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STABILITY IMPROVEMENT BY USING GA & FUZZY LOGIC CONTROLLER OF MULTI-AREA POWER SYSTEM

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Abstract: Variations in load bring about drifts in frequency and voltage which in turn leads to generation loss owing to the line tripping and also blackouts in the power system. These drifts might be reduced to the smallest possible value by automatic generation control (AGC) which constitutes of two sections by using load frequency control (LFC) along with automatic voltage regulation (AVR). Here simulation evaluation is done to know the working of LFC by building models in SIMULINK which helps us to comprehend the principle behind LFC including the challenges and problems. The three area system is considered in this article. Several important parameters of ALFC like integral controller gains (KIi), parameters for governor speed regulation (Ri) as well as parameters for frequency bias (Bi) are being optimized by using an optimization technique that is Bacteria Foraging Optimization Algorithm (BFOA) to solve the frequency deviation problem we use fuzzy logic control, GA-PI. Load Frequency Control (LFC) is used to regulate the generator's output power within a specified area with respect to tie line power and change in the system frequency. In this paper Fuzzy Logic controller is used for load frequency control for multi area system & comparison between Fuzzy logic controller and Genetic algorithm for load frequency control. In power system the interconnected multi-area, as a power load demand varies randomly, in the case of any small load change suddenly in any of the areas, both tie line and frequency flow interchange also vary The main purpose of this paper is basically present an application of Fuzzy Logic Controller (FLC) based load frequency control in multi-area interconnected power system.
Key words: *automatic generation control (AGC), load frequency control (LFC), fuzzy logic controller (FLC), genetic algorithm (GA), proportional integral (PI).*

I. Introduction

Electrical power system is very large and complex electrical network which consists of generation, transmission and distribution network along with loads which are being distributed overall the network over a large geographical area [1]. In the power system, the system load and consumers load keep change time to time according to the needs of the consumers. Properly and good designed controllers are required for the regulation of the system changes in order to maintain the power system's stability as well as provide its reliable operation. The industries has very rapid growth and enlargement creates complexity of the power system. The voltage is greatly depends on the reactive power and Frequency is greatly depends on active power. So difficulty of control in the power system may be divided into two parts. One is related to the control of the reactive power along with the regulation of voltage whereas the other is related to the active power along with the frequency [2]. For very big power systems which consists of inter-connected various control areas, load frequency and it is important to keep the frequency in an inter-connected area of power near to the scheduled values. The input mechanical power is used to control the demand of the generators, alternators and the variations in frequency tie-line power are sensed, which is a measure of the variation in rotor angle. A well designed power system should be able to provide the acceptable levels of power quality and load frequency by keeping the frequency and voltage magnitude within tolerable limits. The changes in power system load and in variation of function of different electrical equipment affect mainly the system frequency, while the reactive power is less sensitive to the changes in load frequency and is mostly dependent on fluctuations of voltage magnitude. So the control of the real and reactive power in the power system is described separately. The load frequency control mainly describe with the control of the system frequency and real power whereas the automatic Voltage regulator loop regulates the variation in the reactive power and voltage magnitude. Load frequency control is uses advanced concepts for the large scale control of the power system. In electric power system, load demand varies continuously and it may cause the affect in power system performance.

Besides this condition, it may create harmonics, disturbance, collapse of voltage and the loss of reactive power in generation station and affect the system stability. The stability of any system is its ability to achieve normal or stable operating condition after been subjected to any types of disturbance. These unstable conditions have to be corrected by Automatic Generation Control (AGC). The primary goal of the AGC power system is to restore the frequency of each area to under desirable limit and minimize the tie line flow throughout area control error (ACE) is minimized to zero. An interconnected power system usually leads to enhance the system performance. The primary objective of an interconnected power system, keeps the system operation in stable condition. In an AGC power system, the frequency should remain nearly constant or under desirable limit (maximum permissible change in frequency is ±0.5Hz). A large frequency fluctuation can damage equipments, diminish the load performance, because the transmission lines to be overloaded due to reactive power and can disturb the system protection schemes and ultimately lead to an unstable condition may create problem for the power system. In an interconnected power system a number of independently control areas, frequency and generation controlled in each area are too maintained by scheduled power interchanged. These control strategies known as load frequency control (LFC). The power interchanged between each area through a tie line.

Objectives Relating To Control Areas

The objectives relating to control areas are as follows:-

To develop the model of three interconnected hybrid power system that consists of various controllers such as GA and Fuzzy.

To design the fuzzy and GA-PI controller order to regulate the frequency whenever the load demand changes.

To design the LQR by using MATLAB in the hybrid system for the optimal control.

To simulate the developed model for three area interconnected system with designed controllers for LFC. To compare the performance of three controllers in terms of settling time, overshoot and undershoot.

To compare the performance of controllers in terms of settling time overshoot and undershoot.

To maintain the real frequency and desired power output in the inter-connected power system.

To control the change in the tie-line power between control area.

Every control area must have adjustable frequency according to the control. Each control area should fulfil its individual load demand in addition to the power transfer through tie lines on the basis of communal agreement.

To take care of the appropriate value of exchange of power linking control areas.

To facilitate control of the frequency for larger interconnection.

To take care of the required megawatt power output of a generator matching with the changing load.

II. Problem Statement

2.1 Power Generating Unit

A comprehensive introduction to the dynamic models of general power systems can be found in [1]. In this paper, the modeling of a typical power generating system, including the modeling of three types of generating units, the tie-line modeling and the modeling of parallel operation of interconnected areas will be introduced. A Laplace transform of a decentralized area of the power generating system will be derived for later frequency-domain analyses.

2.1.1 Turbines

Turbines are employed in power systems for the conversion of the natural energy, just like the energy obtained from the steam or water, into mechanical power (Pm) which may be conveniently supplied to the generator. There are three categories of turbines usually utilized in power systems: non-reheat, reheat additionally to hydraulic turbines, each and each one amongst which can be modeled and designed by transfer functions. we've got non-reheat turbines which are represented as first-order units where the delay in time referred to as time delay (Tch) takes place between the interval during switching of the valve and producing the torque within the turbine. Design of reheat turbines is completed by using second-order units as there are different stage thanks to soaring and low down of the pressure of the steam. thanks to the inertia of the water hydraulic turbines are treated as non-minimum phase units.

