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Some Aspects of Automatic Generation Control

Deepesh Sharma, Naresh Kumar Yadav
Electrical Engineering Department
DCR University of Science &Technology, Murthal
Corresponding Author: Deepesh Sharma

Abstract: Any frequent small load fluctuations in the interconnected area or deregulated power system network results into the deviation of the area frequencies and also of the tie-line powers. For achieving minimum deviation of frequency and tie-line power it is necessary to approach the best method for controlling the governor action. The main motto of AGC is to keep the power system in the normal operating conditions. In this paper, the controller gain is optimized by the PSO technology and it is shown through graphs that the PSO optimization technique application provides better dynamic performance than the conventional controllers. To analyze the system model MATLAB Simulink is used. The results from the simulation shows that the controllers that are based on PSO gives the better result than the integral controller with respect to the change in frequency following the step load change

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I. INTRODUCTION

In the power system, if power demand changes, the frequency of the system would also vary accordingly. For maintaining the frequency in its specified limits i.e 50Hz we have to apply some control technology called AGC. In AGC the power generation is controlled automatically at the generation end [10]. Our main motive is to balance the power, means the power that is generated at the generation end must be equal to the power consumed at the consumer end. Earlier when there was no AGC, power balance was done by the load shedding. But after the emergence of AGC, Power balance was done by the AGC technique [13]. The real power demand "P_D" and the reactive power demand "Q_D" on the power system changes every time. They change all the time 24×7. Therefore, real power and reactive power generations required to change continuously and accordingly to match the load fluctuations. When the power demand is high, the steam valve opens itself and more steam goes into the turbine resulting in increasing the power generation and if the power demand is low, the steam valve closes itself and in this case, comparatively less steam goes into the turbine which results in the decrease of the power generation. In this way, by opening and closing the steam valve automatically the required power demand is fulfilled by AGC technique. The purpose of AGC is to keep the voltage and frequency very close to the nominal values i.e. 230V and 50Hz.

Change in frequency is highly undesirable. Frequency must be within the prescribed limits (49.5Hz-50.5Hz) for the successful operation of power system, especially large interconnected systems. In order to achieve a constant frequency, the input of the turbo-generators should be properly controlled which would result in a controlled generated output. In this paper PSO technique has been employed for controlling the frequency.

II. PARTICLE SWARM OPTIMIZATION

In the Particle Swarm Optimization technique, search space of a given problem is explored in order to find the settings or parameters to maximize the particular objective. This technique is inspired by social behavior of insects, birds, fish etc. Particle Swarm Optimization is a global gradient less stochastic search method. This technique has successfully been applied to numerous problems.

Particle swarm optimization is a simple implementation and insensitive to the scaling of design variables. For concurrent processing, it is easily parallelized. This technique is derivative free and this technique has a few algorithm parameters. Particle Swarm optimization is used in training of neural networks, electric supply network optimization, structural optimization, processing biochemistry and system identification in biomechanics.

The main objective of the PSO algorithm is that the optima is located of all the particles in a multi-dimensional hyper volume. In order to achieve this, one assigns random positions to all particles in the space. Just like a simulation, the algorithm is executed, that advances the position of each particle in terms based on its velocity. After each position update, it is required to sample the objective function and after each iteration the particle velocity is updated which is given as,

$v_i(t+1) = v_i(t) + (c_1 \times rand() \times_i (p^{best} - p_i(t))) + (c_2 \times rand() \times p_{gbest} - p_i(t)))$
Where

$v_i(t+1)$ = i^{th} particle's new velocity
c_1 and c_2 =Personal best and Global best positions' weighting coefficients
$p_i(t)$ =ith position of particle at time t.
P_{ibest} =Best position of individual i until iteration k p_{gbest} =position known to the swarm.

