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GA Technique to Solve the Load Frequency and Tie-Line Power Problem of Thermal Generating Unit

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Abstract: For a wide role of a electric power system, Automatic Generation Control (AGC) is responsible to area load changes and abnormal imprecise system operating parameters essentially means very fast minimization of area frequency changes and mutual tie line power flow changes of the areas for satisfactory and stable operation of the system. Some technique gives the good results in normal operation but in abnormal condition, it take large time to settle down the load disturbance, which is harmful for the system. Genetic Algorithm (GA) Technique) provides better control performance over frequency deviations and tie line power flow deviations due to a normal and abnormal operating condition of sudden load changes. In this paper six area model of thermal generating units has been developed and simulated in MATLAB Simulink software. Response of the developed model has been obtained by GA technique and compared with the other technique like; fuzzy, PID. Tabulated result shows that the GA technique give the better performance over the other technique due to settling down the frequency and tie line power flow changing in less time and maintenance the system constancy with the litmits.

Keywords: Imprecise System, Frequency Deviations, Tie Line Power Flow, Automatic Generation Control, Genetic Algorithm

1. Introduction

Electrical energy is broadly used all over the world because it is a most flexible form of energy. The problem of electrical power system is to randomly change of load due to heavy demand arise from the consumer.

A control strategy has been made which can generate and deliver the power as economically and reliable as possible with limitation of frequency and voltage. Change in real power dependent on the frequency and independent of voltage while voltage dependent on the reactive power and independent of frequency. Thus, real power with frequency and reactive power with voltage are controlled separately. The AGC of a large interconnected electric system has aspects to maintain the frequency and power changes over tie lines on scheduled value in general operating condition and even when there is a small amount of load changing continuously. In steady state condition, the output of the generators at any instant will exactly equal to load on the system and all the generating units operate synchronously with the same operating frequency. [1-9, 12-20].

The developed MATLAB simulink transfer function model for six area thermal generating units (T.G.U) are shown in figure 1. In which governor, turbine and generator model are analyzed with different controllers like GA Technique, PID and Fuzzy.