The turbine model represents changes in the steam turbines power output to variation in the opening of the steam valve. Here we've considered a non-reheat turbine with one gain factor KT and single time constant T in the model the representation of the turbine is,

$$\frac{\Delta P_T(s)}{\Delta P_V(s)} = \frac{K_T}{1+ST_T}$$

Where $\Delta P_V(s)$= the input to the turbine

$\Delta P_T(s)$ =the output from the turbine

2.1.2 Generators

Generators receive mechanical power from the turbines so convert it to power. However our interest concerns the speed of the rotor instead of the facility transformation. The rotor speed is proportional to the frequency of the power system. we want to take care of the balance amid the power generated and therefore the power demands of the load because the power can not be stored in bulk amounts. When there's a variation in load, the mechanical power given out by the turbine doesn't counterpart the wattage generated by the generator which ends up in miscalculation which is being integrated into the rotor speed deviation (Δω). Frequency bias $\Delta f=2\pi\Delta\omega$ the load of the power will be divided into resistive loads (PL), which can be fixed when there's a change within the rotor speed thanks to the motor loads which change with the speed of the load. If the mechanical power doesn't change then the motor loads shall compensate the change within the load at a rotor speed which is totally dissimilar from the planned value.

Once a load change occurs, the mechanical power sent from the turbine will no longer match the electrical power generated by the generator. This error between the mechanical (ΔP_m) and electrical powers (ΔP_{el}) is integrated into the rotor speed deviation ($\Delta\omega_r$), which can be turned into the frequency bias (Δf) by multiplying by 2π. The relationship between ΔP_m and Δf is shown in Figure 2.1, where M is the inertia constant of the generator [1].

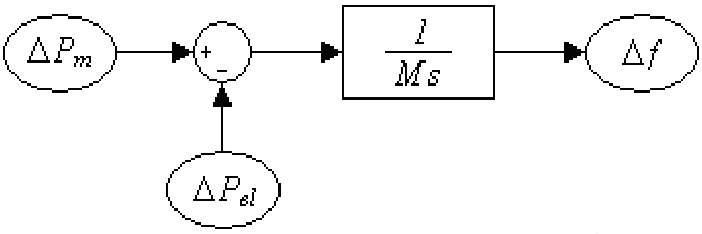

Figure 2.1 Block diagram of the generator

The power loads can be decomposed into resistive loads (ΔPL), which remain constant when the rotor speed is changing, and motor loads that change with load speed [1]. If the mechanical power remains unchanged, the motor loads will compensate the load change at a rotor speed that is different from a scheduled value, which is shown in Figure 2.2, where D is the load damping constant [1].

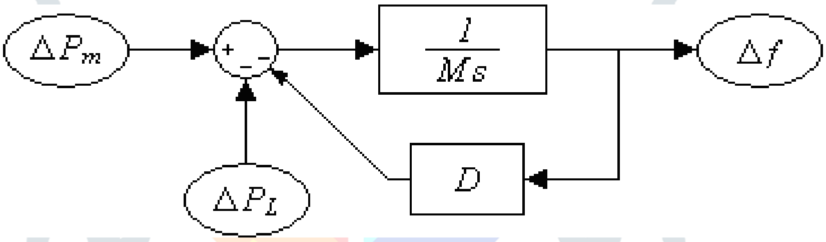

Figure 2.2 Block diagram of the generator with load damping effect

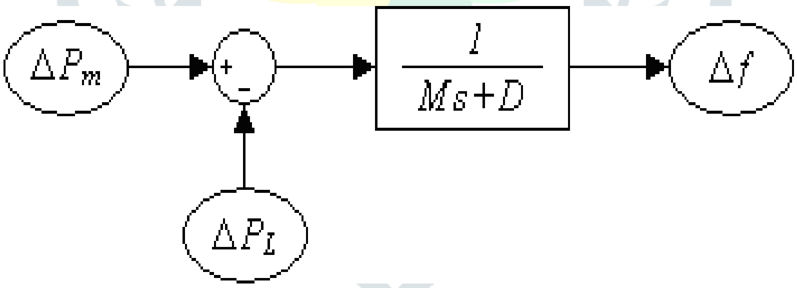

Figure 2.3 Reduced block diagram of the generator with the load damping effect

2.1.3 Governor

Governors are the units that are used in power systems to sense the frequency bias caused by the load change and cancel it by varying the inputs of the turbines. The schematic diagram of a speed governing unit is shown in Figure 2.4, where R is the speed regulation characteristic and T_g is the time constant of the governor [1]. If without load reference, when the load change occurs, part of the change will be compensated by the valve/gate adjustment while the rest of the change is represented in the form of frequency deviation. The goal of LFC is to regulate frequency deviation in the presence of varying active power load. Thus, the load reference set point can be used to adjust the valve/gate positions so that all the load change is cancelled by the power generation rather than resulting in a frequency deviation.

