Fopid based AGC with PSO

Ch. M. S. N. V Sri Sai, Muzeeb Khan Patan, Md. Azahar Ahmed

Abstract: ***This paper explores the analysis of three area interconnected power system by employing optimization techniques to the Automatic Generation Control (AGC) for adjusting of controller parameters of FOPID controller. Here, FOPID controller is taken to diminish the integral time multiplied absolute error (ITAE). Furthermore, the control strategy is verified by Particle Swarm Optimization (PSO) algorithm to test the settling time and peak over shoots values and their contrast with conventional IOPID Controller. The optimal values of the controller are achieved by taking performance measure index as the integral time multiplied absolute error (ITAE) and it is minimized through PSO algorithm. We can observe that the settling time of PID controller with PSO is greater than the FOPID controller with PSO.FOPID controller with PSO is more advantageous than PID controller with PSO .We can also apply the another optimization technique like sine cosine algorithm (SCA) on two area system and all the simulation results are obtained from MATLAB/SIMULINK.***

Index Terms*: *Fractional Order PID Controller (FOPID); Particle Swarm Optimization (PSO); Automatic Generation Control(AGC);

I. INTRODUCTION

Automatic generation control (AGC) is an important concern in frequency stability studies of more than one area interconnected system[1] for managing frequency and tie line power within suitable range during usual and unusual states. The research work of AGC [2],[3] is mainly considered on thermal and hydro power plants. In this paper we can consider the more than one source system like hydro, thermal and gas units [4]. In the interconnected system the variation in load and the power transfer between localities via tie line affects the generator mechanical input. AGC is responsible in order to limit area control error (ACE) to zero. Several classical and modern algorithms are suggested to use the controller parameters to meet optimal solutions of design objectives. The effect of physical constraints are necessary to get accuracy in the AGC problem, the physical limitations are Generation rate constant (GRC) and Governor Dead Band (GDB), these are explained in [5],[6], and [7]. The FACT devices are supports the system for stable [8]. A Superconducting Magnetic Energy Storage (SMES) is effectively controls the reactive and active powers concurrently [9]. These are fast energy compensating devices of large loads for power consumption. Plug-in electric vehicle (PEV) is playing a vital role for emergency reliability services to reduce the use of petroleum [10]. FACTS controllers are categorized into four categories according to their connections. Some of the FACTS controllers are Thyristor Controlled Series Compensator are (TCSC) [11] , (SSSC) [12] and (IPFC) [14]. TCSC and SSSC controllers are essentially control the line current of transmission line and enhanced for power transfer capability of transmission lines and dynamic stability. UPFC [13] consist of series-shunt converters connected by common dc link capacitor and control the active and reactive power flow. The optimization techniques [15], Particle Swarm Optimization[16],[17] and Differential Evolution (DE) algorithms [18] are used to control the FOPID parameters by using objective function (ITAE) and these are presented in [19] and [20] respectively.

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II. INVESTIGATION OF POWER SYSTEM

The two areas interconnected multi source power system having more than one sources as thermal, hydro and gas units, different combinations of FACT devices with energy storage systems in addition to this some algorithms are used to adjusting the parameters of FOPID controller. These are briefly discussed in next section.

Automatic Generation Control

The interconnected power system maintaining frequency is a crucial problem and to solve this by considering automatic generation control (AGC). AGC manage the gap between load and generation for reducing the frequency errors.

A. Thermal power system

Thermal power system consists of reheat turbine with single stage. It consists of steam which has high temperature and high pressure. On later stages the steam can be converted as mechanical energy with the help of steam turbine and generator to produce electricity.

B. Hydro power system

Hydro power system consists of generator. Hydro system converts kinetic energy of stored water into mechanical energy. That mechanical energy given to generator through shaft and it delivers an electrical energy.

C. Gas power system

Gas power system consists of turbine. The burning fuel in a combustion chamber and combustion gases fast flowing are

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used to drive the turbine. Finally electricity produced by generator.

D.Generation rate constant (GRC) and Governor Dead Band (GDB)

Generation rate constant is evaluating as non-linearity in AGC. The response of considering with and without GRC analysis, the frequency changes of with GRC is more compared to without GRC. It is used for controlling the input of the turbine when the rate of limit is exceeded.