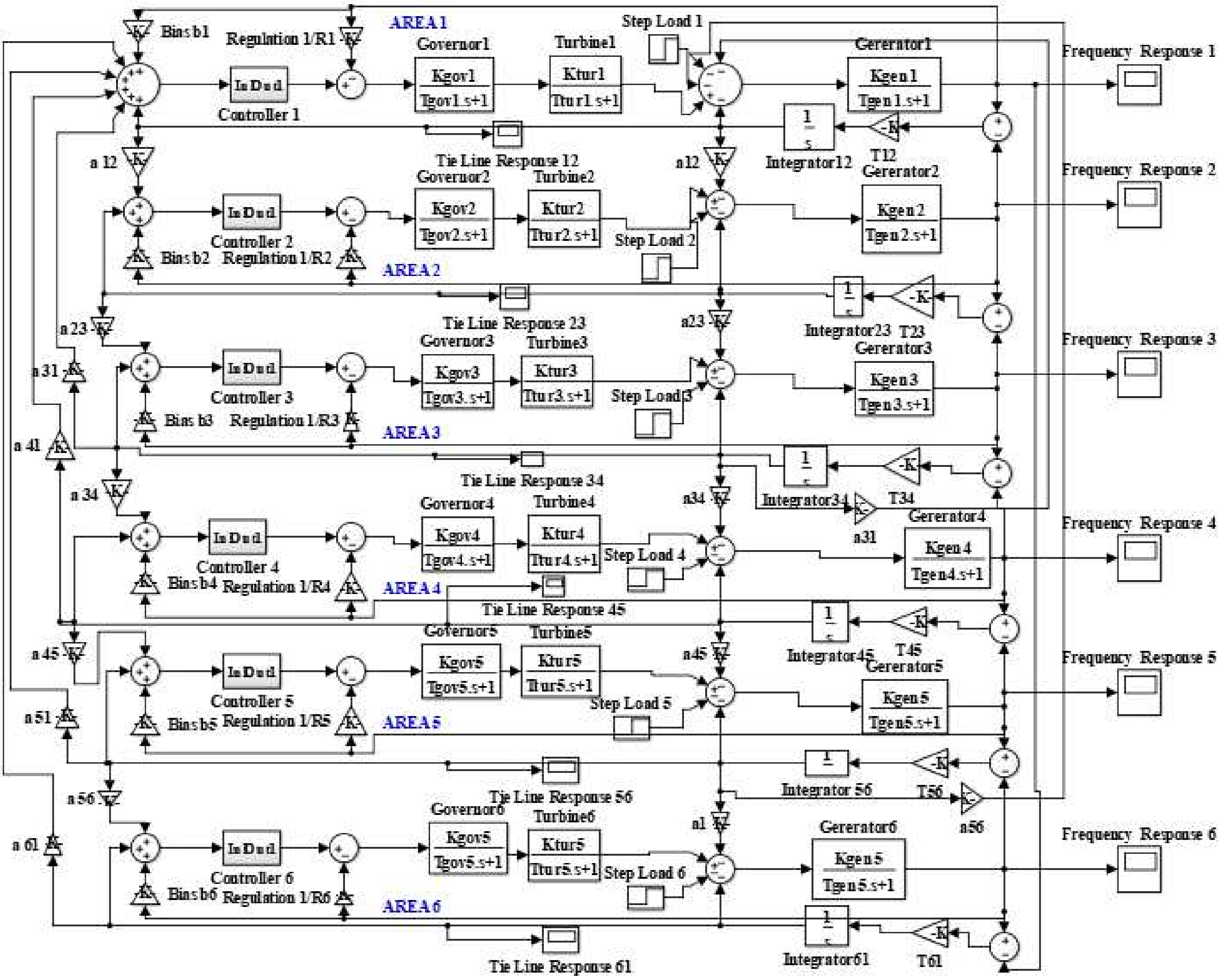

Figure 1. *Six Area Thermal Generating Unit (TGU).*

2. Mathematical Equation of AGC

For such a large and complex systems, the mathematical equations for six area thermal units are given below; [2, 4-5, 10-11]

Load frequency deviation ($\Delta f(t)$) and tie-line power for step load (ΔP_D) changes are given in equation 1 and 2,

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

Power flow out of control area-1 can be expressed as

$$P_{TL1} = \frac{|E_1|\,|E_2|}{X_{TL}} \sin(\delta_1 - \delta_2) \qquad (2)$$

Where $|E_1|$ and $|E_2|$ are voltage magnitude of area 1 and area 2, respectively, δ_1 and δ_2 are the power angles of equivalent machines of their respective area, and X_{TL} is the tie line reactance.

The above equations is used to determine the settling time response of the load changes system corresponding to tie-line power for all areas of thermal generating system.

The increase in load demand (ΔP_D) is met under steady state conditions partly by the increased generation (ΔP_G) due to the opening of the steam valve and partly by the decreased load demand due to droop in frequency.

Increase in generation (ΔP_G) can be expressed by the equation 3,

$$\Delta P_G = -\frac{1}{R}\left[-\left[\frac{1}{B+\frac{1}{R}}\right]\Delta P_D\right] = \left[\frac{1}{R}\times\frac{R}{BR+1}\right]\Delta P_D \qquad (3)$$

Where ΔP_D is increase in demand, R is speed governor regulation, generally B is much less than (i.e., B « $\frac{1}{R}$). Power in p.u. for single area case is

$$\Delta P_{G1}(s) - \Delta P_{D1}(s) = \frac{2H_1}{f_0} s \frac{d}{dt}(\Delta F_1(s)) + B_1\Delta F_1(s) + \Delta P_{TL1}(s) \qquad (4)$$

In single area system, Area Control Error (ACE) is the change in frequency but for two area power system, ACE is the linear combination of the change in frequency and change in tie-line power. Thus, for control area-1 we have

$$ACE_1 = \Delta P_{TL1} + b_1\,\Delta f_1 \qquad (5)$$

Where b_1 = constant area frequency bias. Taking Laplace transform on both sides of equation (5), we get equation 6

$$ACE_1(s) = \Delta P_{TL1}(s) + b1\Delta F1(s) \quad (6)$$

Similarly, ACE for all the six area thermal generating system can be obtained. [15-19]

3. Genetic Algorithm (GA)

This algorithm inspired by the mechanism of natural selection, a biological process in which stronger individual is likely to be the winners in a competing environment. GA uses a direct analogy of such natural evolution to do global optimization in order to solve highly complex 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 form of variables representation is defined by the encoding scheme. The variables can be represented by binary, real numbers or other forms, depending on the application data.