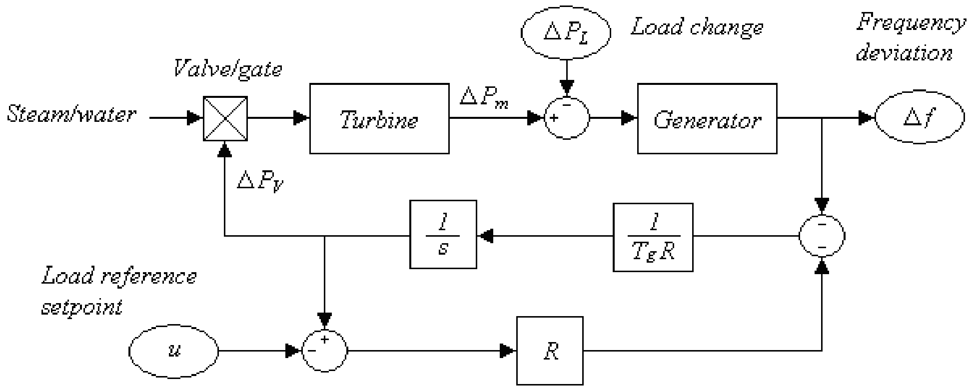

Figure 2.4 Schematic diagram of a speed governing unit

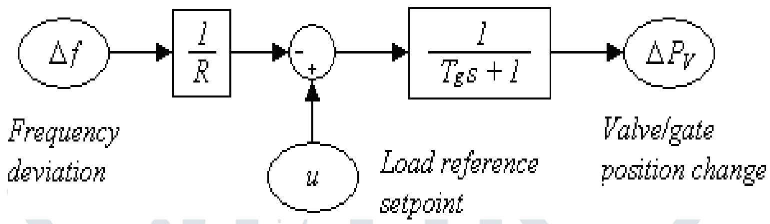

Figure 2.5 Reduced block diagram of the speed governing unit

When the electrical load is suddenly increased then the electrical power exceeds the mechanical power input. As a result of this the deficiency of power in the load side is extracted from the rotating energy of the turbine. Due to this reason the kinetic energy of the turbine i.e. the energy stored in the machine is reduced and the governor sends a signal to supply more volumes of water or steam or gas to increase the speed of the prime-mover so as to compensate speed deficiency.

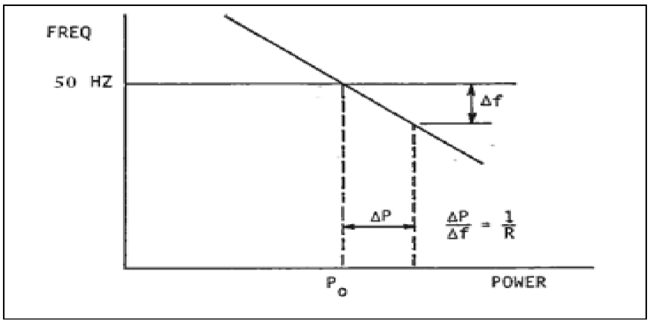

Figure 2.6 Graphical Representation Of Speed Regulation By Governor

The slope of the curve represents speed regulation R. Governors typically has a speed regulation of 5-6 % from no load to full load.

$$\Delta P_g = \Delta p_{ref} - \frac{1}{R}\Delta f \ldots\ldots\ldots eqn(1)$$

Or in s- domain

$$\Delta P_g(s) = \Delta P_{ref} - \frac{1}{R}\Delta\Omega(s) ------ eqn(2)$$

The command ΔP_g is transformed through hydraulic amplifier to the steam valve position Command ΔP_V. We assume a linear relationship and consider simple time constant. we have the followings-domain relation:

$$\Delta P_v(s) = \frac{1}{1+\tau_g}\Delta P_g(s) --------- eqn(3)$$

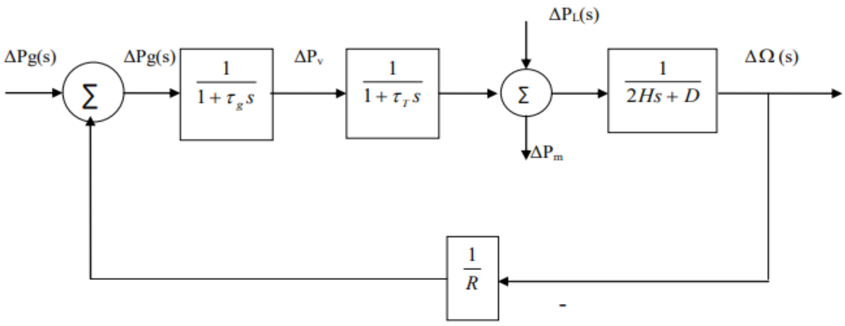

Figure 2.7 Mathematical Modelling of Block Diagram of single system

2.1.4 Mathematical Modeling for Prime Mover

The source of power generation is commonly known as the prime mover. It may be hydraulic turbines at waterfalls, steam turbines whose energy comes from burning of the coal, gas and other fuels. The model for the turbine relates the changes in mechanical power output ΔP_m to the changes in the steam valve position ΔP_V.

$$G_r = \frac{\Delta p_m(s)}{\Delta p_v(s)} = \frac{1}{1+\tau_t s} \cdots\cdots\cdots eqn(4)$$

Where τ_T is the turbine constant, in the range of 0.2 to 2.0 seconds.

2.2 Mathematical Modeling of Load

The load on the power system consists of a variety of electrical drives. The equipments used for lighting purposes are basically resistive in nature and the rotating devices are basically a composite of the resistive and inductive components. The speed-load characteristic of the Composite load is given by

$$\Delta P_e = \Delta P_L + D\Delta w \ ------equ.(5)$$

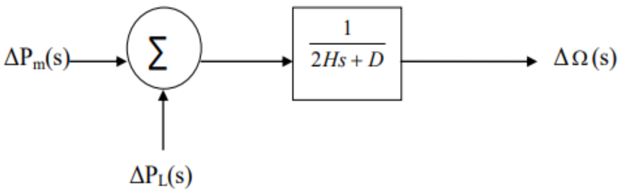

Figure 2.8 Mathematical Modelling Block Diagram of Load

2.3 Tie-Lines

Various areas may be connected with each other by one or more transmission lines in an interconnected grid through the tie-lines. When two areas are having totally different frequencies, then there's an exchange of power between the 2 areas that are linked by the tie lines, the facility because of tie-line trades in area i and area j (ΔPij) and therefore the tie-line synchronizing torque coefficient (Tij). Thus we are able to also say that the integral of the divergence in frequency among the 2 areas is an error within the power due to tie-line. the objective of tie-lines is to trade power with the systems or areas within the neighbourhood whose costs for operation create such transactions cost-effective. Although no power is being transmitted through the tie-lines to the nearby areas and it so happens that suddenly there's a loss of a generating unit in one amongst the systems. In an interconnected power system, different areas are connected with each other via tie lines. When the frequencies in two area are different, a power exchange occur through the tie line that connected both the areas. The tie line connection can be modelled as shown in figure. The Laplace transform representation of the block diagram is given by

$$\Delta Pij(s) = \frac{1}{s} Tij(\Delta Fi(s) - \Delta Fj(s))$$

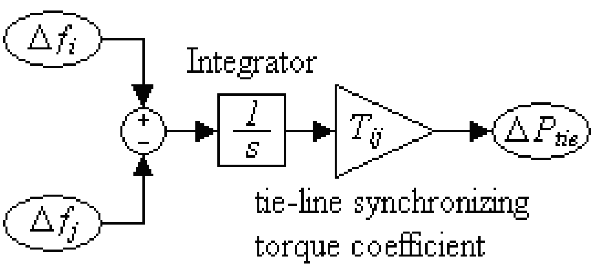

Figure 2.9 Block diagram of the tie-lines

2.4 Reasons for Limits on Frequency

Following are the reasons for keeping a strict limit on the system frequency variation:

1) The speed of the alternating current motors depends on the frequency of the power supply. There are situations where speed consistency is expected to be of high order.

