GA Technique to Solve the AGC Problem of Thermal Generating Unit

ASHISH DHAMANDA
Electrical Engineering Department
Faculty of Engineering & Technology, GKV, Haridwar, UK,
INDIA

***Abstract:* -** In a large range of power system, Automatic Generation Control is mainly accountable to load changes and abnormal imprecise system means quick to minimize frequency changes and corresponding tie line power change for adequate and liable operation of the system. Few techniques provide the adequate results in ordinary operation but in abnormal condition, it take long time to compensate the load disturbance, which is risky for the operation of unit. GA (Genetic Algorithm) Technique improve the controlling performance over frequency deviations and tie line power deviations due to a general and abnormal situation of quick load deviation. This paper consists of multi area model of thermal generating units, which is simulated in MATLAB Simulink software. Response of the simulated model has been found by GA, fuzzy and PID technique. Result has been tabulated for better comparison of all techniques, which shows that the GA technique gives the better result over the other techniques due to settle down the frequency and tie line power deviations in minimum time and preserve the system steadiness.

***Keywords:* -** Imprecise System, Genetic Algorithm, Automatic Generation Control (AGC), Frequency Deviations, System Steadiness.

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1 Introduction

Electricity is used all around the world because of it’s a superbly flexible form of energy. For a large scale of electrical power system, normally consist of interconnected control areas or regions representing coherent groups of generators having the same frequency. The allocation of the required power amongst the generators has to be decided before the load appears. In cases of area load changes at abnormal conditions, such as outages of generation and varying system parameters, mismatches in frequency and scheduled tie-line power flows between areas can be caused. These mismatches are corrected by controlling the frequency, which is defined as the regulation of the power output of generators within a prescribed area. The problem of load frequency control has been one of the most accentuated topics in the operation of interconnected power systems. [1], [2], [3], [4], [5], [6], [7], [8], [9], [12], [13], [14], [15].

The continuous increase of power system complexity and installation of more and more new equipment in power systems has demanded better methods for power system analysis, planning, and control. At present, analysis of modern power systems is generally based on digital computers. Hence, establishment of a mathematical model, describing the physical processes of a power system, is the foundation for the analysis and investigation of various power system problems. Correct and accurate computation for power system analysis requires a correct and accurate mathematical model of the power system. Transient processes of the power system are very fast. This is why power system operation heavily relies on the applications of automatic control. With the installation of many different automatic control devices, the operation of which largely depends on the application of electronic and computing technology, modern power system operation has reached a very high level of automation. [1], [4], [5], [10], [11], [14].