GA parameters for six area thermal generating system has been found with fitness function, population size, selection, mutation, cross over, bound limit etc. listed on Table 1.

Table 1. *GA Parameters for System.*

Parameters	Six Area Thermal Generating System
Fitness Function	@ash_dha
Variables	18
Population Size	20
Selection	Stochastic Uniform
Mutation	Constraint Dependent
Cross Over	Scattered
Bound Limit	Upper [0] and Lower [-5]

4. Result

In this paper PID, Fuzzy and new approach (GA technique) has been used combinedly to obtained the settling time response of load frequency and tie-line power deviation of thermal generating system of six area system with step load 0.01 p.u is applied. The comparative response obtained for load frequency and tie-line power changes of thermal generating system is given below and results are tabulated in Table 2.

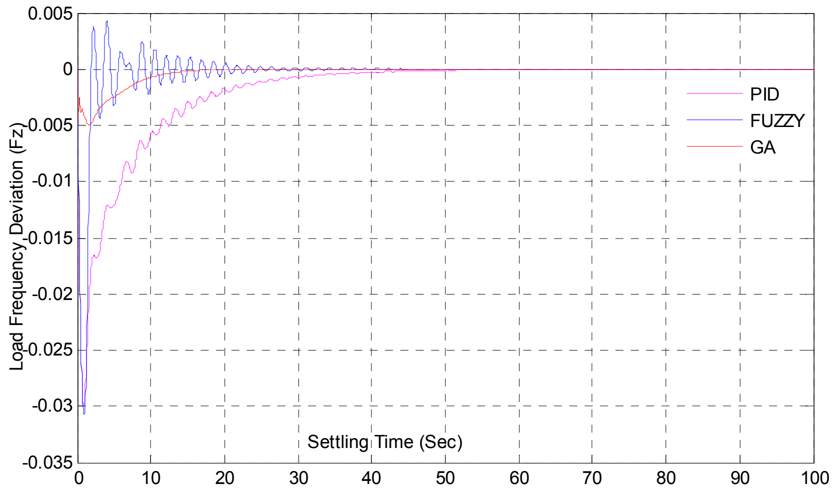

Figure 2. *TGU Frequency changes for area 1.*

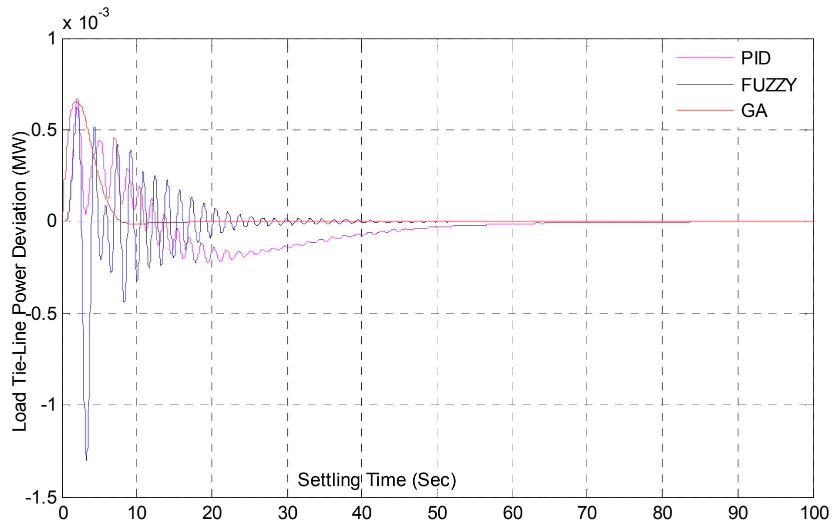

Figure 3. *TGU Tie-line power changes for area 1-2.*

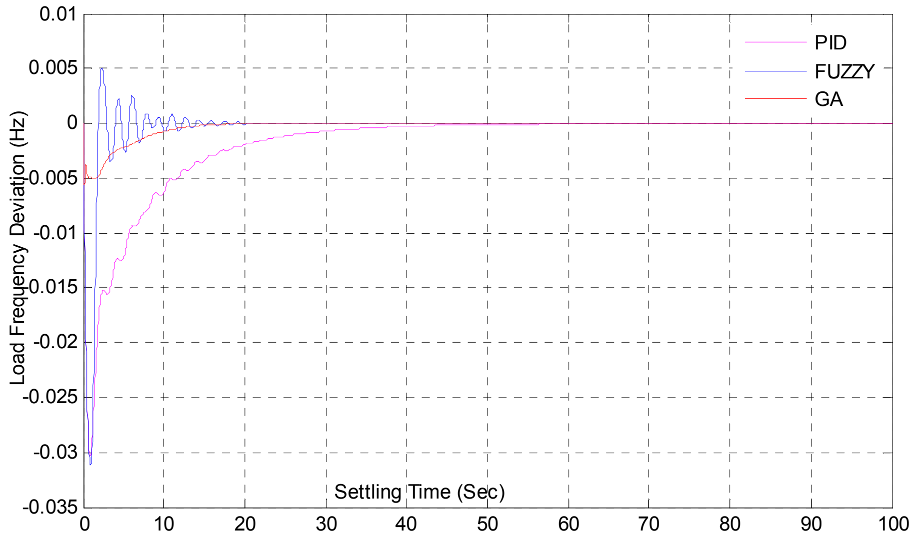

Figure 4. *TGU Frequency changes for area 2.*

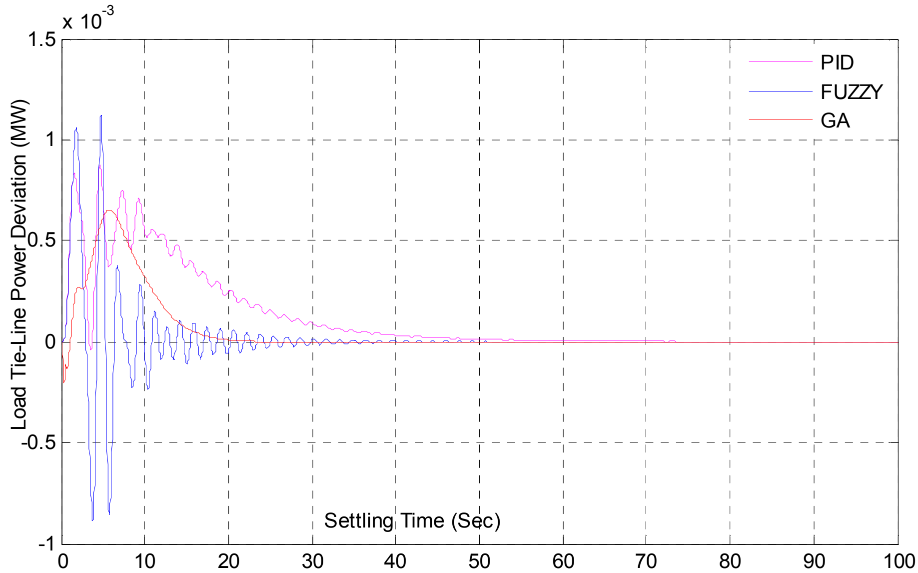

Figure 5. *TGU Tie-line power changes for area 2-3.*

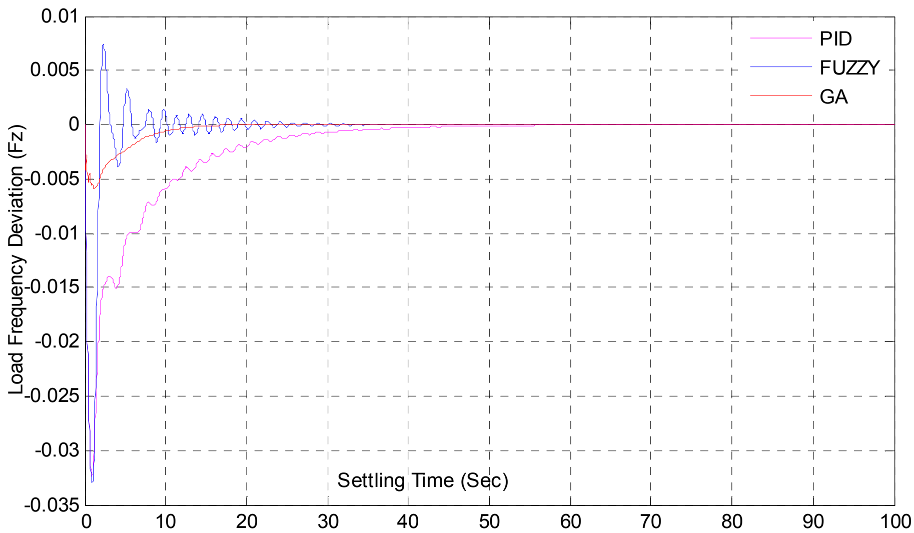

Figure 6. *TGU Frequency changes for area 3.*

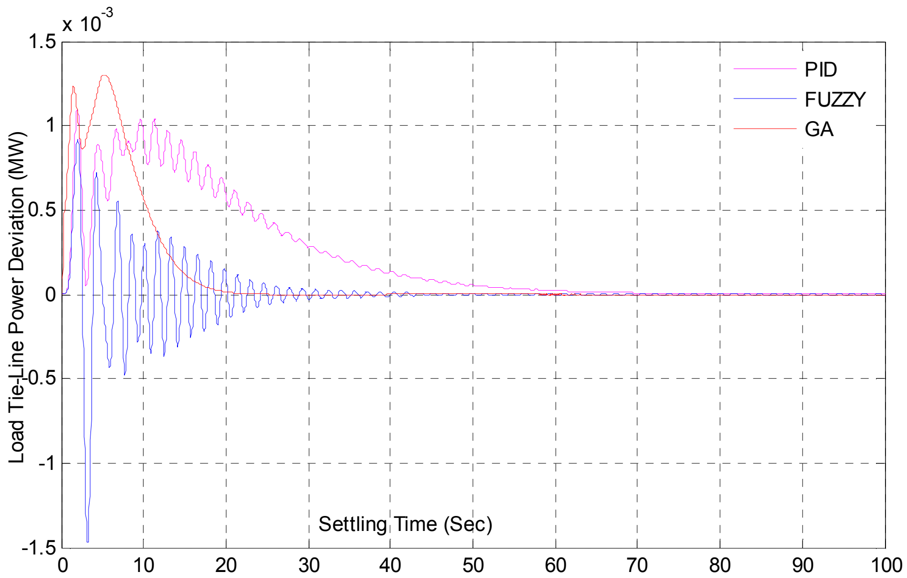

Figure 7. *TGU Tie-line power changes for area 3-4.*

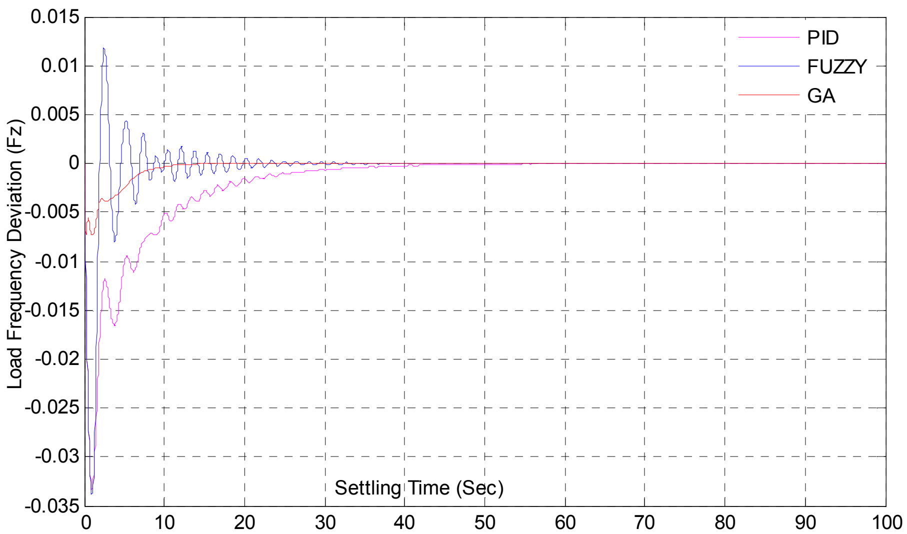

Figure 8. *TGU Frequency changes for area 4.*

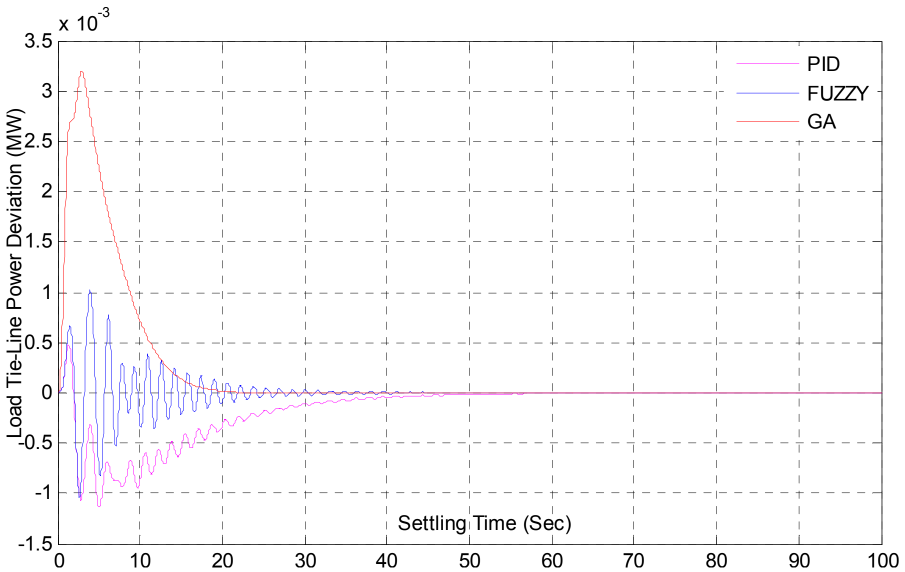

Figure 9. *TGU Tie-line power changes for area 4-5.*