2) The electric clocks are driven by the synchronous motors. The accuracy of the clocks are not only dependent on the frequency but also is an integral of this frequency error.

3) If the normal frequency id 50 Hertz and the system frequency falls below 47.5 Hertz or goes up above 52.5 Hertz then the blades of the turbine are likely to get damaged so as to prevent the stalling of the generator.

4) The under frequency operation of the power transformer is not desirable. For constant system voltage if the frequency is below the desired level then the normal flux in the core increases. This sustained under frequency operation of the power transformer results in low efficiency and over-heating of the transformer windings.

5) Most serious effect of subnormal frequency operation is observed in the case of Thermal Power Plants. Due to the subnormal frequency operation the blast of the ID and FD fans in the power stations get reduced and thereby reduce the generation power in the thermal plants. This phenomenon has got a cumulative effect and in turn is able to make complete shutdown of the power plant if proper steps of load shedding technique is not engaged. It is pertinent to mention that, in load shedding technique a sizable chunk of load from the power system is disconnected from the generating units so as to restore the frequency to the desired level.

III. Methodology

3.1 Load Frequency Control

If the system is connected to a number of different loads in a power system then the system frequency and speed change with the governor characteristics as the load changes. If it is not required to keep the frequency constant in a system then the operator is not required to change the setting of the generator. But if constant frequency is required the operator can adjust the speed of the turbine by changing the governor characteristic as and when required The possibility of sharing the load by two machines is as follow:

Suppose there are two generating stations that are connected to each other by tie line. If the change in load is either at A or at B and the generation of A is alone asked to regulate so as to have constant frequency then this kind of regulation is called Flat Frequency Regulation.

The other possibility of sharing the load the load is that both A and B would regulate their generations to maintain the constant frequency. This is called parallel frequency regulation.

The third possibility is that the change in the frequency of a particular area is taken care of by the generator of that area thereby the tie-line loading remains the same. This method is known as flat tie-line loading control.

In Selective Frequency control each system in a group is takes care of the load changes on its own system and does not aid the other systems in the group for changes outside its own limits. In Tie-line Load-bias control all the power systems in the interconnection aid in regulating frequency regardless of where the frequency change originates. The equipment consists of a master load frequency controller and a tie line recorder measuring the power input on the tie as for the selective frequency control.

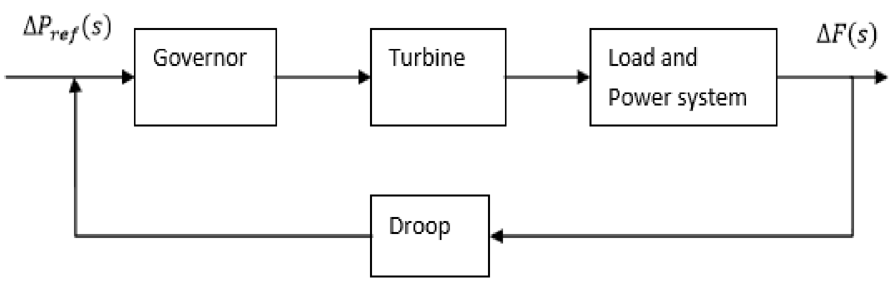

Figure 3.1 Load Frequency Control

3.2 Automatic Generation Control

If the load on the system is increased suddenly then the turbine speed drops before the governor can adjust the input of the steam to the new load. As the change in the value of speed diminishes, the error signal becomes smaller and the position of the governor and not of the fly balls get closer to the point required maintaining the constant speed. One way to restore the speed or frequency to its nominal value is to add an integrator on the way. The integrator will unit shall monitor the average error over a period of time and will overcome the offset. Thus as the load of the system changes continuously the generation is adjusted automatically to restore the frequency to the nominal value. This scheme is known as automatic generation control. In an interconnected system consisting of several pools, the role of the AGC is to divide the load among the system, stations and generators so as to achieve maximum economy and reasonably uniform frequency.

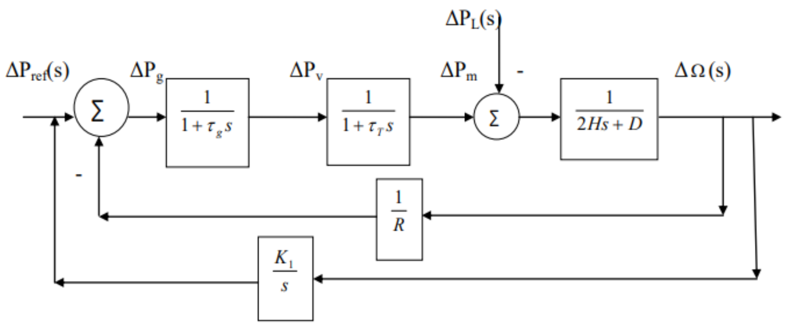

Figure 3.2 Mathematical modeling of AGC

3.3 Fuzzy Logic and Fuzzy Controller

Fuzzy Logic is the theory of fuzzy logic are often seen as a generalization of classical logic theory, that the basic knowledge of classical(Boolean) logic is firstly given as a reference for the development of fuzzy logic theory. Fuzzy logic has two different meanings. in an exceedingly narrow sense it's a logical system. So, an element could also be a part of a community, partially avoided evaluation, is complete or not the least bit. This can be expressed by the fuzzy theory.