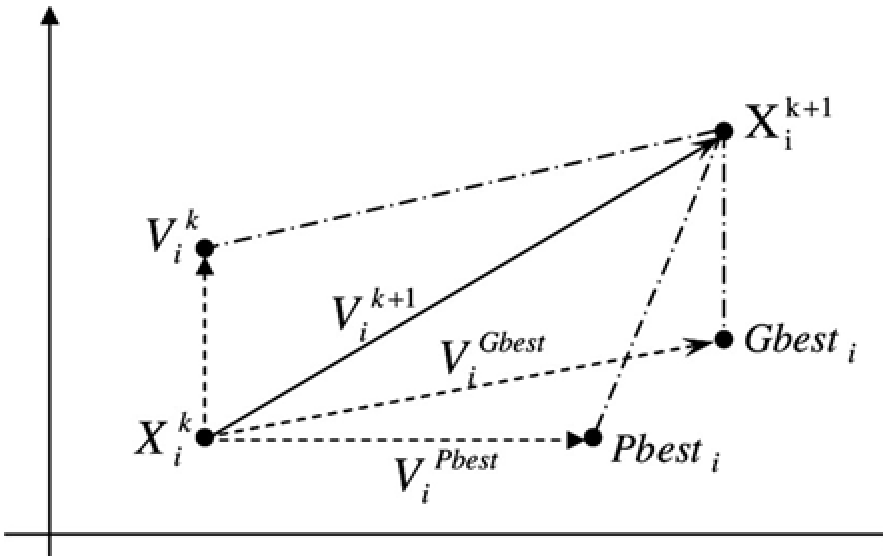

Fig. 1: Concept of modification of a searching

III. MODELING OF AUTOMATIC GENERATION CONTROL

The frequency response of single area with time, two areas with time and two areas with restructuring thermal power system with different controllers are considered. The transfer function model of single area and two areas are designed by using the MATLAB Simulink.

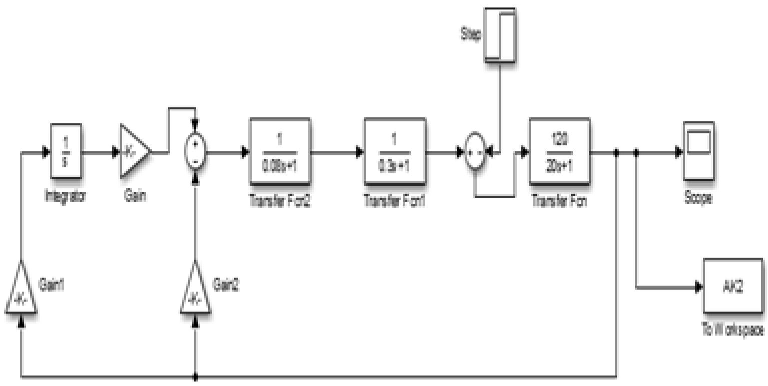

Fig. 2: Simulation model of single area power system

Fig. 2 shows the interconnected system for single area with an integral controller. As an integral controller is used, so no steady state error occurred.

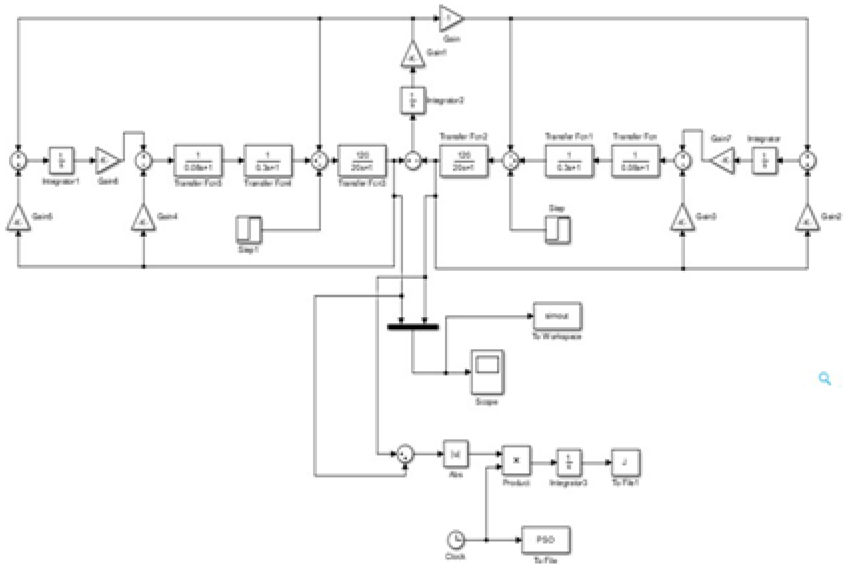

Fig. 3: Two area model with PSO controller

Fig. 3 shows an interconnected power system with two area model with PSO controller.

