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d. A Price-based Availibility based tarrif (ABT) mechanism can be implemented for AGC sytem under deregulation.
e. On-line tuning of AGC system can be carried out.

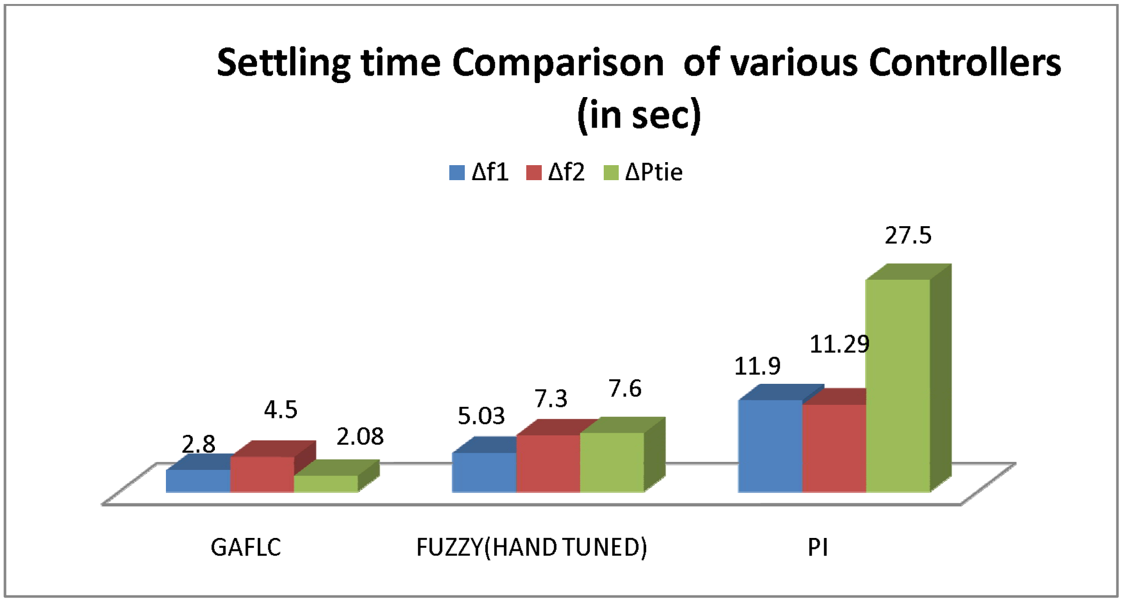


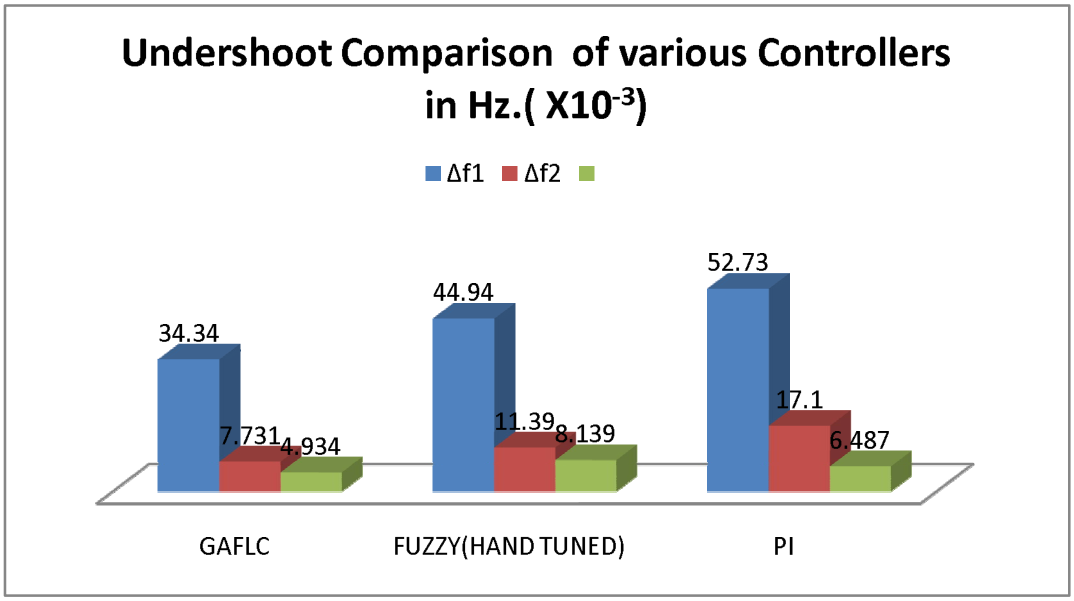
Figure 6.3 Response comparisons of various controllers under Deregulation