3.3.1 Fuzzy Controller

In this paper the Fuzzy controller proposed is with two inputs membership functions and one output membership functions. One input is that the area control error signal and second is that the speed change of area control error signal. The output of Fuzzy controller is that the control operation applied for control the system. The subsequent

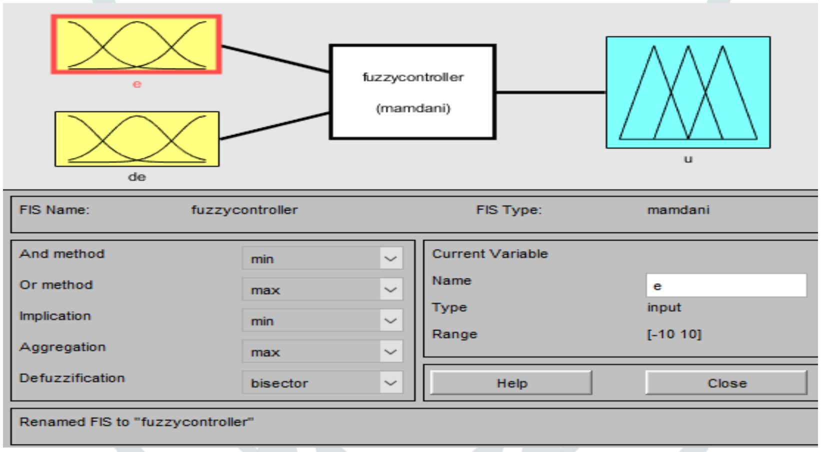

Figure 3.3 Fuzzy controller

The following are the features of the Fuzzy logic of the proposed Fuzzy controller-

[System] Name='maxrangecontroller'
Type='mamdani'
Version=2.0
NumInputs=2
NumOutputs=1
NumRules=25
AndMethod='min'
OrMethod='max'
ImpMethod='min'
AggMethod='max'
DefuzzMethod='bisector'
[Input1]
Name=‘e'
Range=[-10 10]
Num of MFs=5
MF1='NB':'trimf', [-15 -10 -5]
MF2='NS':'trimf',[-10 -5 0]
MF3='ZZ':'trimf',[-5 0 5]
MF4='PS':'trimf',[0 5 10]
MF5='PB':'trimf',[5 10 15]
[Input2]

Name='dE'
Range=[-10 10]
NumMFs=5
MF1='NB':'trimf', [-15 -10 -5]
MF2='NS':'trimf',[-10 -5 0]
MF3='ZZ':'trimf',[-5 0 5]
MF4='PS':'trimf',[0 5 10]
MF5='PB':'trimf',[5 10 15]
[Output1]
Name='u'
Range=[-5 5]
NumMFs=5
MF1='S':'trimf', [-7.5 -5 -2.5]
MF2='M':'trimf',[-5 -2.5 0]
MF3='B':'trimf',[-2.5 0 2.5]
MF4='VB':'trimf',[0 2.5 5]
MF5='VVB':'trimf',[2.5 5 7.5]
[Rules]
1 1, 1 (1):1; 1 2, 1 (1): 1; 1 3, 2 (1): 1; 1 4, 2 (1): 1; 1 5, 3 (1): 1;
2 1, 1 (1): 1; 2 2, 2 (1): 1; 2 3, 2 (1): 1; 2 4, 3 (1): 1; 2 5, 4 (1): 1;
3 1, 2 (1): 1;3 2, 2 (1): 1; 3 3, 3 (1): 1; 3 4, 4 (1): 1; 3 5, 4 (1): 1;
4 1, 2 (1): 1; 4 2, 3 (1): 1; 4 3, 4 (1): 1; 4 4, 4 (1): 1; 4 5, 5 (1): 1;
5 1, 3 (1): 1; 5 2, 4 (1): 1; 5 3, 4 (1): 1; 5 4, 5 (1): 1; 5 5, 5 (1): 1;

3.3.2 Fuzzification: it is related to the indefinite and indeterminate in a natural language. In application of fuzzy control the observed data are usually crisp. The data manipulation in an fuzzy logic controller & it is based on fuzzy set theory, fuzzification will necessary in an earlier stage. Following function is performed by fuzzification, it measures the input variables values and it performs a scale mapping that transforms the range of input variables values into corresponding universe or discourse. Performance the function of fuzzification that converts input into suitable linguistic values, which can be viewed labels of fuzzy sets. For LFC triangular membership function is used.

3.3.3 Knowledge base: The knowledge base of a fuzzy logic control (FLC) consists of a database and a rule base. the fundamental function of a database is to provide necessary information for the proper functioning of the Fuzzification, the rule base, and therefore the defuzzification. the data base gives information about fuzzy sets representing the meaning of the linguistic values of the process and therefore the control output variables. The basic function of the rule base is to represent in a structure way the control policy of an experienced process operator and control engineer in the form of a set of production rules like, If (process state) then (control output),if a part of such a rule is termed rule antecedent and may be a description of a process state in term of logical combination of atomic fuzzy propositions, then a part of rule is called rule consequent and is again the description of control output in terms of a logical combination of fuzzy proposition.

3.3.4 Fuzzy Inference System (FIS): it is way of mapping an input space to an output space by using fuzzy logic .Fuzzy inference system (FIS) uses a set of fuzzy rules and membership functions, rather than Boolean logic, to reason about data. Large negative (Ln), Medium negative (Mn), Small negative (Sn), Zero (Ze), Small positive (Sp), Medium positive (Mp), large positive (Lp). In Table 1, it can see the seven linguistic variables for input-1 error e and derivative of error Δe input-2 the linguistic variables are taken, and this linguistic variable are multiple with is other within the inference engine and 49 rule are formed for load frequency control (LFC). In Defuzzification, the fuzzy output set is converted in to a crisp number. Some commonly used technique is the centroid and maximum methods within the centroid method, the crisp value of the output variable is computed by obtaining the variable value of the centre of gravity of the membership function for the fuzzy value. Within the maximum method, one in all the variable values at which the fuzzy set has its maximum truth value is chosen as the crisp value for the output variable.

