simulating the Load frequency Control block model with each particle row value as the PI controller gain value and calculate Performance index (ISE/ITAE) for each particle.

Step5.Initialize local minimum (P_{best}) for each particle.

Step6. Find the best particle (G_{best}) in initial particle matrix based on the minimum performance index.

Step7. Start the iteration iter=1

Step8. Update the velocity of the particle using the equation shown below,

VelocityV_i^{k+1}=C* (W*V_1^k + C_1rand x (pbest$_i$ – S_i^k) + C_2rand x (gbest - S_i^k))

Where Constriction factor C=1
Cognitive parameter c1 =2
Social parameter c2 = 4-c1
Inertia weight

$$w = w_{max} - \frac{w_{max} - w_{min}}{iter_{max}} * iter$$

rand1, rand2 are the random numbers between 0 and 1

Step9. Create new particle from the updated velocity.

Step10. If any of the new Particles violate the search space limit then choose the particle and generate new values Within the particle search space.

Step11. Evaluate the performance index value for each new particle by simulating the LFC block model.

Step12.Update the best local position (P_{best}) for each particle based on the minimum value comparison between new Particle performance index and old P_{best} performance index.

Step13. Update Gbest Global minimum particle and its performance index.

step14.gen=gen+1

step15. If gen>maxgen go to step 7, otherwise go to next step.

step16. Print the global best PID controller gain values and its performance index value.

V11SIMULATION RESULT AND DISCUSSION

In this chapter different control strategies for supplementary control are implemented through MATLAB simulink model. Integral (I) controller, Proportional Integral (PI) controllers, and Particle Swarm Optimization (PSO) based controllers are implemented and the results are compared.

Case 1

First we apply the integral control gains Ki1&Ki2 in pid controller in simulink model of two area interconnected power system and result waveform is shown in scope and study the variation of setlling time and overshoot time of load frequency control of area-1 & area-2 resp.as shown in fig 1&2 as well as tie line power is also studied and also show the variation in fig3.

Case 2

Secondly we apply the proportional integral control gains Kp1,Kp2 & Ki1,Ki2 in PID controller in simulink model of two area interconnected power system and same factor of load frequency control is studied and shown in fig.4&5 which shows that the settling time and overshoot time is reduced as compared to previous case of area-1 & area-2.also tie line power is compared as shown in fig.6

Case 3

Thirdly we apply the particle swarm optimization technique to automatically select and optimized the controller parameters through the number of populations of particle best and group best. And compared the result of both previous controller with this technique as shown in fig 7.also tie line power is observe and shown in fig . 8

And the reading of all considering parameter is tabulate in table 1&2 respectively.

Area-1	B1	Ki1	Kp1	R1	F1 Settling time	P tie-settling time
Pso	0	1.4204	1.1210	0.6747	11.3	12.3
Integral Controller	0.0001	0.09	0	0.3333	23.8	21.2
Prop. Integral controller	0.0001	0.09	0.8	0.3333	18.1	15.6

TABLE-1

Area-2	B2	Ki2	Kp2	R2	F2 Settling time	P tie-settling time
Pso	0.2911	1.4609	1.3687	1.4023	11.7	12.3
Integral Controller	0.0001	0.09	0	0.3333	22.2	21.2
Prop. Integral controller	0.0001	0.09	0.8	0.3333	18.7	15.6

TABLE-2

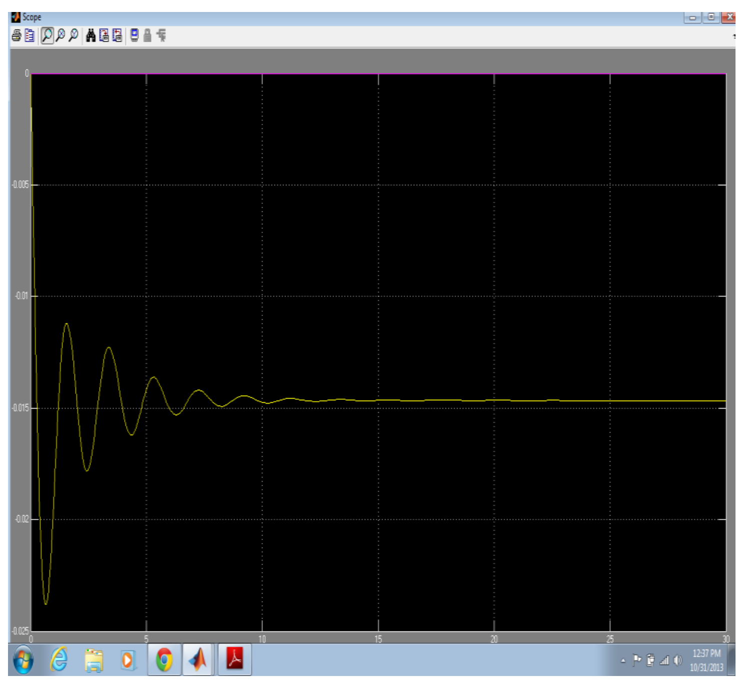


Fig1 Frequency deviation in area-1 of thermal reheats power system with integral controller

