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GA Based Design of PID Controller for Two Area Load Frequency Control

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Abstract— Maintaining demand-supply balance and regulating frequency are key issues in power system control. Conventional approaches focus on adjusting the generation so that it follows the load. Power system deals with continuously varying load with respect to time which results variation in frequency, thus leading to load frequency control problem (LFC). These variations in frequency is highly undesirable and have maximum acceptable variation in the range of ± 0.5Hz.In this paper,GA tuned PID controller is used to improve the dynamic response.The results show that by use of GA tuned PID controller, frequency reaches a steady state value within a specified time. By developing MATLAB code for GA based PID controller, satisfactory results are obtained. The strength of the controller is confirmed by using MATLAB/SIMULINK software.

Keywords— Genetic Algorithm, Load frequency control, PID controller, MATLAB/SIMULINK.

I. INTRODUCTION

In power system the imbalance between generating side and load side should be corrected within a short period of time otherwise it will drive the line frequency into unstable region. If the frequency deviation is large then it will negative effect on the system and sometimes in worse conditions it can also permanently damage our system.

The overall operation of power system can be much better controlled if the frequency is kept within particular limits.Therefore maintaining balance between generation and load have become a significant topic in power system operations.If we need to keep our system in balance than we have to control both the active and reactive power.The main aim of the control strategy is to generate and deliver power in an interconnected system as economically and reliably as possible while maintaining the voltage and frequency within permissible limits.

Real power mainly affects the system frequency while the reactive power is less sensitive to change in frequency. Reactive power is mainly depends on the change in voltage magnitude. The load frequency control loop controls the real power and frequency and the automatic voltage regulator regulates the reactive power and voltage magnitude. Load frequency control plays a significant role in the interconnected power system and has made the operation of interconnected systems possible.

In literature, there are several control strategies which are based on conventional linear control[1]. But these conventional controllers do not provide suitable results because of the complexity of the power system like non linear load characteristics and variable operating points. The conventional PID control scheme does not provide a high degree of control performance[2]. PID controllers are extensively used in industrial applications to control the different parameters of a plant. Conventional PID controllers contain non linearities and have high overshoot and settling time[3]. Our motive is to design a controller, which has a good frequency response. To achieve this we are required to tune the parameters of PID controller to get an output with better dynamic and static performance[4]. PID controllers efficiently reduces the area control error.

When we use a PID controller in a system it will improve the transient response of a system by improving the overshoot and by reducing the settling time[5].The PID control algorithm is used to control all the process loops in process industries.For a control loop to work properly,a PID loop should be properly tuned.There are some standard methods available for tuning like Ziegler-Nichols Ultimate-cycle tuning[6], Cohen-Coon's[7], Astrom and Hagglund[8] etc.Even though there are also some new methods available for tuning of PID controller but their use is restricted due to the complexness coming at the time of implementation.Since Genetic Algorithm is is an optimization method that will provide the best parameters for controller[9]. In this paper Genetic Algorithm is used to find out the parameters of a PID controller according to the system dynamics. For tuning purpose, we can also use PSO because it is also a population based heuristic search method like GA.

II. LOAD FREQUENCY CONTROL

A large power system can be further subdivided into a number of load frequency control areas interconnected by means of tie lines. The main motive of Two area load frequency control is to regulate the frequency of each area and to regulate the tie-line power as per inter-area power contracts.Simple block diagram of two area load frequency control with the controller is shown in figure 1.This concept can be explained with the help of an example.

In India there are five regional grids Western,Eastern,Southern,Northern and North Eastern.Each of these grid is conncted to its neighbouring grid with the help of transmission lines which are called tie lines.If there is deficiency of power in any of the grid than its possible to transfer power through these tie lines.So load frequency control as the name implies maintains the power flow between different areas while maintaining frequency constant.Since,PID controllers are very much used in process control.There are several tuning approaches for for controlling these controllers but each has its own advantages and disadvantages. In other words we can also say that the PID controller is used to eliminate the steady state error and to improve the dynamic response of a system.

A PID controller comprises of three controllers namely Proportional,Integral and Derivative. The integral term adds a pole at the origin, which will increase the system type and hence reduce the steady state error while the derivative term will add a zero at the origin, which in turn improve the transient response of the system. PID controller is also known as robust controller.The overall function of a PID controller is as follows:

$$Kp + Kd \times s + \frac{Ki}{s} \qquad \ldots\ldots(1)$$

Where Kp, Ki, Kd are proportional, integral and derivative constants.