Table 3.1 Rule Base for Load Frequency Control

Frequency deviations	Rate of change of frequency deviations						
	Ln	Mn	Sn	Ze	Lp	Mp	Sp
Ln	Ln	Ln	Mn	Ln	Mn	Sn	Ze
Mn	Ln	Ln	Ln	Mn	Sn	Ze	Mp
Sn	Ln	Ln	Mn	Sn	Ze	Lp	Mp
Ze	Ln	Mn	Sn	Ze	Lp	Mp	Sp
Lp	Mn	Sn	Ze	Lp	Mp	Sp	Sp
Mp	Sn	Ze	Lp	Mp	Sp	Sp	Sp
Sp	Ze	Mp	Mp	Sp	Sp	Sp	Sp

3.4 Genetic Algorithm

Electrical Power system is an arrangement of number of Equipments. Over, the various components are connected in to the power system are very sensitive to the continuity and quality of power supply like voltage and frequency. The frequency is inversely proportional the load that's changing continuously, and therefore the change in real power affects the system frequency. Load frequency control related to AGC and improves system stability. So control of frequency, each generating unit is operate with speed governor and Load Frequency control loop to regulate the real power and frequency and hold their values at the scheduled values. The leading aim of load frequency control (LFC) is to keep the frequency near the specified par value (50Hz) against the randomly varying active power loads and minimize the tie-line power exchange error.

GA may offer better advantages over the conventional optimization method for a huge area for best output. They are

(i) its work on the control variables those are encoded for optimization technique, rather than variables themselves,

(ii) its work on only one population of solution for other population, rather than conventional solve individually,

(iii) its use only objective functions for any types of given problem, not derivatives function, hence the optimization technique is free derivative term and the optimization technique does not depend on the systematic. Figure shows the block diagram for obtaining the fitness function for different controller via GA optimum tool, where the controller parameter shown in figure. And the dynamic system represents the isolated control area of power system.

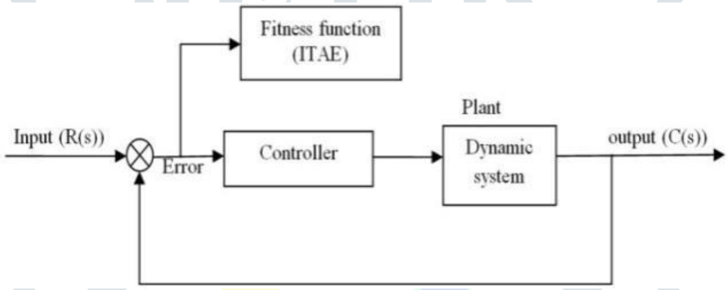

Figure 3.4 Genetic Algorithm

IV. Simulink and Result

4.1 Simulink Model by Using PI

we have considered three area interconnected power system for LFC analysis is shown in figure 4.1. In which each control area connected to another two areas and the scheduled power interchange of any area is the algebraic sum of all the two area through tie line.

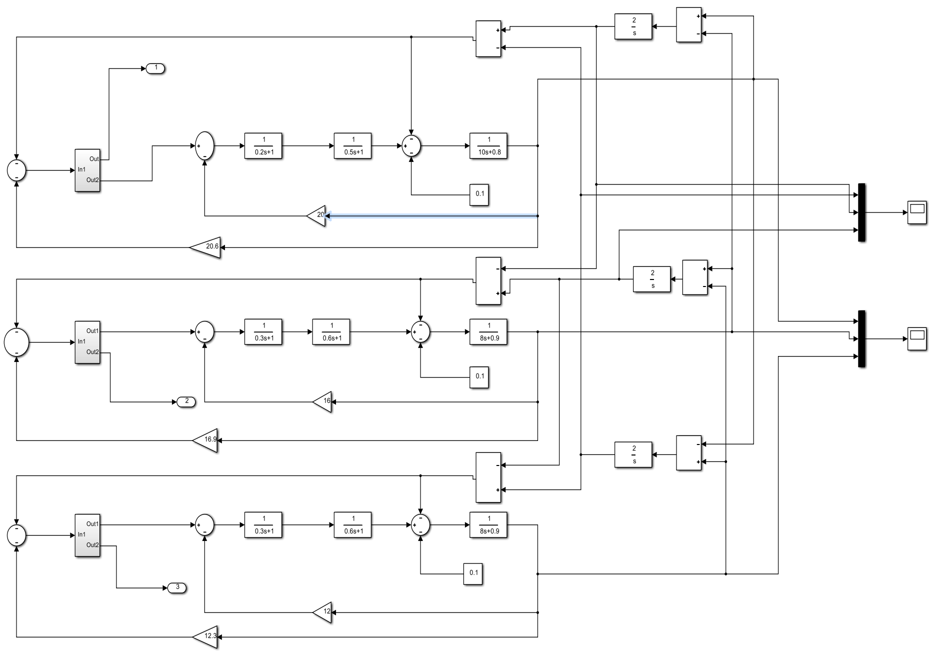

Figure 4.1 Simulink of Three Area Interconnected System

4.2 Simulink Model by Using Fuzzy

Given below figure is also three area inter-connected power system by using fuzzy logic controller.