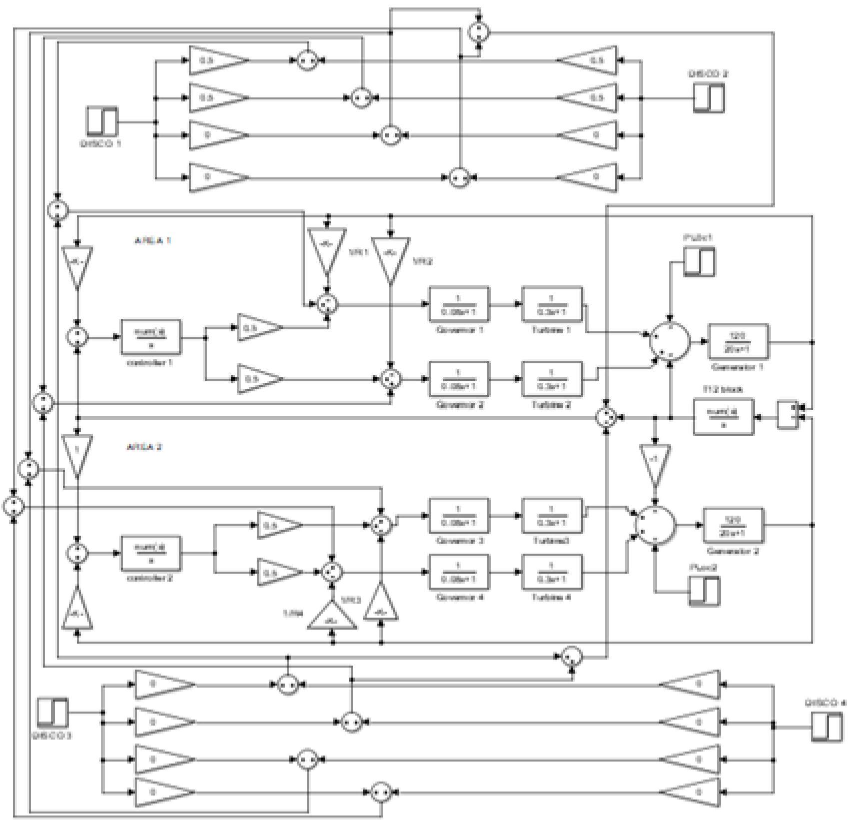

Fig. 4: A two area power system with restructuring

Fig. 4 shows the interconnected power system with two areas with restructuring.

IV. RESULT AND DISCUSSION

If one does not apply an integral controller, there exists a steady state error. In order to remove the steady state error, an integral controller has been employed. In this proposed work, it is concluded that after the application of an integral controller steady state error will be reduced to zero.

Again by the application of PSO technique the steady state error as well as settling time will reduce in comparison to integral controller. The peak overshoot will also reduce by a considerable amount by the application of PSO technique.

The result is also observed in the deregulated environment. After the restructuring of the power system, there is a decrement in the settling time as well as in the peak overshoot.

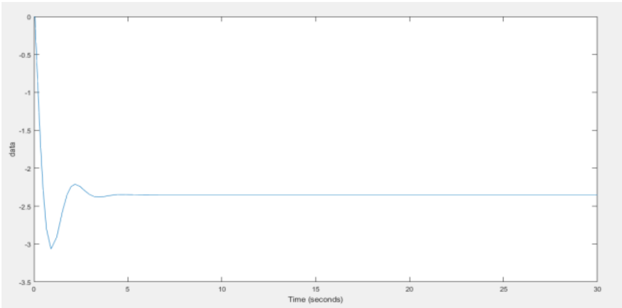

Fig. 5: Response of frequency with time of single area without controller

The behavior of frequency of single area network without controller is depicted in Fig. 5. As we are not using an integral controller here, there exists steady-state error.

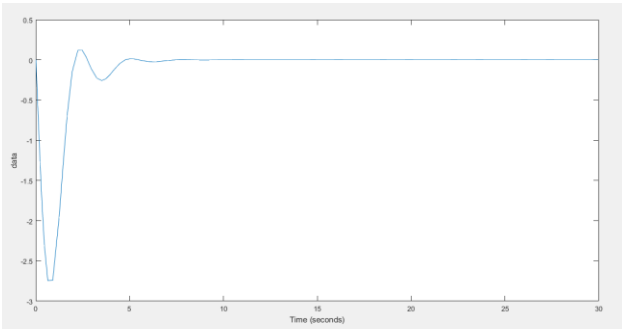

Fig. 6: Frequency response of single area with controller

Fig. 6 shows response of frequency with time of single area with controller.