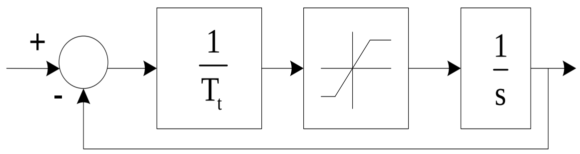


Fig.1.Non linear turbine with GRC

The Governor Dead Band is considered as non linearity and it is accelerated characteristics of generator. GDB is used for controlling the speed before the control valve position, and there is no change in control valve while controlling the speed.

E. Fractional Order Proportional Integral Derivative (FOPID)

Proportional Integral Derivative (PID) is a popular feedback controller and it is used in the process industries. FOPID provides excellent control performance, where P controller reducing the rise time, I controller eliminating steady state error and D controller reduces the over shoot. FOPID have two or more tuning knobs than the IOPID controller. FOPID controller can be able to provide more flexibility.

$$u(t) = K_p e(t) + K_i D^{-\lambda} e(t) + K_d D^{\mu} e(t) \quad (1)$$

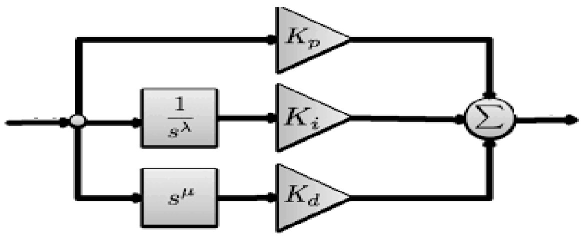
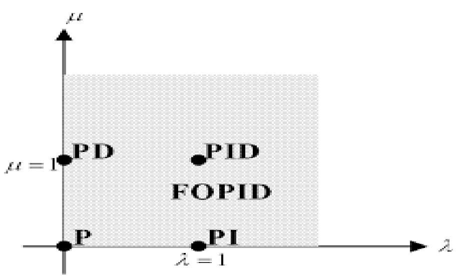


Fig.2 FOPID Controller

Fig.3 FOPID controller regions based on the tuning



parameters

F. Integral Time Multiplied Absolute Error (ITAE)

The integral time multiplied absolute error is preferred to meet the design of impartial function and control specifications. ITAE produce low oscillations and smaller overshoots so the minimization of ITAE gives better fulfillment of the controller. The function is

$$J = ITAE = \int_0^{\infty} t(\Delta F_1 + \Delta F_2 + \Delta P_{tie})dt \quad (2)$$

To minimize J, the problem constraints are taken as:

$$K_{I_{min}} \le K_I \le K_{I_{max}} \quad (3)$$

Where J is the impartial function, $K_{I_{min}}$ and $K_{I_{max}}$ are control parameters of least and higher values.

III. PROPOSED METHODOLOGIES

The optimization algorithm presented in this paper to get the optimum values of the controller is as follows

A. Particle Swarm Optimization (PSO)

In PSO represents the population of solutions is referred as swarm of particles. Every particle in space depends on state and velocity. Every particle moves to new position using some velocity. Particles use information available to them to either explore new solutions or more closer to already known solution. This process is repeated again and again to get best result. Each particle has started with a random velocity and position, and it reaches the new position and find out the velocity. In this manner we need to evaluate the best fitness value from then evaluated values which are compared to the previous values. Each trial the fitness value is measured and contrast to previous best fitness value of the whole search space or swarm, and personal best, global best are updated. If doesn't get best value then updated velocity and position creates new swarm. Updated velocity based on old velocity, self learning term and social learning term. If we didn't get the best value then we need go for again comparison value and choose the best fitness value which is nearby the best solution

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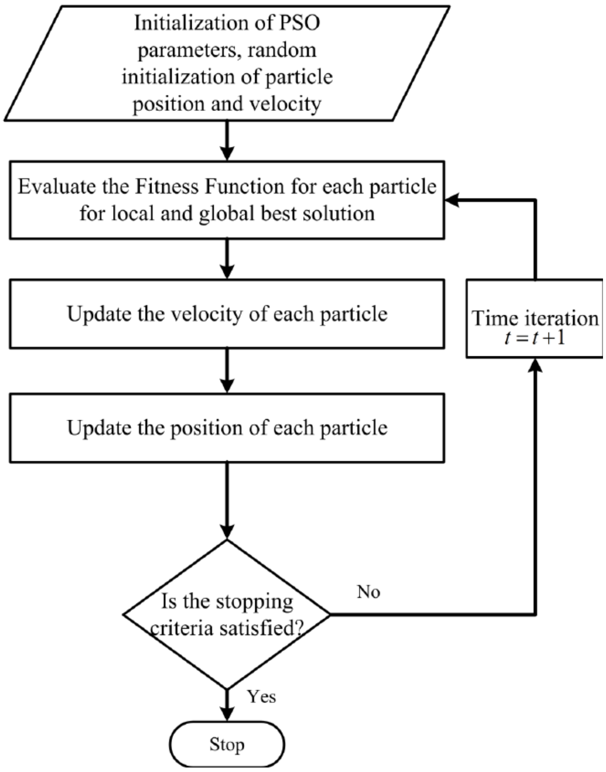