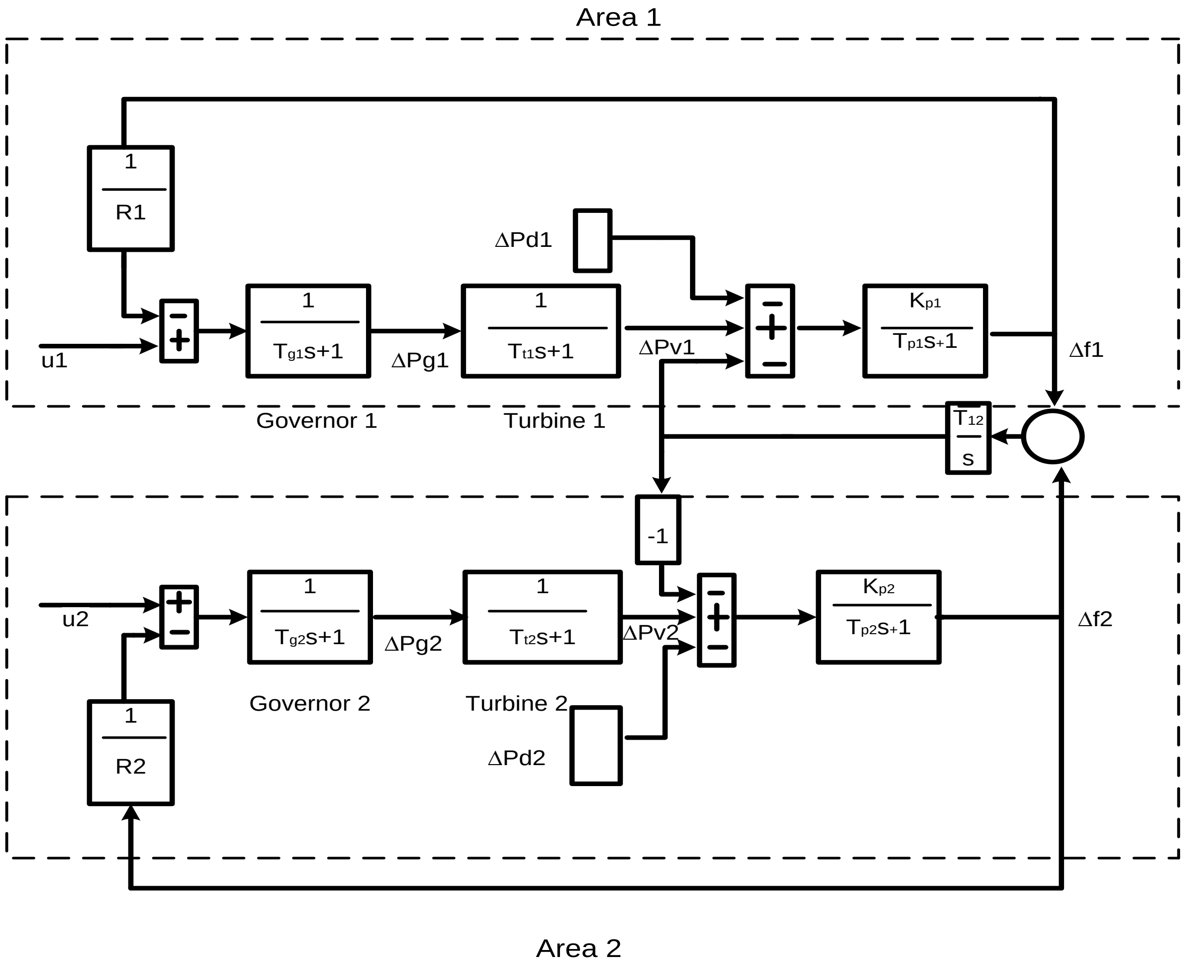

Figure 1.Block diagram of two area power system

III. THEORITICAL BASICS

A. PID CONTROLLER

With the help of a PID Controller we will get an output which have better static and dynamic performance, such as it has low settling time and low overshoot. PID controller have the adavantages of proportional,integral and derivative controllers thats why it improves both the transient and steady state response characterstics.It reduces rise time,increases bandwidth,increases stability and increases type and order of the system by 1.The magnitude of peak overshoot depends on the properly tuned values of both Td and Ti.The mathematical equation of a PID controller is given as:

$$y(t) = Kpe(t) + Ki\int_0^t e(\tau)d\tau + Kd\frac{d}{dt}e(t) \qquad ....(2)$$

Here y (t) is the output of the controller. KP, Ki and Kd are the proportional, integral and derivative gains of the controller. Conventional PID controllers are usually slow due to the presence of non linearities. So to overcome this these gain values are tuned with the help of using different optimizing methods such as a Ziegler Nicholas method, Genetic Algorithm, etc... As the load in a power system is continuously varying,so the values of these gains should also be tuned continuously.