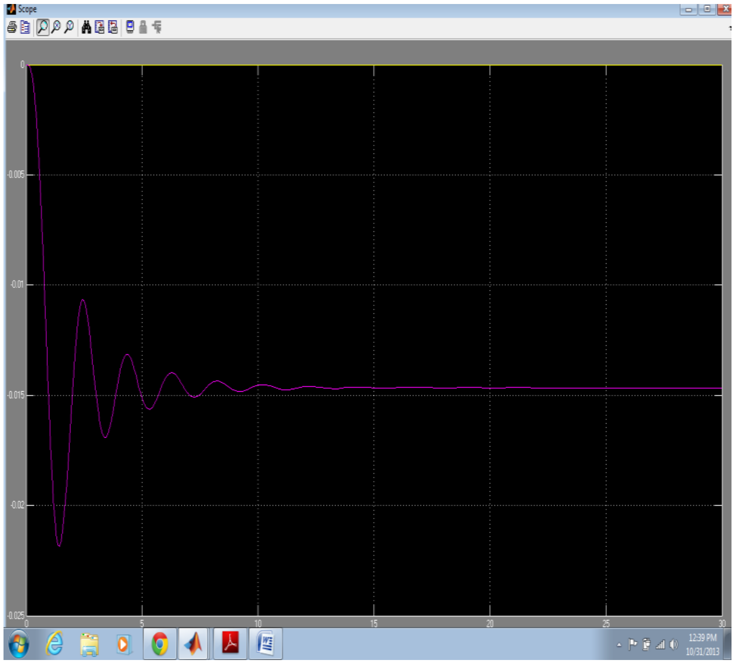


Fig2 Frequency deviations in area-2 of thermal reheat power system with integral controller

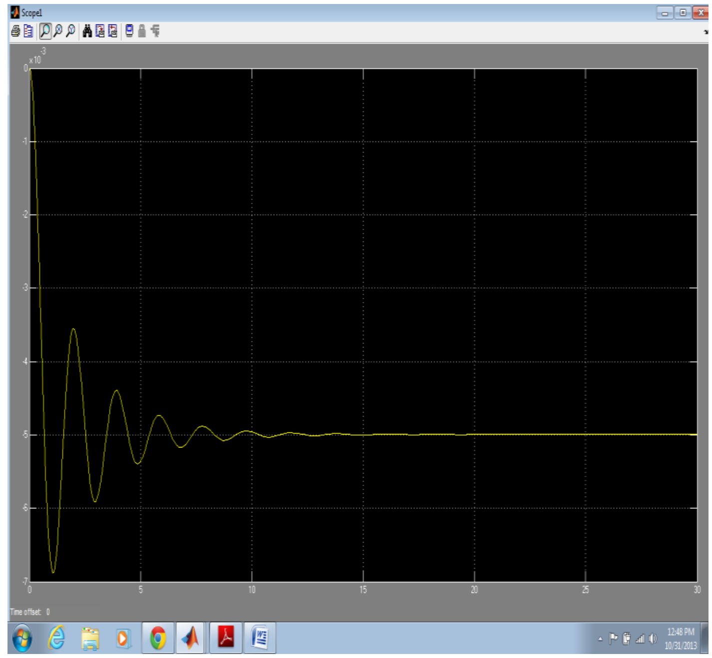


Fig 3 Tie line power deviation in two area interconnected thermal reheat power system with integral controller.