Fig.4. Flow chart for PSO

B. Optimization of FOPID Controller's parameters

In this we need to delineation the optimal goal, and also encode the parameters to be searched. The values Kp, Ki, Kd, and λ, μ are required to be delineation, according to reigned the objectives. The calculation of these specifications cannot be possible by the traditional controllers and only possible of fast, accurate and efficient controllers like PSO or FOPID controllers. By using these optimization controllers we can found the optimization parameters.

In the PSO first we need to initialize the parameters randomly and the initialization can show its present position and velocity of the particle. By using some optimization techniques like PSO evaluate the fitness function of each particle and reaches towards the best solution and again update the weights like velocity and position of particle and often updated till optimization reaches otherwise again update the velocity and position of the particle. This process is never end process and finally reaches the system towards to optimization.

C. Fitness function

The delineation of $PI^{\lambda}D^{\mu}$ controller is a multi-dimensional function optimization problem. The objective of the controller is to achieve the optimization solution with in less time and optimization values are observed. These observed values are fitness values and these values update one or more time and finally reach the problem towards the optimization. By using these fitness values the optimization problem can be solved with in less time and get the solution must be accurate and efficient. By using fitness function the problem can be optimized with in less time and maintains accuracy of the problem.

IV. SINE COSINE ALGORITHM (SCA)

Sine cosine algorithm provides the multiple initial random solutions and it is directed towards the best solution using mathematical model based on Sine and Cosine functions. It requires more time to resolve the optimization problem. Optimization means that the process of finding the optimum value for the parameters of the system which makes the improvement of optimization techniques and finally we can get the maximum and minimum value of the output.