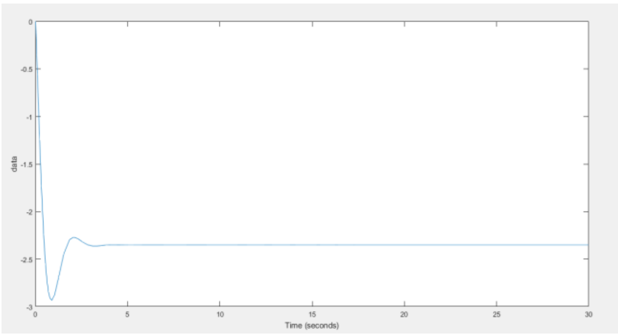

Fig. 7: Frequency response of two area without controller (area 1)

Fig. 7 shows response of frequency with time of single area without controller for area 1. Here steady-state error exists.

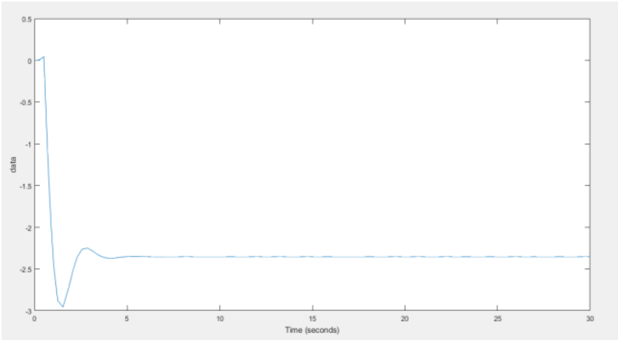

Fig. 8: Frequency response of two area without controller (area2)

Fig. 8 shows response of frequency with time of two area without controller for area 2. Here also steady-state error exists.

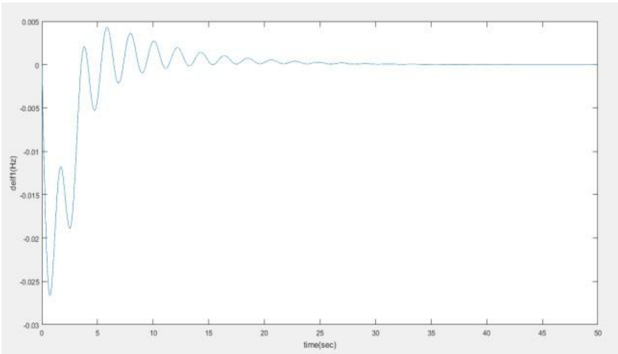

Fig. 9: Frequency response of two area with controller (area1)

Fig. 9 shows response of frequency with time of two area with controller for area 1.

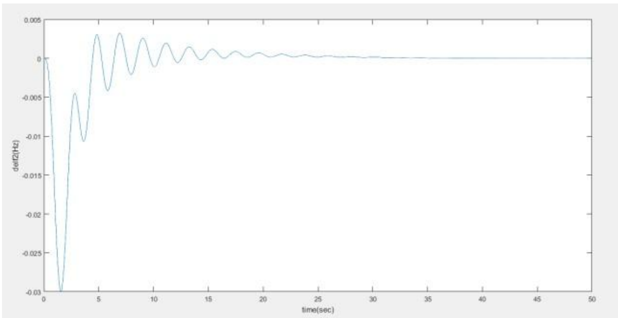

Fig. 10: Frequency Response with time of two area with controller

The behavior of frequency of two area network with controller for area 2 is depicted in Fig. 10. Here also, steady-state error is removed by the application of integral controller.