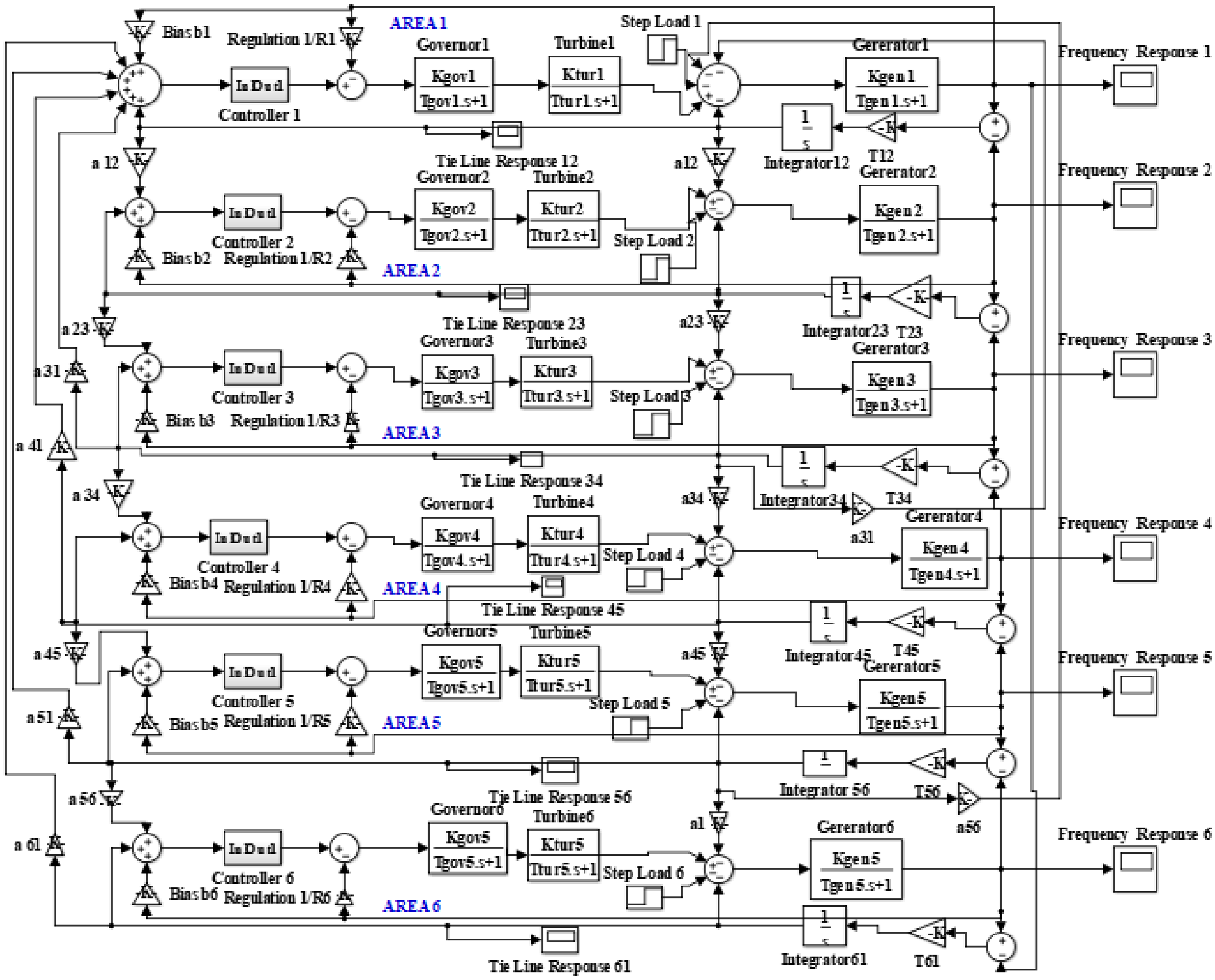

Figure 1: Multi Area Thermal Generating System

2 Mathematical Equation of AGC

For multi area and complicated structure of system, the mathematical equations for multi area units are given under; [4], [5], [10], [11]

Speed Governor's Transfer Function $=\left[\frac{K_{gov}}{1+sT_{gov}}\right]$ (1)

Turbine's Transfer Function = $\left[\frac{K_{tur}}{1+sT_{tur}}\right]$ (2)

Generator' Transfer Function = $\left[\frac{K_{gen}}{1+T_{gen}}\right]$ (3)

The above equation is used to determine the settling time response of the load changes system.

From equation 1, 2, 3, K_{gov} and T_{gov} are speed governor gain and time constant, K_{tur} and T_{tur} are Turbine gain and time constant whenever K_{gen} and T_{gen} are gain and time constant of generator. The range of parameters K_{gov}, K_{tur}, K_{gen}, T_{gov}, T_{tur}, T_{gen} are given in appendix.

Load frequency deviation $(\Delta f(t))$ for step load (ΔP_D) changes are given in equation 4,

$$\Delta f(t) = -\frac{RK_{gen}}{K_{gen+R}}\left[1 - e^{\left[-\frac{t}{T_{gen}}\frac{RT_{gen}}{K_{gen+R}}\right]}\right]\Delta P_D \quad (4)$$

3 Genetic Algorithm (GA)

Genetic algorithm uses an unambiguous analogy of such natural progression to do global optimization in order to solve highly complicated problems. It presumes that the potential solution of a problem is an individual and can be represented by a set of parameters. These parameters are regarded as genes of a chromosome and can be structured by a string of concatenated values. The variables can be represented by binary, real numbers or other forms, depending on the application data. The form of variables representation is defined by the encoding scheme.