The block diagram of a PID Controller is shown in the fig.2

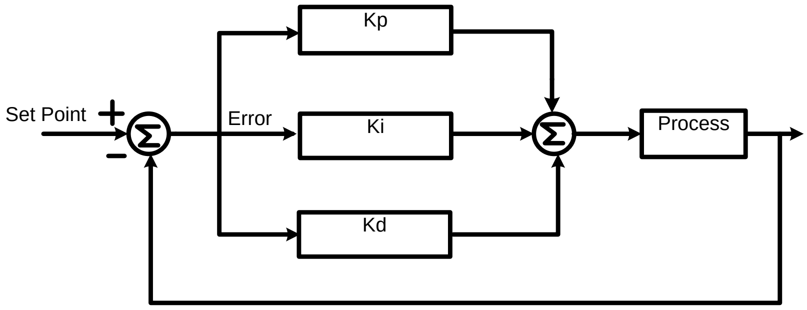

Figure 2. Block diagram of a PID Controller

B. Genetic Algorithm

GA are basically search methods works on the principle of natural selection.It converts the decision variables of a search problem into finite length strings of alphabets of certain cardinality.The strings which are candidate solution to the search problem are referred as chromosomes,the alphabets are referred as genes,and the values of alphabets are referred as alleles.GA works on the phenomenon of coding of parameters.But to achieve good solution and to use natural selection we need a measure which will differentiate a good solution from a bad solution.

The measure could be in the form of the objective function that may be a mathematical model or a computer simulation.We have to use a fitness measure which will determine the relative fitness of a candidate solution.GA uses this fitness function to find out better solutions.The first step is to encode the problem into a chromosomal order and to fitness function is chosen to discriminate a good solution from a bad one.The working steps for GA are as follows:

- ✓ Initialization=First of all the initial population of candidate solution is generated randomly across the search space.

- ✓ Evaluation=After the population is initialized, the fitness value of the candidate solution is calculated.

- ✓ Selection=Those solutions which have higher fitness values will allocate more copies and than survival of the fittest phenomenon will be imposed on candidate solution.There are some selection methods by which we can perform a selection.They are as follows:

    - Roulette wheel
    - Ranking Selection
    - Stochastic universal selection
    - tournament selection

- ✓ Recombination & Mutation=Under this process some parts of two or more parental solutions are recombined to create a new best solution and mutation helps in modifying a solution randomly.