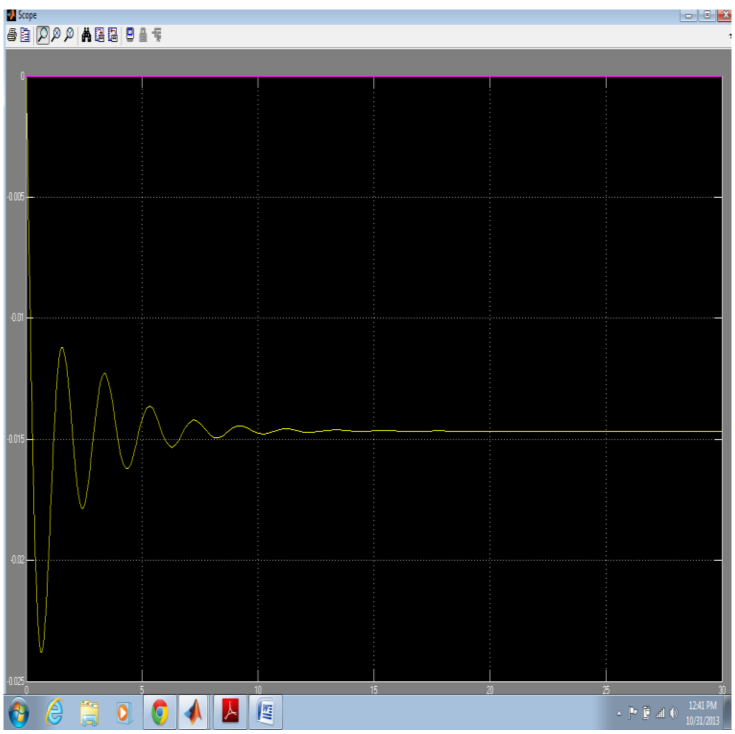


Fig 4 Frequency deviations in area-1 of thermal reheat power system with proportional integral controller

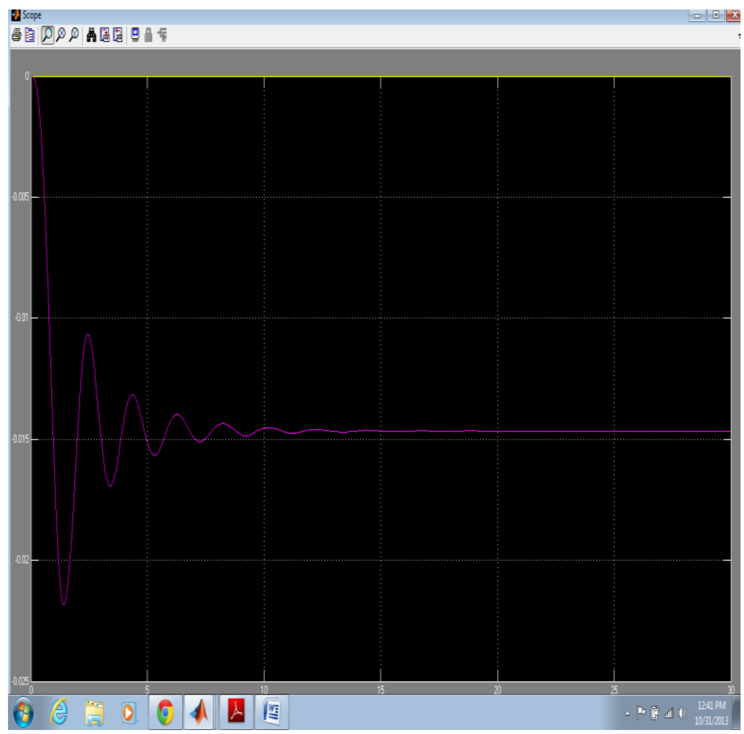


Fig 5 Frequency deviations in area-2 of thermal reheat power system with proportional integral controller

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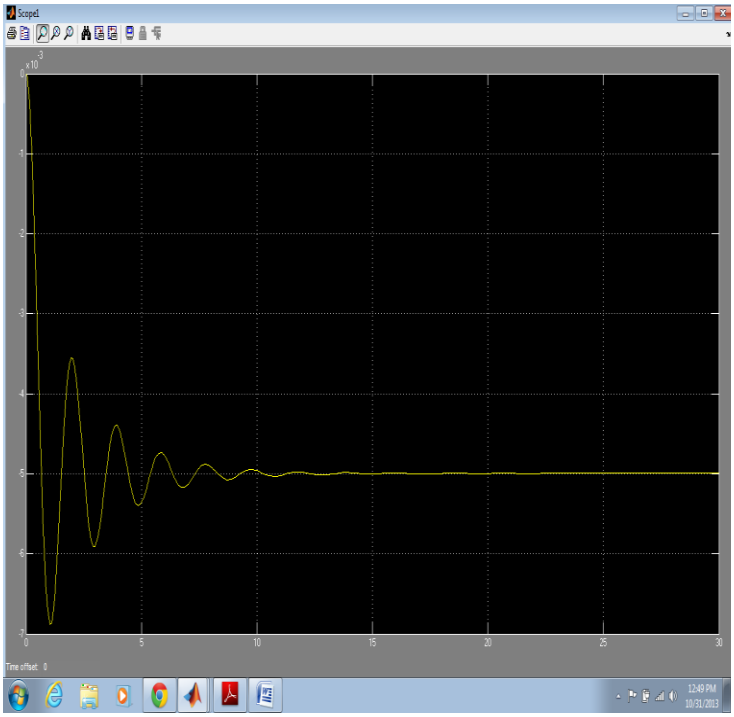