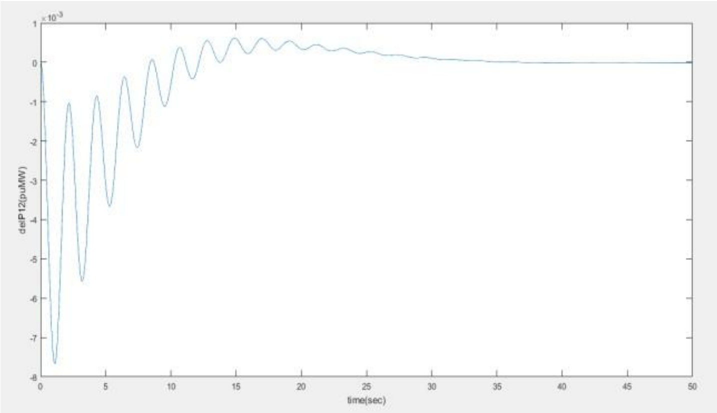

Fig. 11: Response of frequency with time of two area with controller

The behavior of frequency of two area network with controller for tie-line is depicted in Fig. 11
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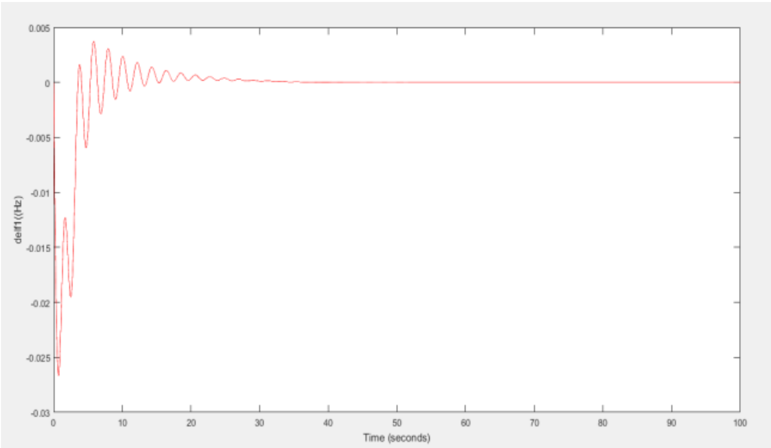

Fig. 12: Frequency response of two area with PSO (area 1)

The behavior of frequency of two area network with PSO for area 1 is depicted in Fig. 12.

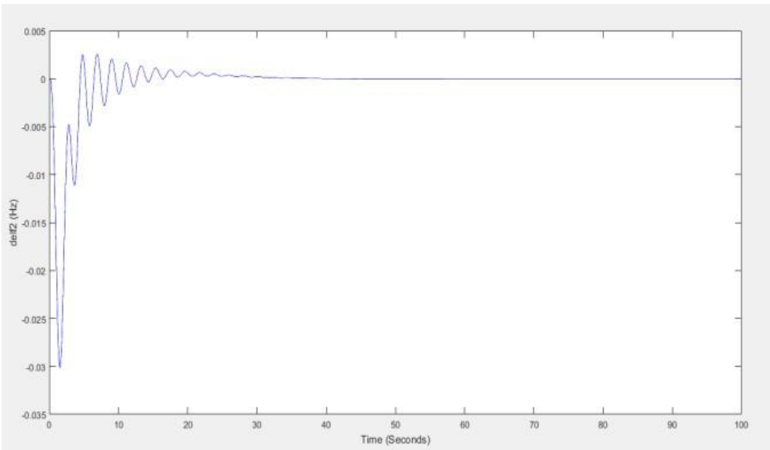

Fig. 13: Response of Frequency of two area with PSO (area 2)

The behavior of frequency of two area network with PSO for area 2 is depicted in Fig.13.

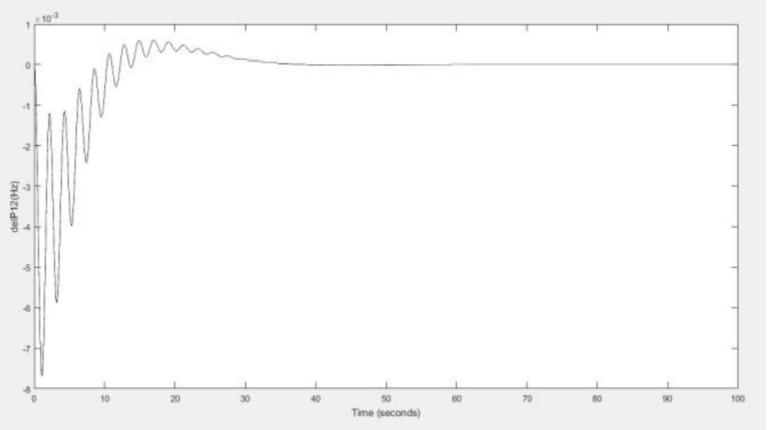

Fig. 14: Frequency response of two area with PSO (Tie- line)

Fig. 14 shows response of frequency with time of two area with PSO for tie-line.