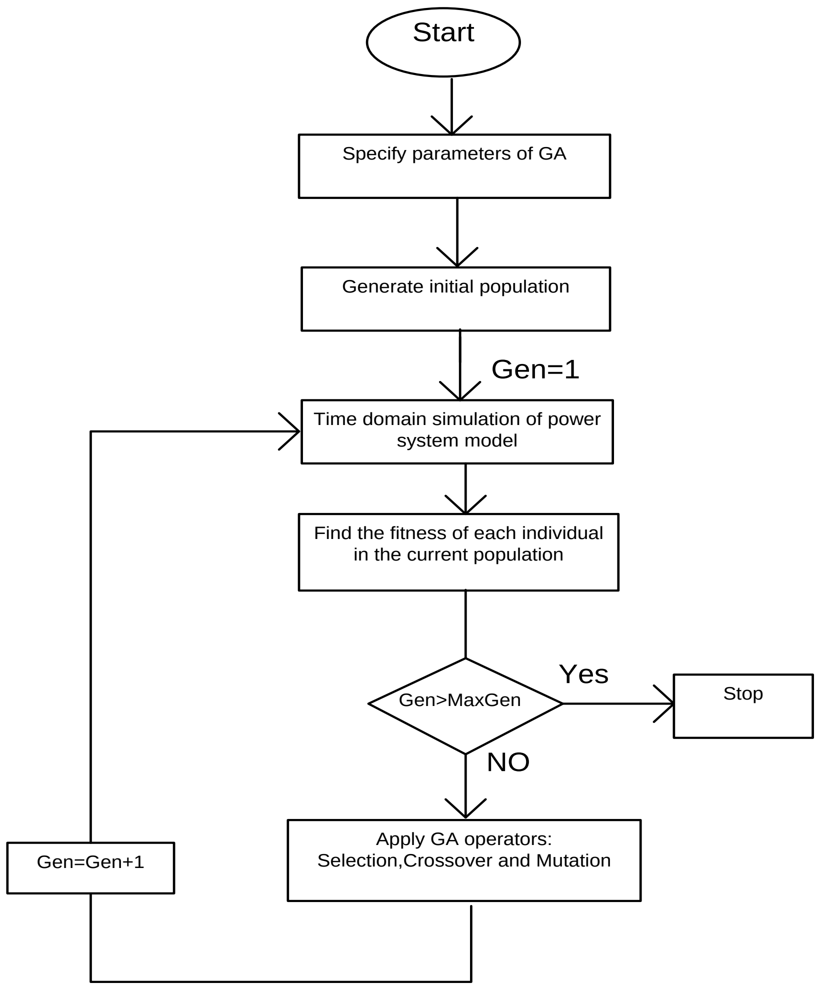

Figure 3. Flow chart of GA

IV. PROPOSED PID CONTROLLER

PID controllers are very much used in industries because of its simplicity. Our main aim here is to reduce the steady state error and to improve the dynamic response. In case of integral controller it will add a pole at the origin, therefore increasing the type of the system by one and reducing the steady state error to zero. But in case of derivative controller it will add a zero at the open loop transfer function and thus improves transient response. Here, by using genetic algorithm we tune the parameters of a PID controller to get best results.

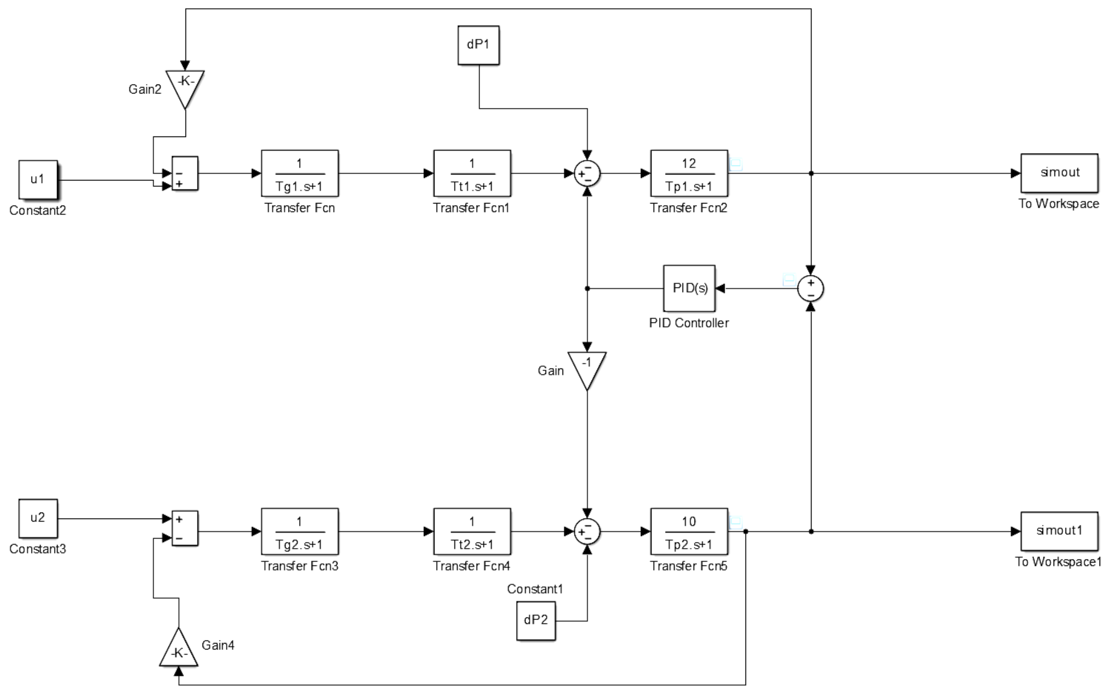

Figure 4.Two area power system with GA tuned PID controller

V. SIMULATION RESULTS

MATLAB/SIMULINK software is used to determine the results for two area power system with PID controller. A normal power system consists of governor, turbine and generator. We chose certain values for these parameters which is given in table 1.