Table 1: Parameters of GA for Multi Area System

Parameters	**Multi Area System**
Fitness Function	@ash_dha
Variables	19
Population Size	25
Selection	Stochastic Uniform
Mutation	Constraint Dependent
Cross Over	Scattered
Bound Limit	Upper [0] and Lower [-5]

4 Result

This paper consists of different technique like PID, Fuzzy and GA, to solve the problem of multi area thermal generating system. The response of settling time of load frequency and tie-line power deviation has been obtained using PID, Fuzzy and GA technique. The comparative response is given below;

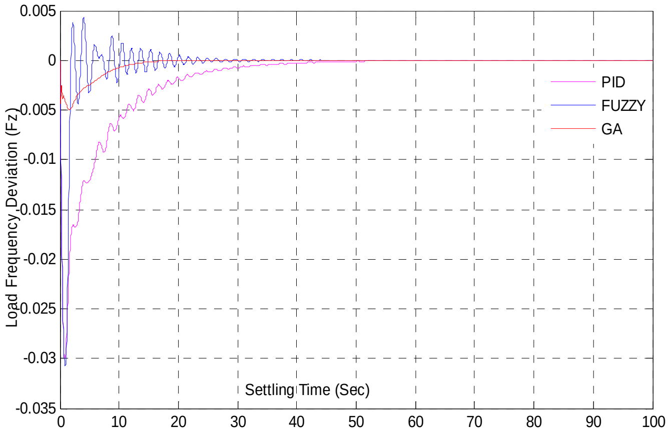

Figure 2: Response of load frequency deviation for area 1

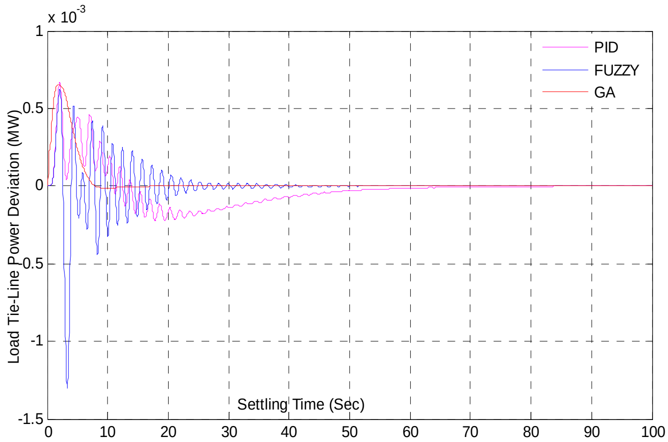

Figure 3: Response of load tie-line power deviation for area 1-2

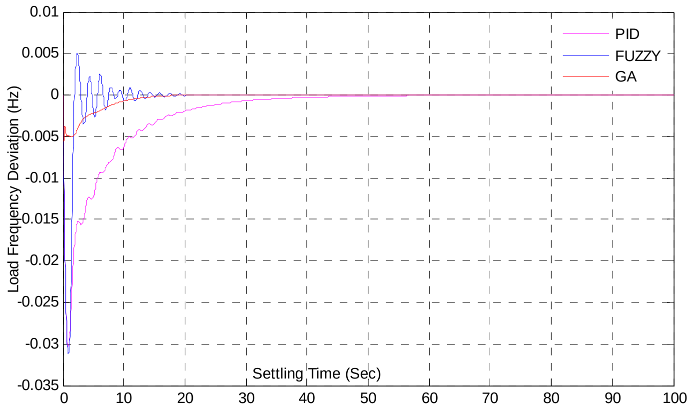

Figure 4: Response of load frequency deviation for area 2

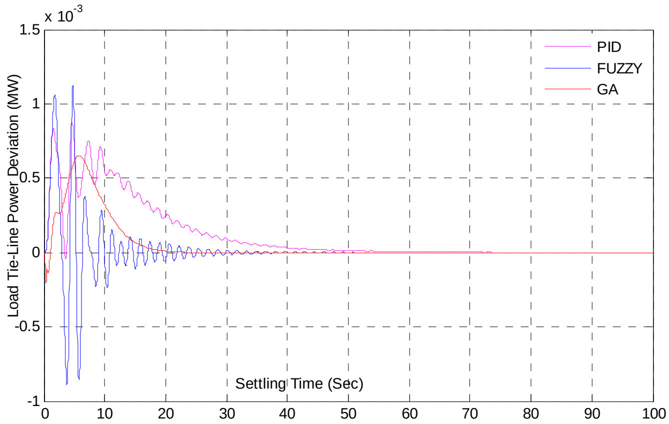

Figure 5: Response of load tie-line power deviation for area 2-3

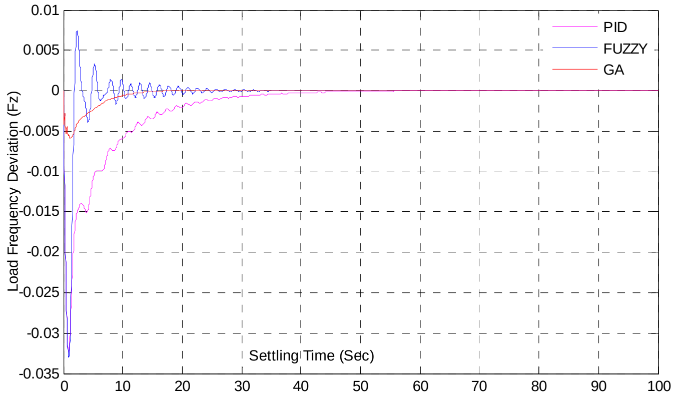