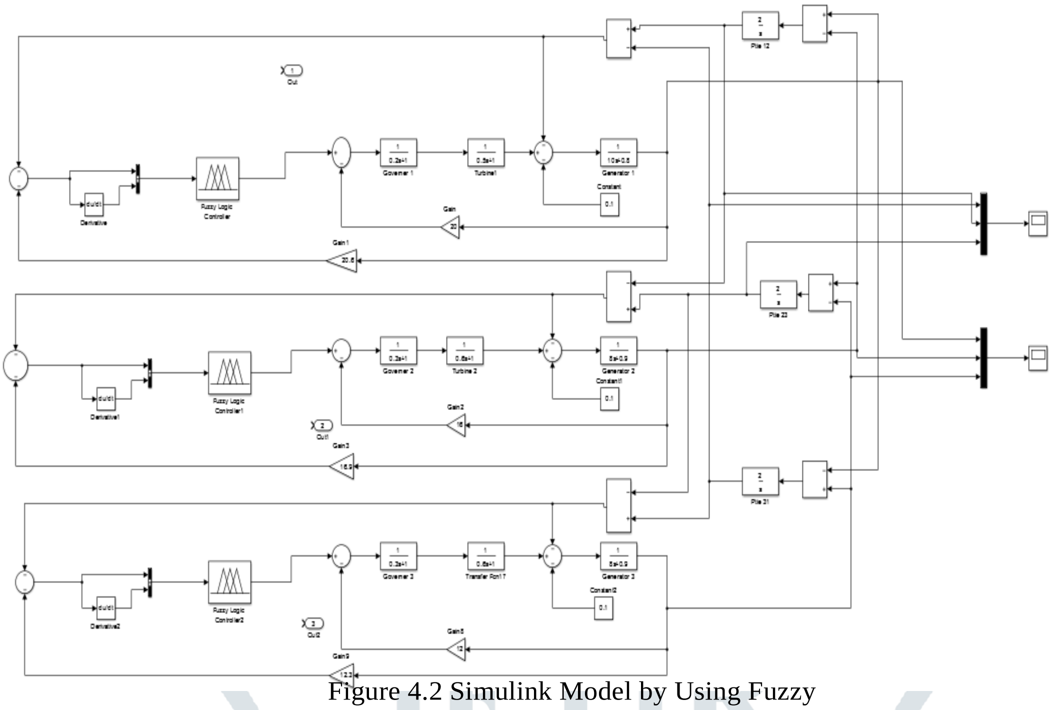

Figure 4.2 Simulink Model by Using Fuzzy

4.3 Results

4.3.1 Response of GA-PI controllers

The controller parameter value is shown below in table 4.1. When comparing the both the tuned value we find the amount of overshoot is reduced in the case of GA-PI.

Table 4.1 Parameters for GA-PI Controller

Parameter	Area 1	Area 2	Area 3
Kp	0.0219	0.0273	0.2615
Ki	0.0201	0.1066	0.0598

Frequency Deviation & Tie-Line power exchange response of GA-PI system

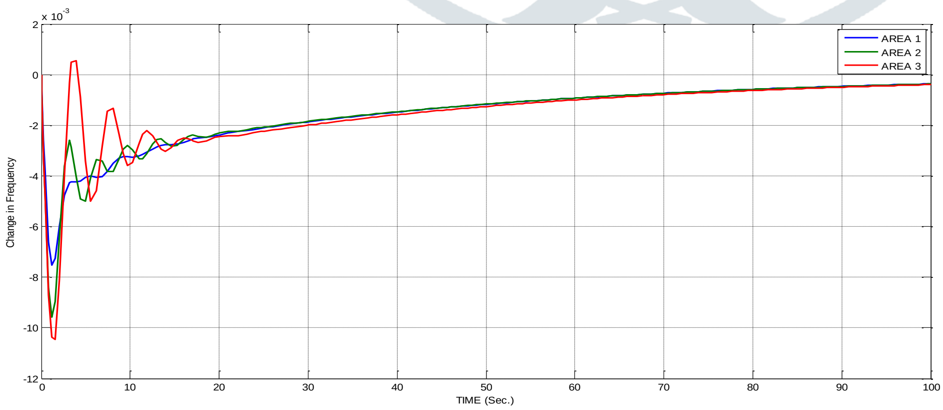

Figure 4.3 Frequency Deviation of the GA-PI System

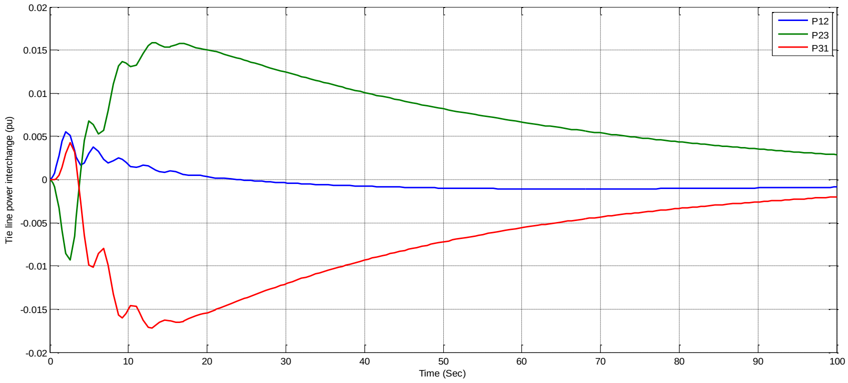

Figure 4.4 Tie-Line power exchange response of GA-PI system

4.3.2 Response of Fuzzy Logic Controllers
Frequency Deviation & Tie-Lin power interchanges response of fuzzy system

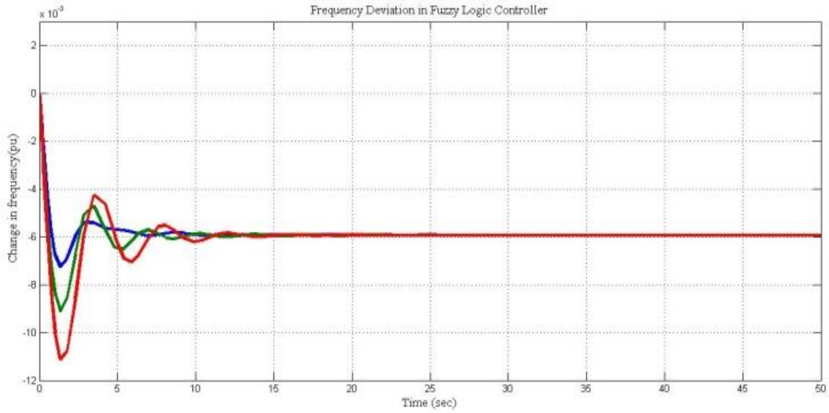

Figure 4.5 Frequency Deviation in fuzzy system

Figure 4.5 shows the frequency deviations for three areas by using fuzzy logic control, blue colour is for area 1, green colour is for area 2 and red colour is for area 3. When three generators working together, at starting we got transient value, during starting frequency deviation for all area (area1, area2, area3) is deferent, but almost after 10 sec frequency deviation is constant in all three areas. The frequency deviation in fuzzy for all three areas is 6×10^{-3} = 0.006 per unit or 0.6% mean if frequency is 50 Hz so 0.6% is error. Error is very less in fuzzy logic controller.