Table 1.

Description	Parameter	Values
Time constant of governor 1	T_{g1}	0.08
Time constant of turbine 1	T_{t1}	0.28
Time constant of generator 1	T_{p1}	18
Time constant of governor 2	T_{g2}	0.2
Time constant of turbine 2	T_{t2}	0.28
Time constant of generator 2	T_{p2}	20
Gain of generator 1	K_{p1}	12
Gain of generator 2	K_{p2}	10

The value of PID parameters which are obtained by Genetic Algorithm are Kd = 34.1708, Ki = 25.8554 and Kp = 40.5855. By using GA tuned PID controller we get optimum results for a two area power system which are shown below in table 2.

Table 2.

Area	Parameter	Without any controller	With PI controller	With fuzzy controller	With GA tuned PID controller
1	Peak Overshoot(Hz)	1.9	0.09	0.045	0
	Settling time(sec)	Never settles to steady state value	8	3	2.2
2	Peak Overshoot(Hz)	1.89	0.08	0.06	0
	Settling time(sec)	Never settles to steady state value	19	4.5	2.2

The best fitness value obtained is 6.9107e-07 which is also given in the shown figure.

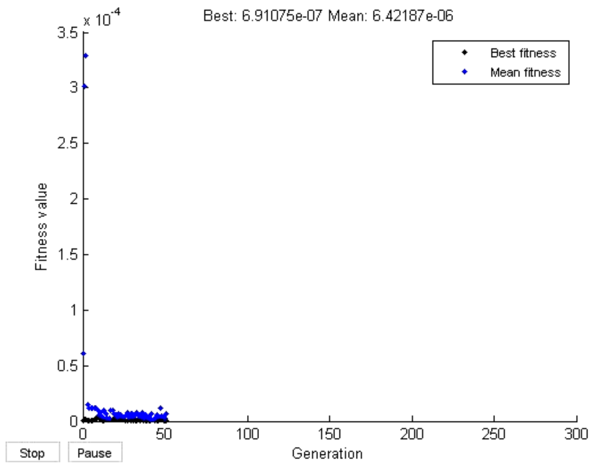

Figure 5.Graph showing best fitness value

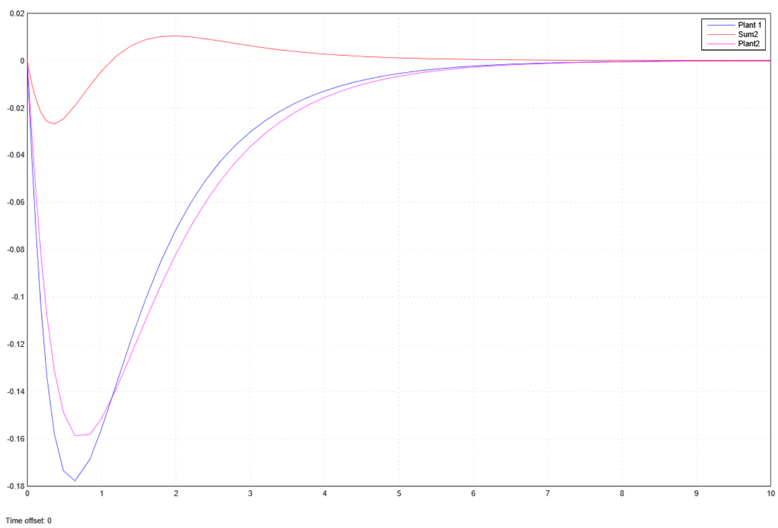