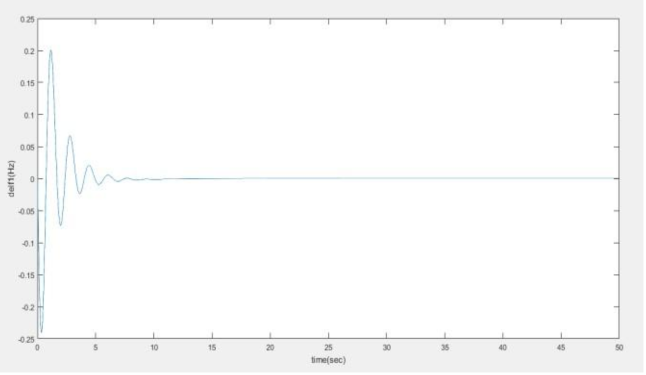

Fig. 15: Frequency response of two area with restructuring (area1)

The behavior of frequency of two area network with restructuring for area 1 is depicted in Fig. 15.

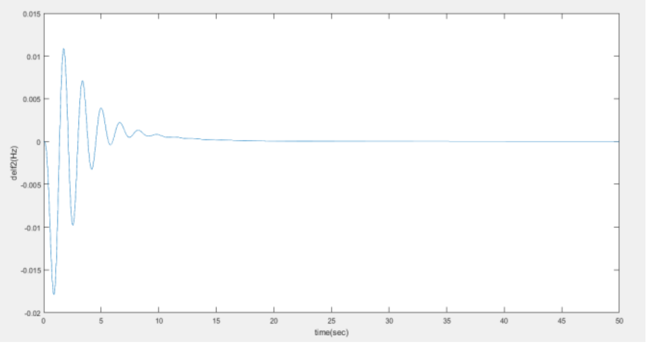

Fig. 16: Response of Frequency of two area with restructuring (area2)

The behavior of frequency of two area network with restructuring for area 2 is depicted in Fig. 16.

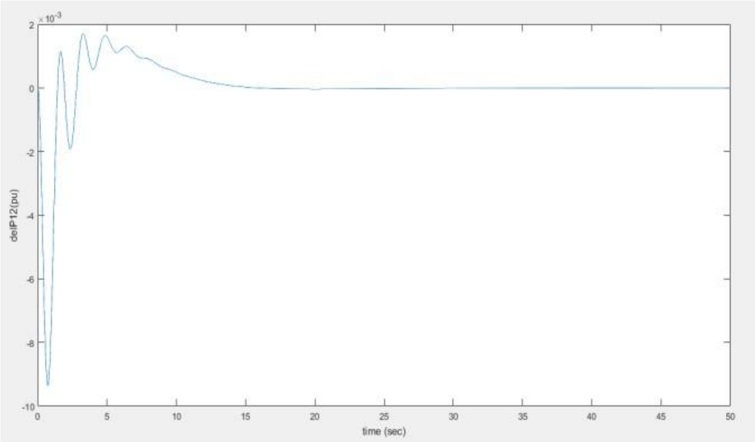

Fig. 17: Response of frequency with time of two area with restructuring (Tie-line)

The behavior of frequency of two area network with restructuring for tie-line is depicted in Fig. 17.

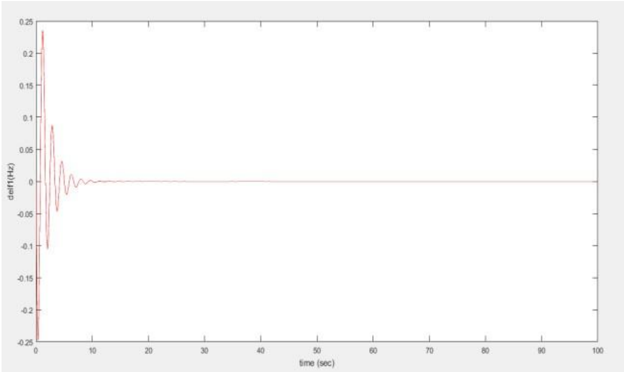

Fig. 18: Frequency response of two area with restructuring with PSO (area1)

Fig. 18 shows response of frequency with time of two area with restructuring with PSO for area 1.