Fig 6 Tie line power deviation in two area interconnected thermal reheat power system with proportional integral controller

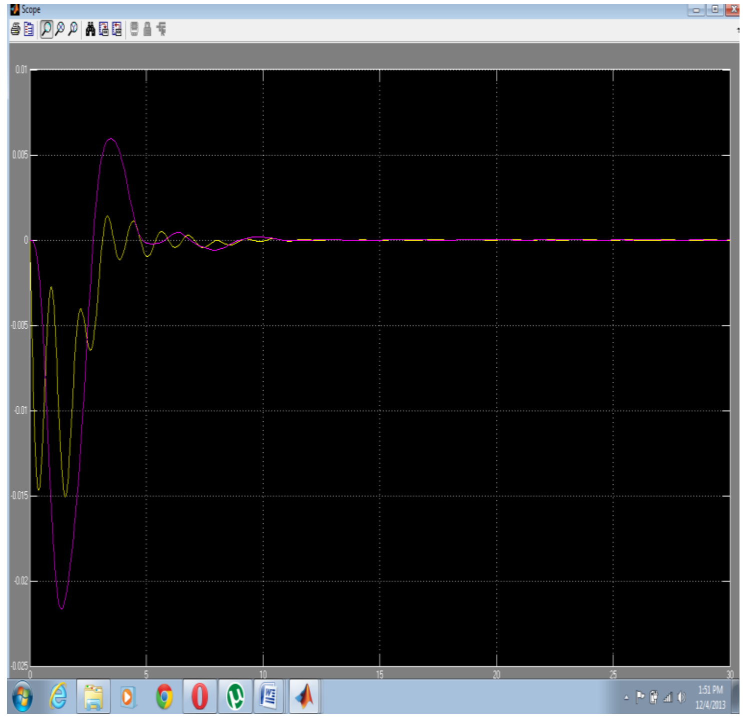

Fig7 frequency deviation in area-1&2 of interconnected thermal reheat power system with PI controller with particle swarm optimization

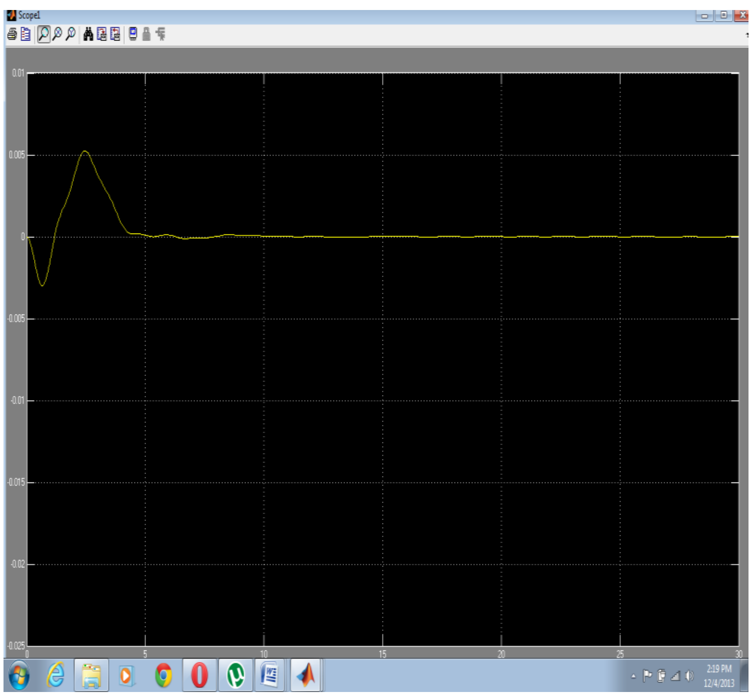

Fig 8Tie line power deviation in two area interconnected thermal reheat power system with particle swarm optimization

VIIICONCLUSION

In the present work, a control scheme for AGC of two area interconnected power system by using Particle Swarm Optimization technique is implemented. It is clear from the results that the performance of PI controller is better than I . In case of PI with PSO controller settling time of frequency and tie line power is smaller as compared to I and PI controller. For a two-area power system various parameters are calculated by PSO technique. The results show that the performance of PSO based controllers is better than the performance of conventional controllers. The peak overshoot andsettling time is reduced in case of PSO based controllers.

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