Figure 6. Deviation of frequency of two area power system without PID controller

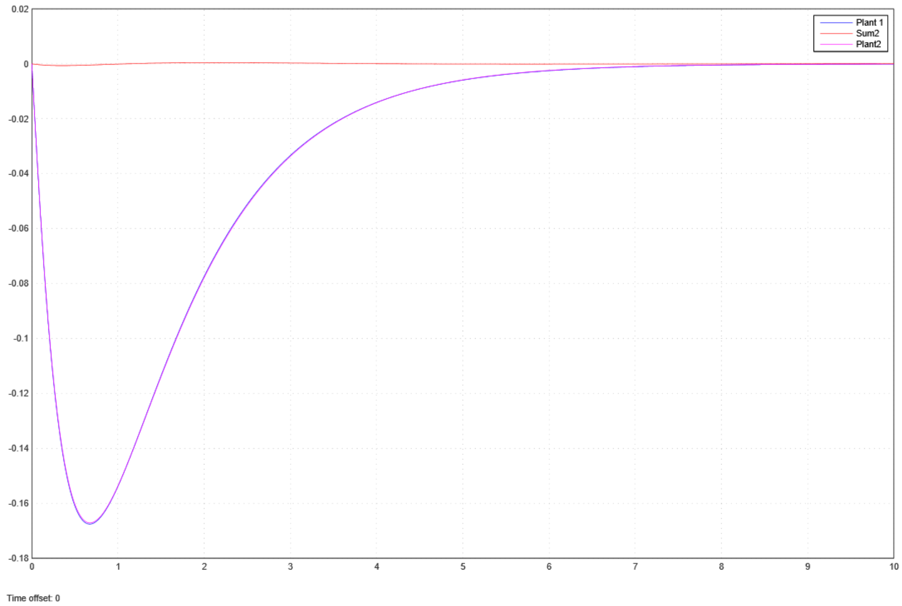

Figure 7. Deviation of frequency of two area power system with GA tuned PID controller

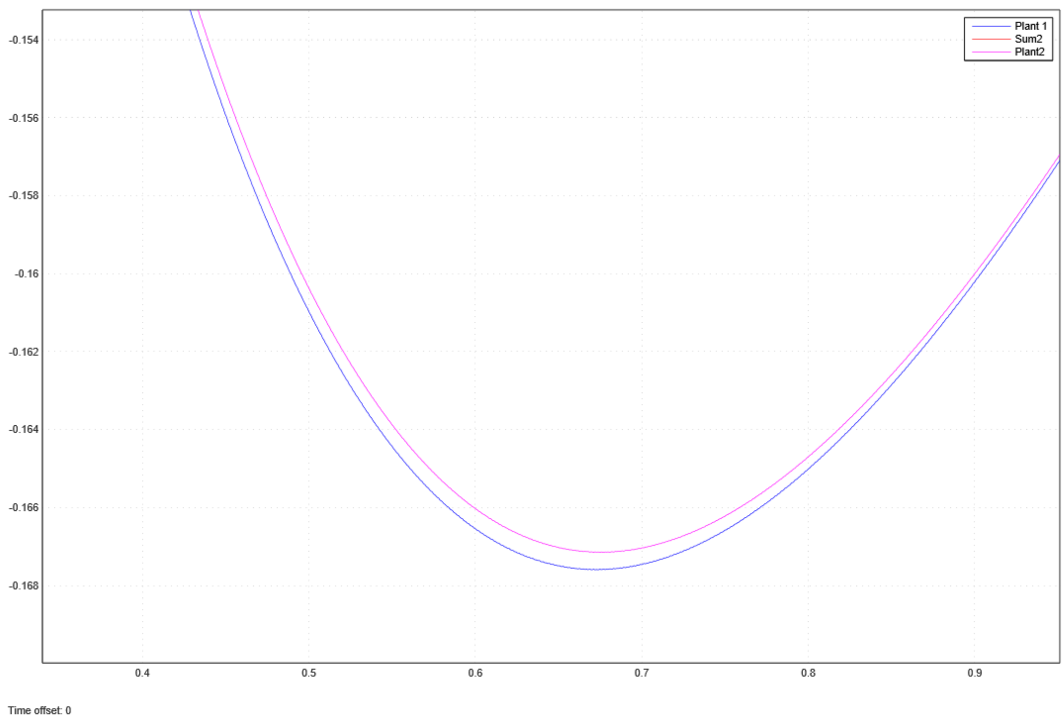

Figure 8. Clear view of deviation in frequency of two area power system with GA tuned PID controller

VI. CONCLUSION

In this work, Genetic Algorithm is used to tune the parameters of PID controller for two area power system. MATLAB software is used to analyze the result of two area power system with the help of developing a SIMULINK model which is shown in figure 4. The simulation result shows that the results obtained with GA tuned PID controller possess much better than the results when we don't use PID controller. By using this controller steady state error, setting time and peak overshoot are reduced to a very less value. In future we can also use this proposed methodology for multi area power system network. And also we will get optimum results by using some more logics like fuzzy system, PSO, Neural network etc.

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