It is demonstrated within the planned work that the problem of AGC design can be easily transferred into a performance optimization problem that is appropriate for application of artificial intelligent techniques. Intelligent AGC design using Fuzzy logic and Genetic Algorithm provides an adaptive and self tuning scheme to tackle the uncertainly issues in AGC arising due to parametric and load perturbations.

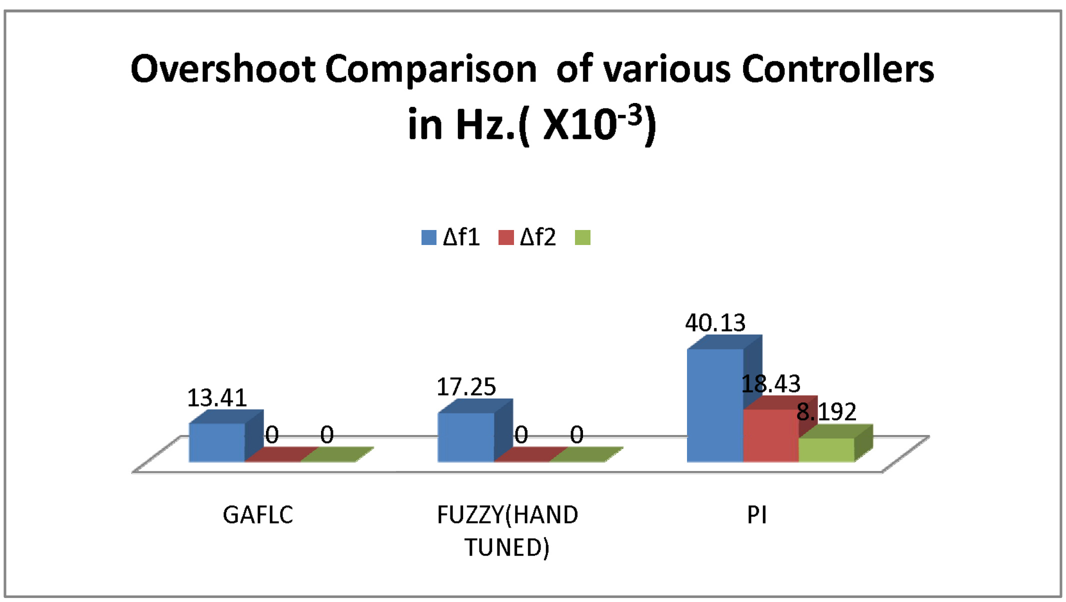
6.4 SUGGESTIONS & FUTURE SCOPE

During this thesis work, a broad investigation on Intelligent controllers for AGC is carried out. Suggestions for follow-up work that may come after this work are listed below:

a. The current work used Mamdani Fuzzy Controllers, however, TSK Fuzzy Controllers can be used.
b. Optimization of the controller can be carried out with various upcoming Intelligent Algorithms.
c. Compliance of the AGC controllers with NERC standards can be carried out.



Undershoot Comparison of various Controllers in Hz.(X10-3)
Δf1
Δf2
34.34
7.731
4.934
44.94
11.39
8.139
52.73
17.1
6.487
GAFLC
FUZZY(HAND TUNED)
PI



Overshoot Comparison of various Controllers in Hz.(X10-3)
Δf1
Δf2
13.41
0
0
17.25
0
0
40.13
18.43
8.192
GAFLC
FUZZY(HAND TUNED)
PI