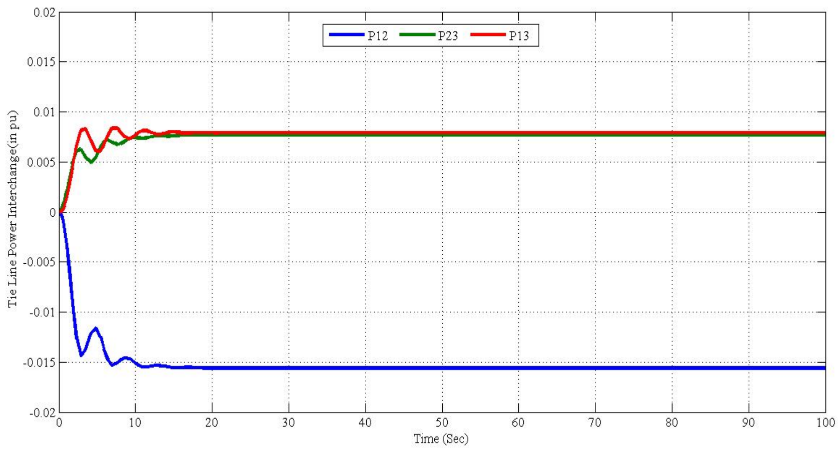

Figure 4.6 Tie-Lin power interchange response of fuzzy system

4.3.4 Comparisons between Frequency Deviation in GA-PI and Fuzzy System

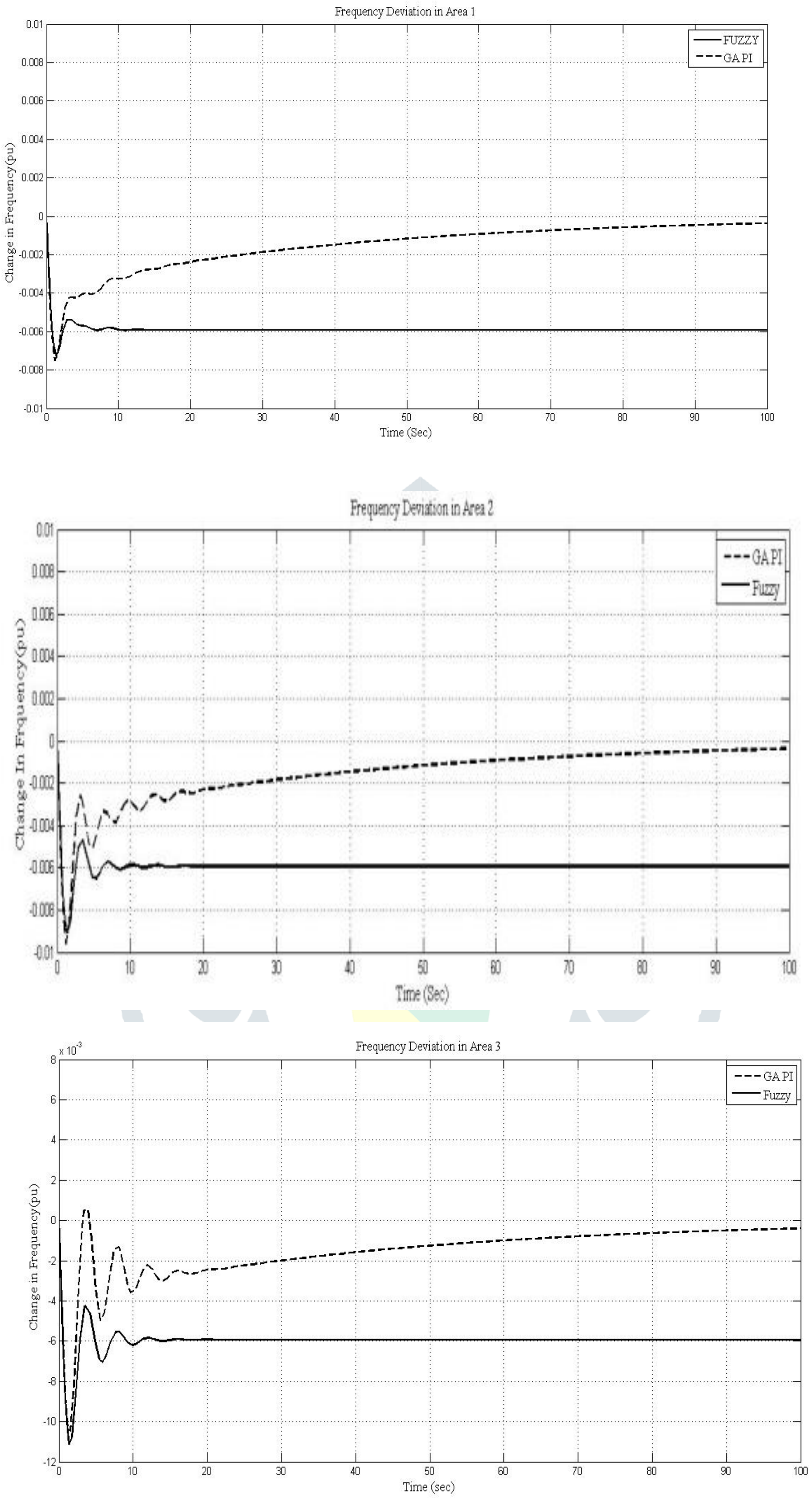

Figure 4.7 comparisons of GA-PI & Fuzzy Frequency Deviation in area 1, 2, 3.

V. Conclusion and Future Scope

5.1 Conclusion

In GA-PI the value of change in frequency is very less but it gives more variation. In fuzzy we got steady state value and in GA-PI we also got steady state value but after a very a long time. We got the value of steady state frequency deviations in fuzzy is almost less than 10 sec (>10 sec) and in GA-PI is approx 100 sec. In GA-PI the steady state error is less but frequency deviation is not constant. In fuzzy error is more but the frequency deviation is constant and in GA-PI the error is less but frequency deviation is more.

Firstly a control is being introduced for minimizing the deviations in frequency. This is usually vital in case of a single area system or an isolated system as the secondary control loop i.e. an integral controller is generally responsible for reducing the changes in the frequency deviations and maintains the system stability. Therefore without the presence of secondary loop the system losses its stability.

Finally we concluded that in GA-PI control system less deviation obtain as compare to fuzzy logic control system because of frequency response of GA-PI system very close to zero in the output response. But in fuzzy logic control system more stability obtain as compare to the GA-PI control system because after some deviations a straight line found in the fuzzy logic control system of the output response.

5.2 Future Scope

It may be implemented to system with four areas and also the performance of the system may be studied.

Various other optimization algorithmic programs can be used for optimization.

Various controllers may be used like PID, PSS etc to manage the frequency deviations and changes in tie line power.

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