Figure 6: Response of load frequency deviation for area 3

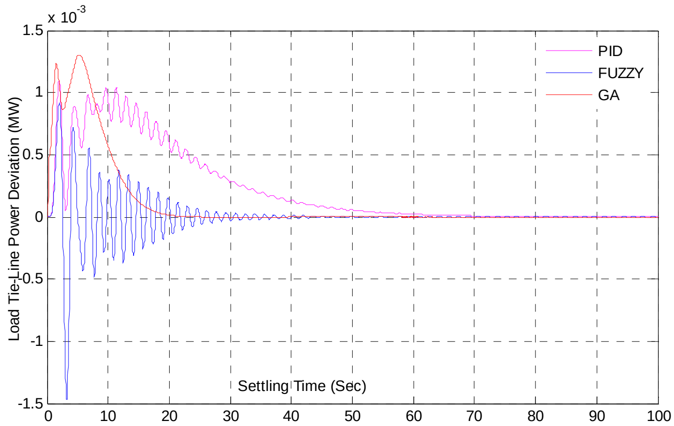

Figure 7: Response of load tie-line power deviation for area 3-4

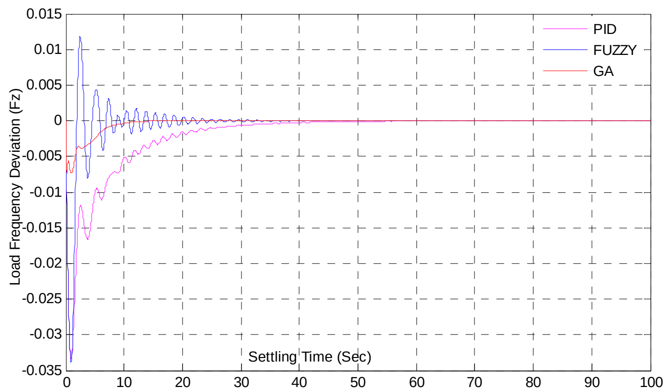

Figure 8: Response of load frequency deviation for area 4

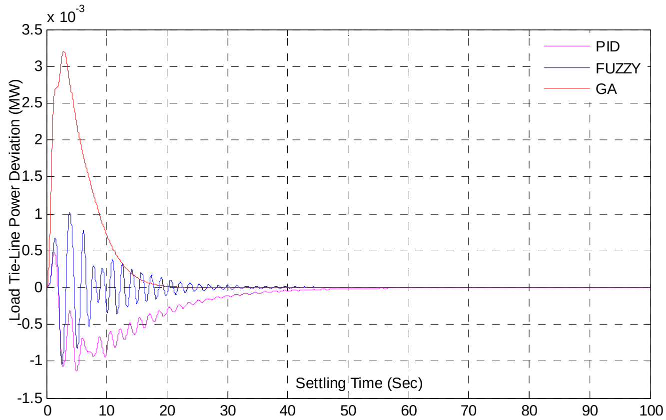

Figure 9: Response of load tie-line power deviation for area 4-5

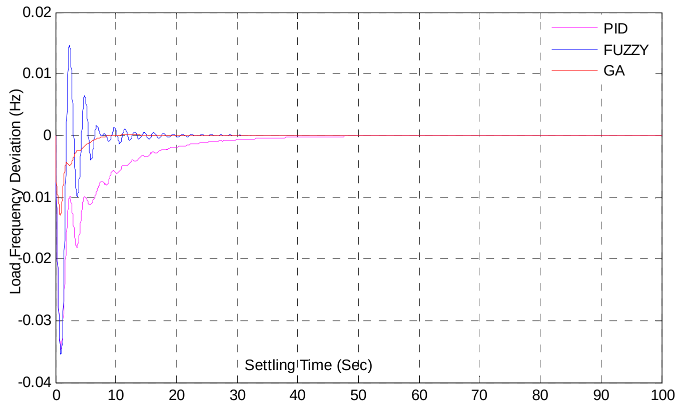

Figure 10: Response of load frequency deviation for area 5

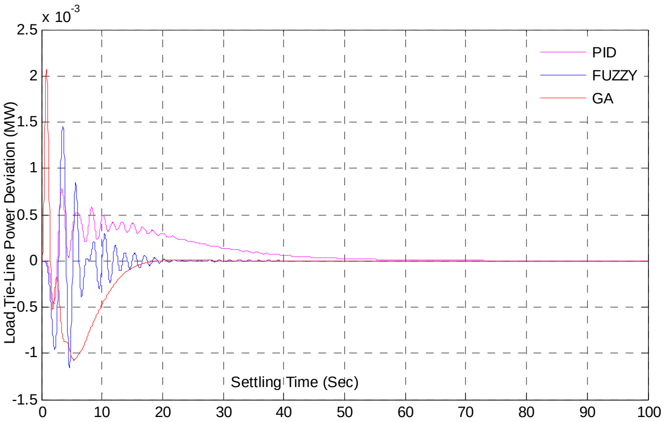

Figure 11: Response of load tie-line power deviation for area 5-6

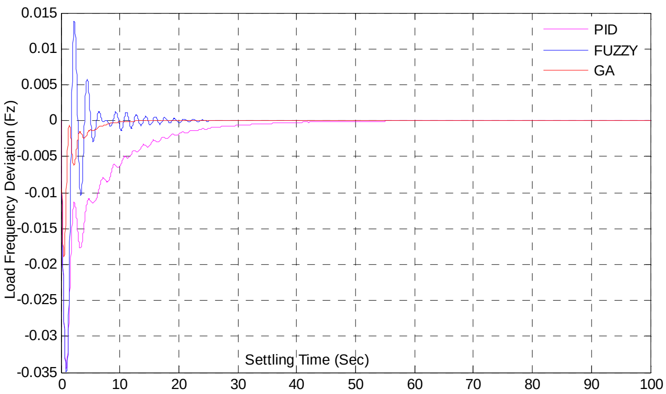

Figure 12: Response of load frequency deviation for area 6

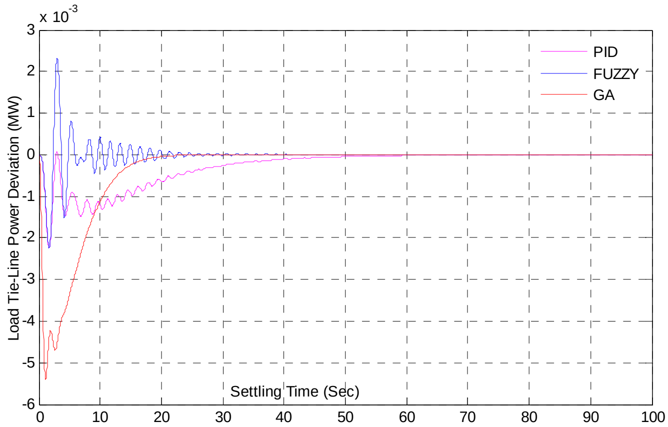

Figure 13: Response of load tie-line power deviation for area 6-1

The comparative result of settling time of load frequency and tie-line power deviation are tabulated as under;

Table 2: Comparative results of Load Frequency and Tie-Line Power Deviation

Techniques	**Settling Time (Sec)**											