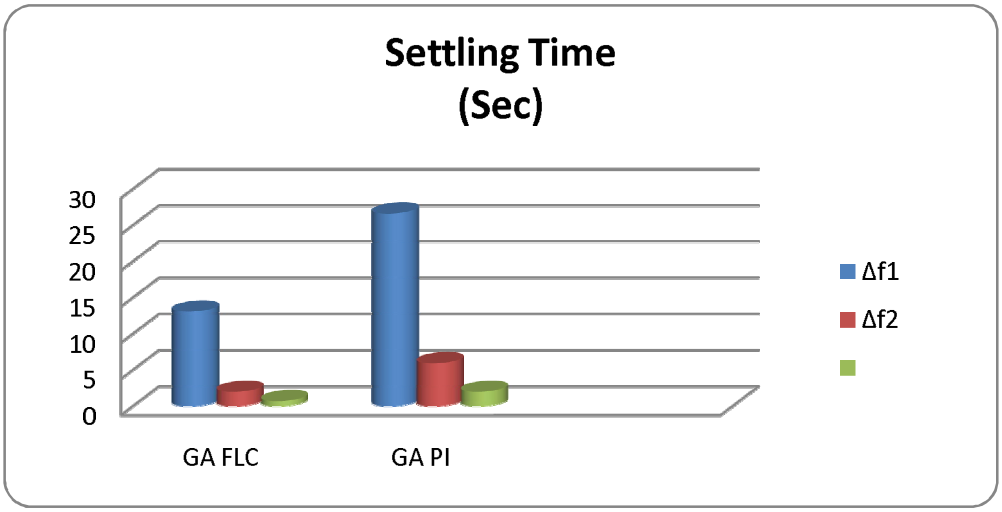


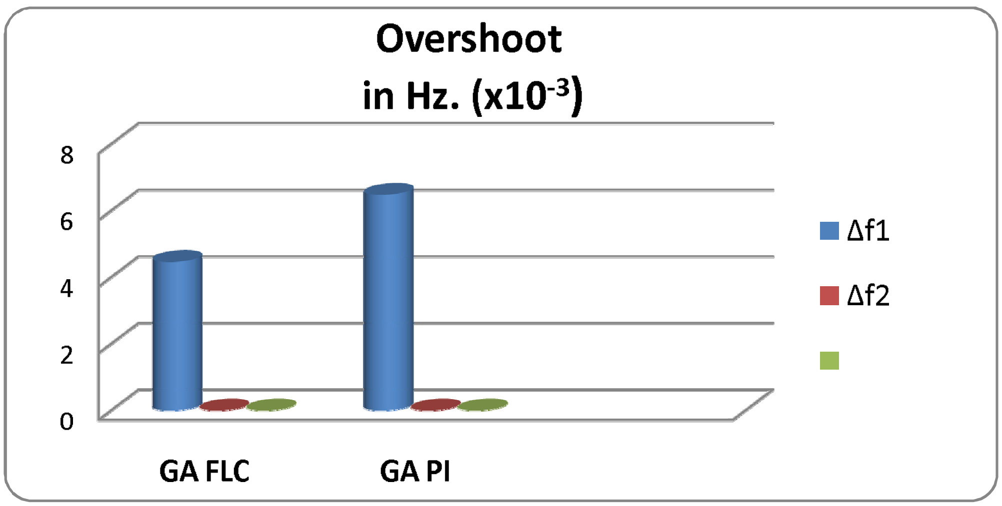
Figure 6.2 Pictorial representation of performance comparison of GAFLC & GAPI controllers in terms of Overshoot, Undershoot and Settling time.