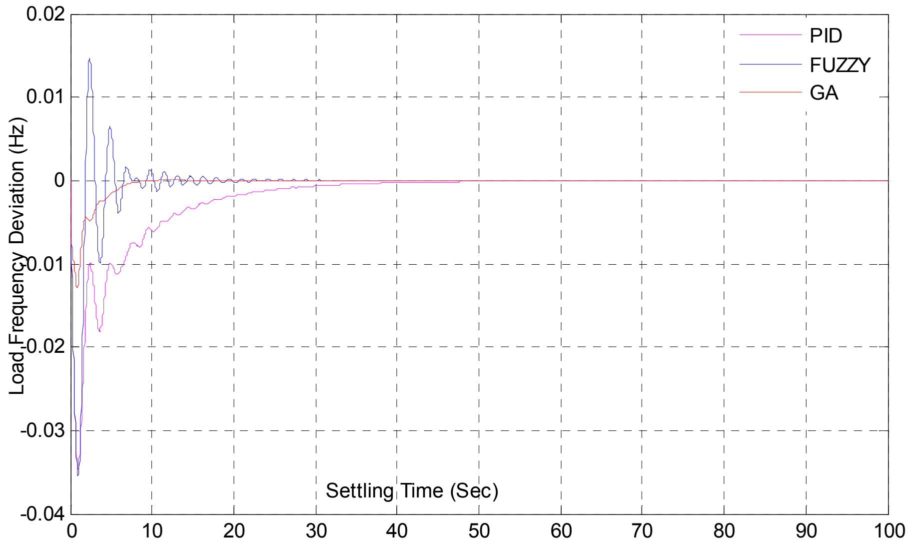

Figure 10. *TGU Frequency changes for area 5.*

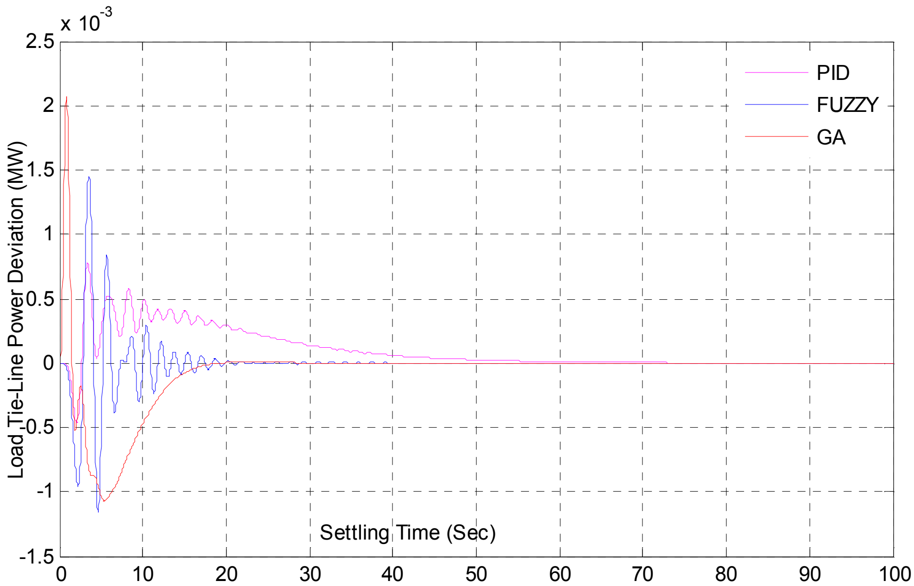

Figure 11. *TGU Tie-line power changes for area 5-6.*

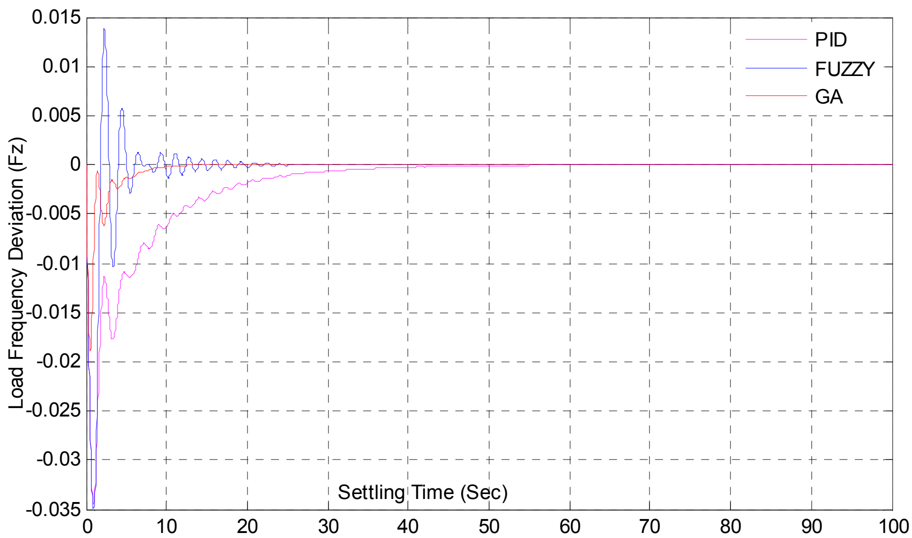

Figure 12. *TGU Frequency changes for area 6.*

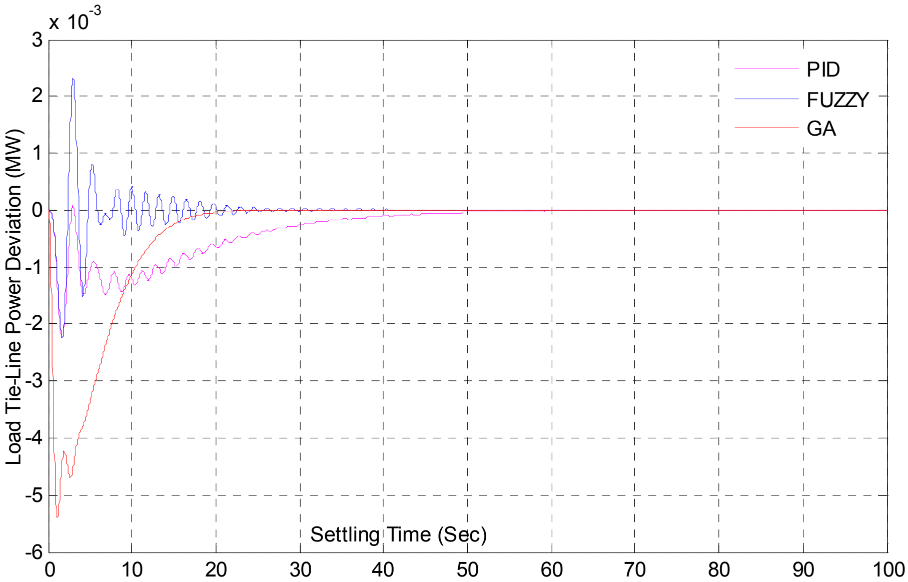

Figure 13. *TGU Tie-line power changes for area 6-1.*

The results of combined response obtained from figure 2 to figure 13, settling time of load frequency and tie-line changes are tabulated in below Table 2.

Table 2. *Comparative Results of Load Frequency and Tie-Line change of TGU.*

Controllers	Settling Time (Sec)											
	Load Frequency Change						Load Tie-Line Change					
	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 1 Area 2	Area 2 Area 3	Area 3 Area 4	Area 4 Area 5	Area 5 Area 6	Area 6 Area 1