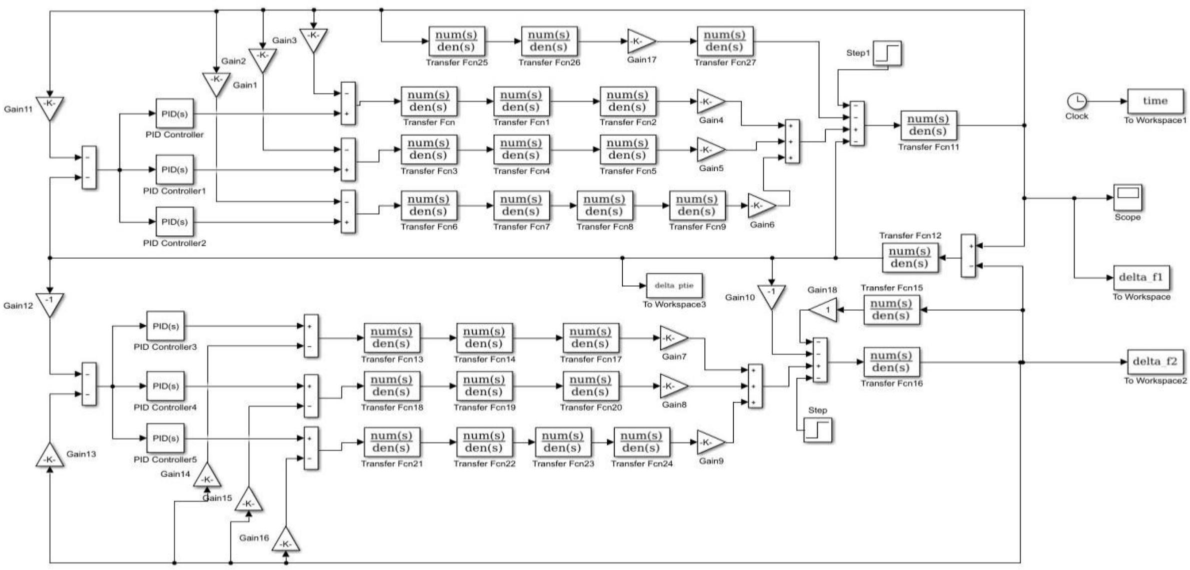


Fig.5. Block diagram of two area system

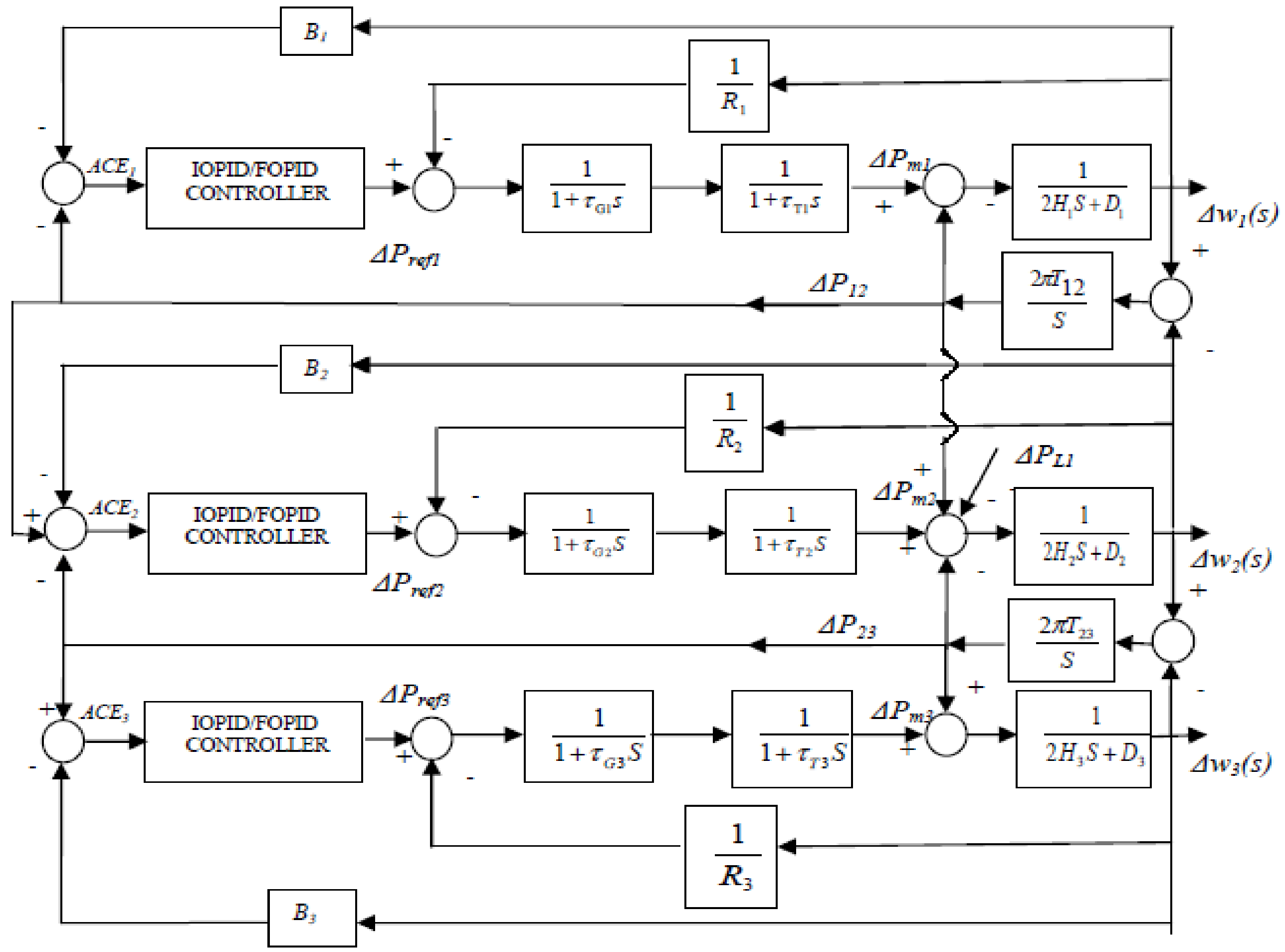
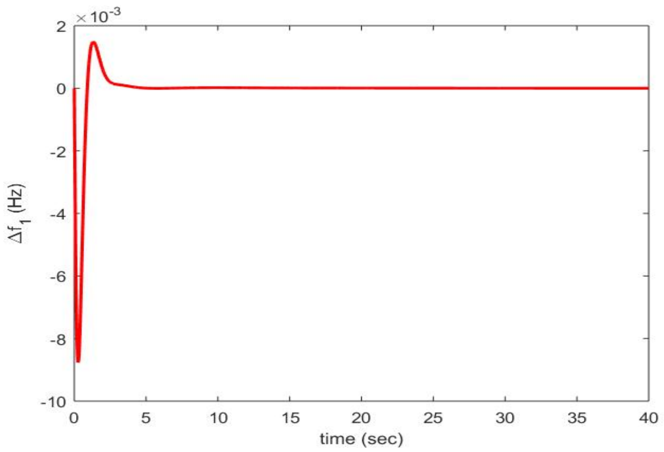