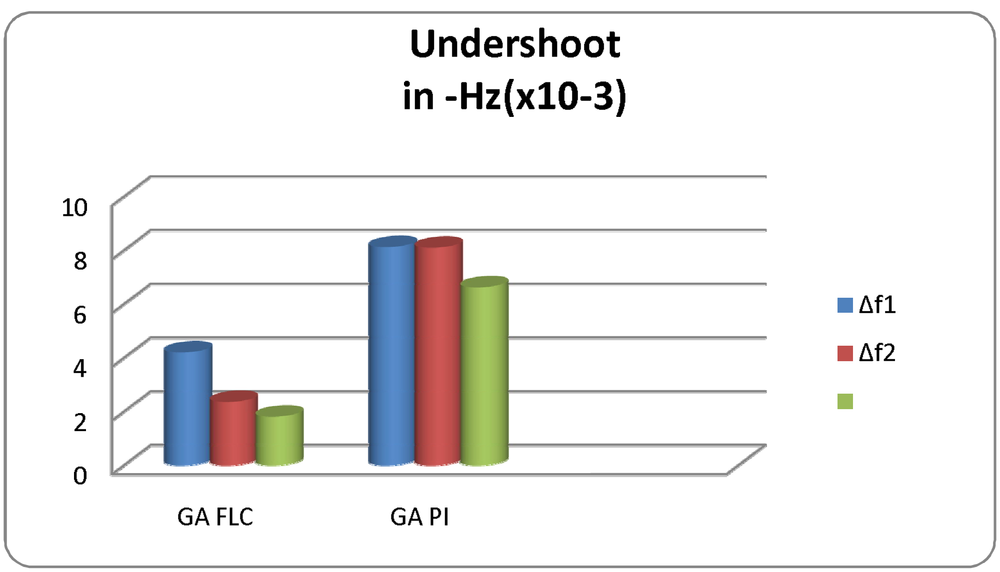
6.3 FINDINGS WITH REGARDS TO AGC SYSTEM UNDER RESTRUCTURED SCENARIO

Furthermore the study is carried forward to an AGC of power system under Deregulation, where, the gains of the Fuzzy logic controllers in both areas are optimized using GA. Simulation results are compared with a standard PI controller. The result shows that the planned intelligent controller has improved dynamic response quicker than typical PI controller. Additionally, sensitivity analysis is performed by varying the nominal parameters of the system over a large range portraying the robustness of the proposed controller.

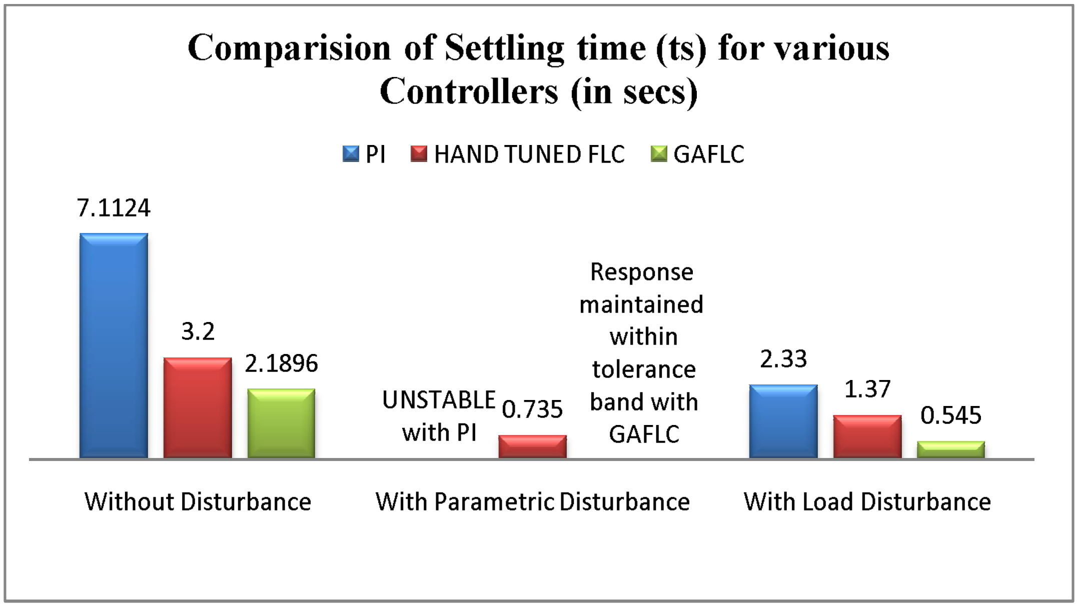
6.2 FINDINGS WITH REGARDS TO MULTI-AREA AGC SYSTEM

A standard two-area model of an AGC has been proposed where the FLC in each area is tuned automatically by Genetic Algorithm. IATE-based fitness function is minimized for the sake of optimization. Various performance indices such as undershoot, overshoot, Settling time and IATE are evaluated to compare the proposed GAFLC and GAPI controller implemented on the same model. The performance comparison in Fig. 6.2 shows the ascendance of





to a hand designed FLC. Figure 6.1 shows the pictographic performance comparison of various controllers for an isolated Power System with respect to settling time and overshoots. The figure clearly shows that the performance of intelligent GAFLC is far better than other controllers.