PID	55	53	54	54	54	54	75	74	88	68	72	78
Fuzzy	40	35	40	40	30	30	57	55	60	50	40	45
GA	21	23	22	19	19	15	19	24	25	24	24	28

Table 2 shows that the settling time of load frequency and tie-line power changes for six area thermal generating unit (TGU) obtained by different technique like PID, Fuzzy and GA. For all the six areas result obtained by PID and Fuzzy technique taking large time to settle down the deviation in load frequency and corresponding tie-line power if 0.01 p.u step load is applied. Whenever GA technique take less time with respect to other technique to settle down the same deviation problem. So, it can say that the GA Technique gives the better result with reducing the settling time with respect to the other technique.

5. Conclusion

In a power system there is a continuous variation of load increasing the difficulty to maintenance the load frequency and tie-line power change. To solve these problems a six-area thermal generating unit (TGU) has been taking into consideration and solve by using PID, Fuzzy and GA Technique. The result obtained from these techniques has been illustrated in Table 2, which shows that the settle down time of frequency and tie-line power changes found by GA Technique improve the performance of the system by taking less time to settle down the variation and maintain the system operation. So, it can be concluded that the proposed GA technique gives better dynamic result.

Appendix

Six Area TGU System Parameters are given below:

F = 60Hz; $R_1 = R_2 = R_3 = R_4 = R_5 = R_6$ = 2.4Hz/p.uMW; $T_{gov1} = T_{gov2} = T_{gov3} = T_{gov4} = T_{gov5} = T_{gov6}$ = 0.08Sec; $T_{gen1} = T_{gen2} = T_{gen3} = T_{gen4} = T_{gen5} = T_{gen6}$ = 20Sec; $Ttur_1 = Ttur_2 = Ttur_3 = Ttur_4 = Ttur_5 = Ttur_6$ = 0.3Sec; $A_{12} = A_{23} = A_{34} = A_{45} = A_{56} = A_{61} = 1$; $h_1 = h_2 = h_3 = h_4 = h_5 = h_6$ = 5MW-S/MVA; $p_{r1} = p_{r2} = p_{r3} = p_{r4} = p_{r5} = p_{r6}$ = 2000MW; $K_{gen1} = K_{gen2} = K_{gen3} = K_{gen4} = K_{gen5} = K_{gen6}$ = 120Hz/puMW; $K_{gov1} = K_{gov2} = K_{gov3} = K_{gov4} = K_{gov5} = K_{gov6} = 1$; $K_{tur1} = K_{tur2} = K_{tur3} = K_{tur4} = K_{tur5} = K_{tur6} = 1$; d_{1234} = 8.33*10p.uMW/hz.; b_{123456} = 0.425p.uMW/Hz; $\Delta P_{D123456}$ = 0.01p.u; $T_{12} = T_{23} = T_{34} = T_{45} = T_{56} = T_{61}$ = 0.0 867MW/Rad; $P_{tie\ max}$ = 200MW.

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