	Load Frequency Deviation						**Load Tie-Line Power Deviation**					
	Area 1	**Area 2**	**Area 3**	**Area 4**	**Area 5**	**Area 6**	**Area1 Area2**	**Area2 Area3**	**Area3 Area4**	**Area4 Area5**	**Area5 Area6**	**Area6 Area1**
GA	16	19	17	14	10	11	17	21	23	20	21	22
Fuzzy	36	20	32	35	28	25	50	52	45	48	30	40
PID	50	48	50	53	38	43	65	70	75	55	60	58

Table 2 shows that the comparative response results of multi area system's settling time obtained by different technique like PID, Fuzzy and GA. From the different technique GA gives the better result with reducing the settling time with respect to the other technique.

5 Conclusion

For a complicated multi area thermal generating unit, there is a challenge to maintain the load frequency and tie line power deviation due to continuous variation of load increasing throughout of the year. To solve these problem, different technique has been taken for consideration like PID, Fuzzy and GA technique. The result obtained from these techniques have been tabulated in Table 2, which shows that the settling time (Sec) result of frequency and tie-line power deviation obtained by GA technique improve the controlling performance of the system by taking less time to settle down the variation and maintain

the system constancy. So, it can be concluded that the GA technique gives better dynamic result in a normal and abnormal situation.

Appendix

Multi area thermal generating system's parameters are as under:

f=50Hz;

$R_1=R_2=R_3=R_4=2.4$Hz/p.uMW;

$T_{gov1}=T_{gov2}= T_{gov3}= T_{gov4}=0.0$ 8Sec;

$T_{gen1}=T_{gen2}=T_{gen3}=T_{gen4}$ =20Sec;

$Ttur_1= Ttur_2= Ttur_3=Ttur_4=0.3$Sec;$a_{12}=a_{23}=a_{34}=a_{41}=1$;
$H_1=H_2=H_3=H_4=5$

MW-S/MVA;$P_{r1}=P_{r2}=P_{r3}=P_{r4}=2000$MW;
$K_{gen1}=K_{gen2}=K_{gen3}= K_{gen4}=120$Hz/puMW;

$K_{gov1}=K_{gov2}=K_{gov3}=K_{gov4}=1$;

$K_{tur1}= K_{tur2}=K_{tur3}=K_{tur4}=1$;

$D_{1234}=8.33*10^{-3}$p.uMW/Hz.;

$b_{1234}=0.425$ p.u.MW/ hz;

$\Delta P_{D1234}=0.01$p.u;

$T_{12}=T_{23}=T_{34}=T_{41}=0.0$ 867MW/ Radian;

$P_{tie\,max}=200$MW.

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