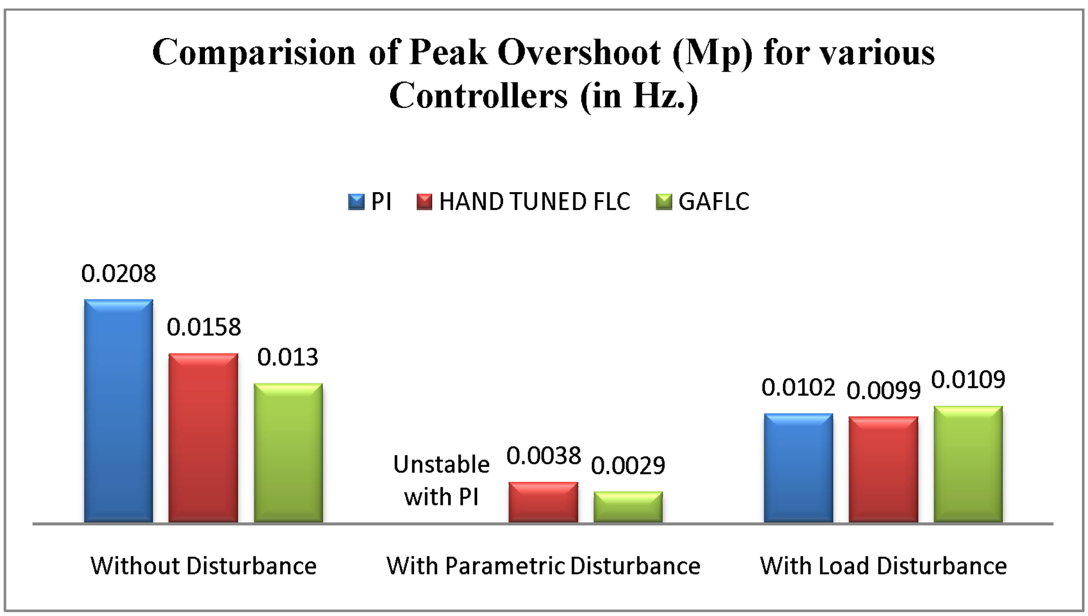


Figure 6.1 Pictorial representation of performance indices of various controllers under different testing conditions for an Isolated Power system

CHAPTER 6
CONCLUSION AND FUTURE SCOPE

The presented research work is mainly on the load frequency problem in power system and detailed modeling of an AGC system. A rigorous review of literature available under conventional and restructured scenario is presented. The Conventional PI and Fuzzy logic controllers are designed for AGC in an isolated system and in multi-area power systems. However the scope of fine-tuning several levers/parameters of the FLC is identified to yield better performance which paves the path for using evolutionary computational techniques in the design and implementation of AGC.

The GAs because of its inherent adaptability and ability to converge to optimal solutions has become an alternative to optimization methods used in many applications to solve many complex problems over the years. Here GAs are effectively applied in tuning the FLC parameters of AGC, thus making the controllers intelligent. The efficiency of the proposed intelligent algorithms has been verified through simulations by using the GA programs interfaced with AGC models in MATLAB Simulink.