Fig 6 Block diagram of muti area AGC

V. RESULTS AND DISCUSSION

Sine Cosine Algorithm (SCA) has applied on the two area system and the results are as shown in Fig 7, Fig 8 and Fig9. Automatic Generation Control (AGC) of three area connected system has developed IOPID with PSO derived and FOPID controller with PSO derived using Matlab/Simulink package. From the Table 1, FOPID control (PSO) based requires only 10 sec of settling time where as IOPID control (PSO) derived requires 20 sec settling time as a result we can say that PSO derived FOPID controller has superior dynamic performance than PSO derived IOPID controller

Fig 7 Frequency changes at Area-1



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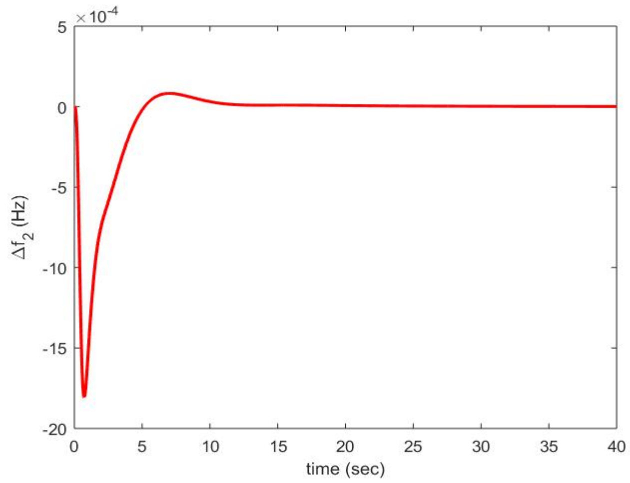