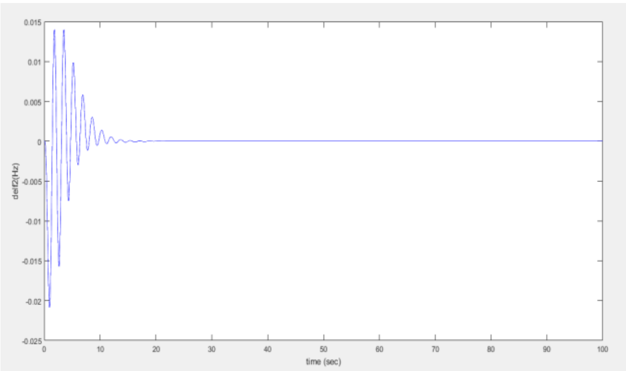

Fig. 19 Frequency response of two area with restructuring with PSO (area2)

Fig. 19 shows response of frequency with time of two area with restructuring with PSO for area 2.

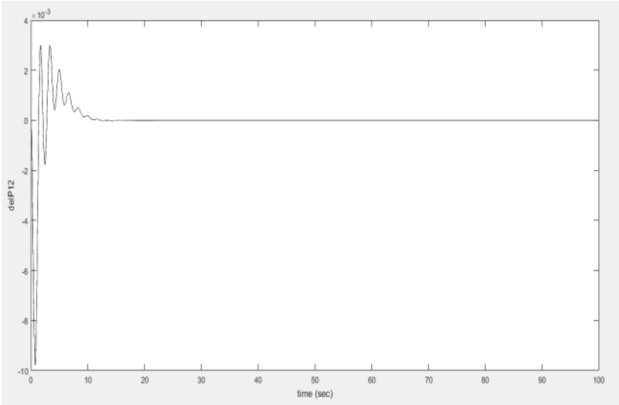

Fig. 20: Response of frequency with time of two area with restructuring with PSO (Tie-line)

The behavior of frequency of two area network with restructuring with PSO for tie-line is depicted in Fig. 20.

Table1. Comparison of Settling Time and Maximum Peak Overshoot of Single area and Two-area without Controller, with Controller, With PSO, With Restructuring and with Restructuring & PSO

	Stea dy- State Error	Settling Time			Peak Overshoot		
		delf1	delf2	Ptie1 2	delf1	delf2	Ptie1 2
Without Controller (single-area)	-2.3	7s	-	-	-3.1s	-	-
With controller (single-area)	0	7s	-	-	-2.7s	-	-
Without Controller (two-area)	-2.3	7s	7s	-	-2.9s	-2.9s	-
With Controller (two-area)	0	35s	35s	40s	-0.027s	-0.03s	-7.8s
With PSO (two-area)	0	30s	30s	35s	-0.025s	-0.029s	-7.7s
With controller (two-area restructurin g)	0	13s	20s	20s	-0.24s	-0.020s	- 0.00 88s
With PSO (two-area restructurin g)	0	12s	15s	15s	-0.22s	-0.019s	- 0.00 86s

V. CONCLUSION

Table 1 shows the overall comparison of settling time and maximum peak overshoot of single area and two- area without controller, with controller, with PSO, with restructuring and with PSO with restructuring. For area 1, the settling time for two area is reduced to 12s (with PSO and restructuring) from 13s (with controller and restructuring), 30s (two-area with PSO), 35s (two-area with controller). Similarly for the area 2, the settling time is 35s in two–area with controller which is reduced to 30s with the application of PSO technique and it is further reduced to 20s (with controller with restructuring) and finally to 15s (with PSO with restructuring). Finally for the tie-line, the settling time is reduced to 15s (with PSO with restructuring) from 20s (with controller and restructuring), 35s (two-area with PSO), 40s (two-area with controller).

Peak overshoot is reduced to a great extent by employing PSO technique. For the single area, the peak overshoot is -3.1s without controller which is reduced to -2.7s by the application of integral controller. Coming to the two-area, the peak overshoot is reduced to -0.22s (with PSO with restructuring) from -0.24s (with controller with restructuring), -0.025s (two-Area with PSO), -0.027 (two- area with controller). Similarly, for area 2, the peak overshoot is reduced to -0.019s (with PSO with restructuring) from -0.020s (with controller with restructuring), -0.029s (two-area with PSO), -0.03s (two- area with controller). And finally for the tie-line, the peak overshoot time is reduced to -0.0086s (with PSO with restructuring), from -0.0088s (with controller with restructuring), -7.7s (two-area with PSO), -7.8s (two-area with controller).

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