Fig 8 Frequency changes at Area-2

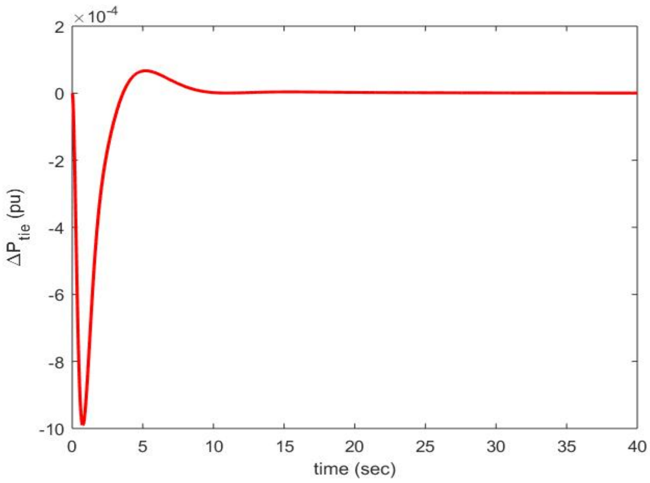

Fig 9 Change in Tie Line power of two area system

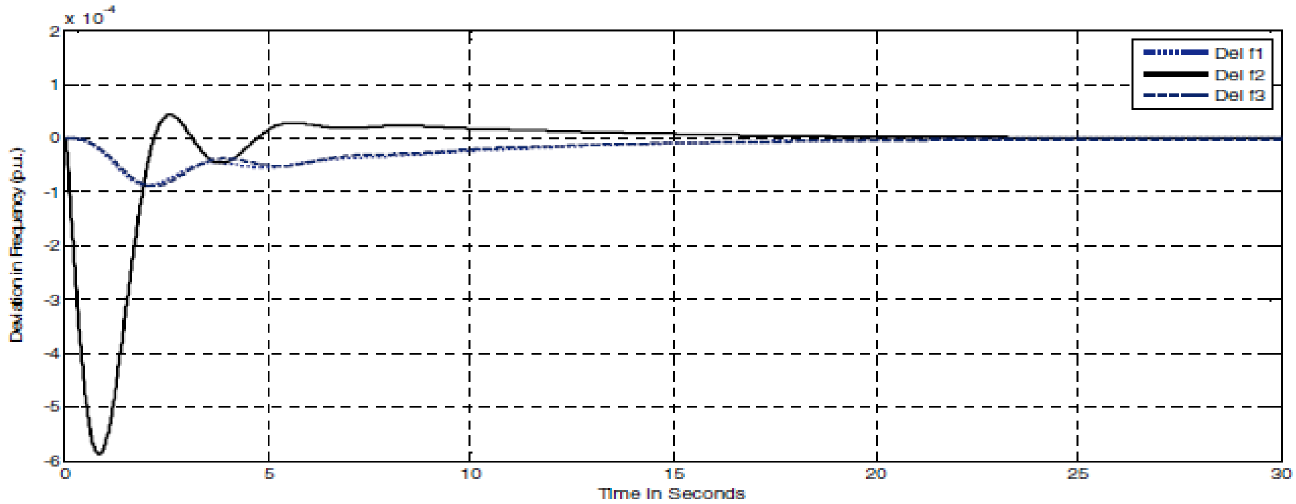

Fig. 10 Frequency variation with IOPID Controller for 1% Step load Vexation

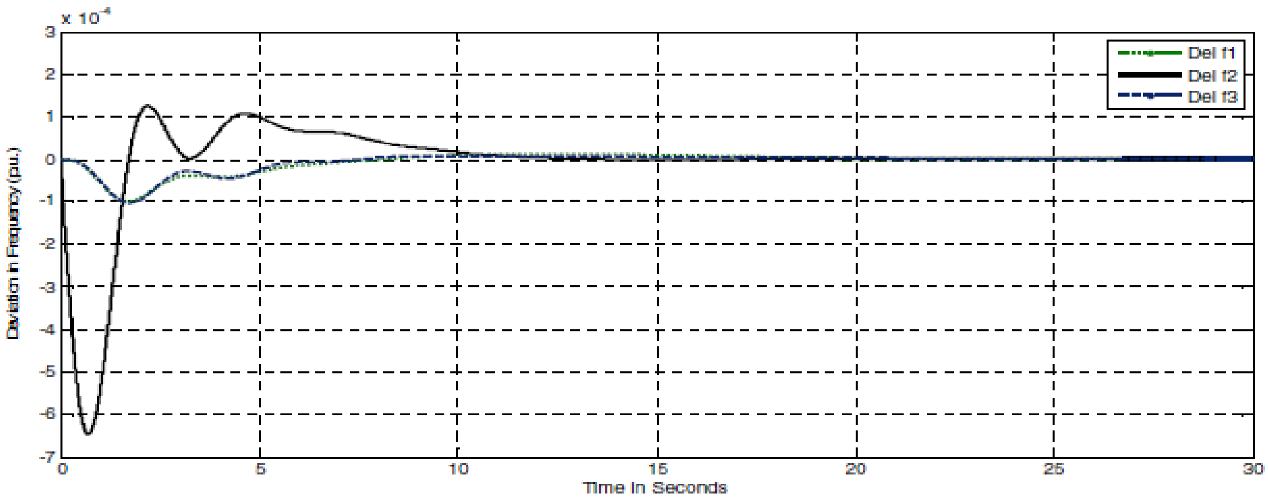

Fig. 11 Frequency variation with FOPID Controller for 1% Step load Vexation

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Controllers	Settling time in (Sec)		
	Δf Area 1	Δf Area 2	Δf Area 3
IOPID Control (PSO based)	20	20	20
FOPID Control (PSO based)	10	10	10

Table 1 Settling time of controllers for 1% step load variation

VI. CONCLUSION

In this AGC of three area interconnected power system has been improved using PSO based IOPID Control and PSO based FOPID controller using Matlab/Simulink package. From the Table 1 we can say that FOPID control (PSO) based requires only 10 sec of settling time where as IOPID control (PSO) based requires 20 sec settling time so that as per Simulation results we can say that PSO derived FOPID controller has superior dynamic performance than PSO derived IOPID controller.

VII. APPENDIX

B_1=17.8228, B_2=19.8321, B_3=18.4995, K_{p1}=1.1242, K_{i1}=1.2422, K_{d1}=1.1223, λ_1=1.5438, μ_1=1.3652. K_{p2}=1.2936, K_{i2}=1.5, K_{d2}=1.1903, λ_2=1.2249, μ_2=1.0548, K_{p3}=1.3288, K_{i3}=1.5, K_{d3}=1.4474, λ_3=0.3554, μ_3=0.1306.

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