6.1 FINDINGS WITH REGARDS TO AN ISOLATED SYSTEM

GA tuned FLC produced some good solutions. The load frequency control model of an isolated power system under different testing conditions are novel in that in the hitherto published papers on AGC, such parametric and load disturbances had not been injected while the same have been applied here. Also during this work, a comprehensive fitness function has been accustomed to assess three different performance indices of the response. The results show that the projected GAFLC is extremely powerful in reducing the frequency deviations even underneath parametric and load disturbances in distinction

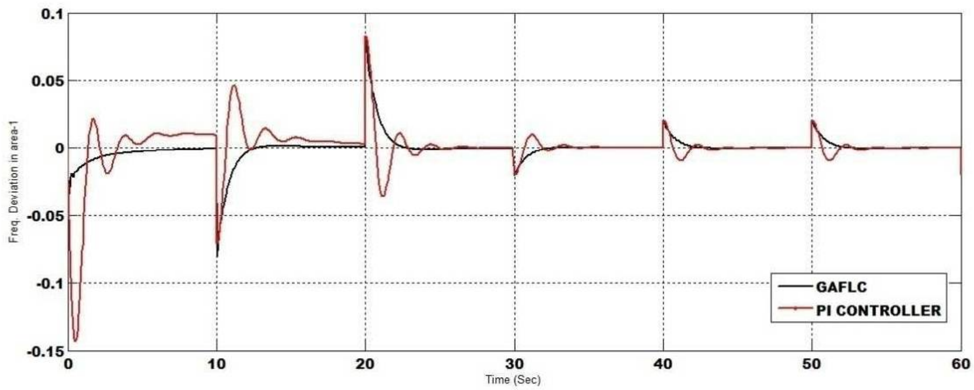
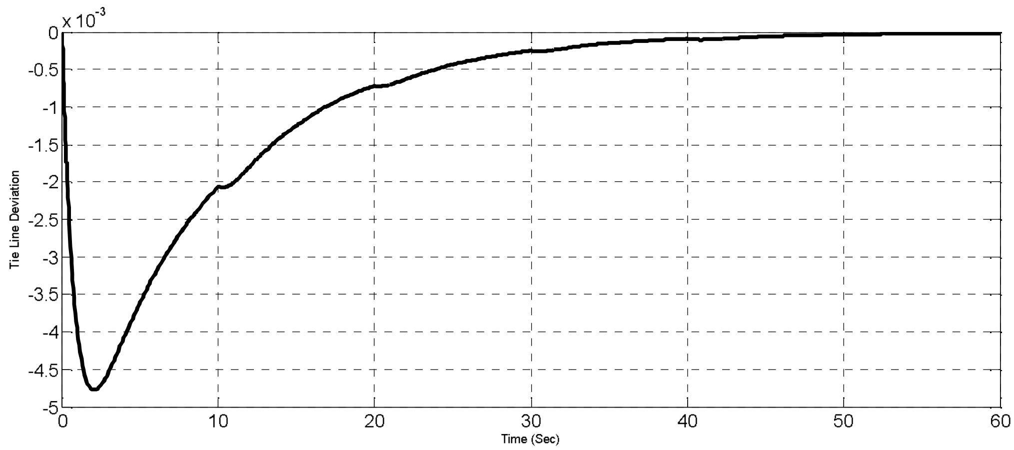


Figure 5.14 Frequency response under Random step load disturbance in area-1

It is apparent from the Fig. 5.14 that proposed intelligent controller delivers a better transient response under such random load disturbances as compared to the conventional PI controller.

5.9 CONCLUSION

In this chapter, FLC with and without GA is implemented for an Automatic Generation Control (AGC) of interconnected power system under Deregulation. Simulation results are compared with a conventional PI controller. As revealed in the simulation results, using the proposed method, the deviation in the tie-line power and frequency deviation of both the areas are driven near to zero. Furthermore, the proposed method of optimization using GA is very effective, i.e., it is able to find the local optimum solution to determine the system objective (minimizing control error), the intelligent controller offers smooth response, and deviation in frequency are a reduced in the same system with conventional controllers. Sensitivity analysis performed by varying the nominal parameters of the system over a wide range depicts the robustness of the proposed controller. Furthermore system is subjected to dynamically changing parameters of generator in Area-1 and random step load patterns are injected in Area-1 to test the robustness of the proposed intelligent controller. It is clear from the result that the proposed controller is very effective.



c) Tie Line Deviation

Figure 5.12 Responses with varying Parameters of Generator model in area-1

Figure 5.12 depicts the performance of proposed intelligent controller (GA-tuned FLC) under the dynamically changing parameters of the generator model in Area 1. It is observed that the controller performance is robust and the response remain well within the tolerable range even under changing transfer function of generator every 10 seconds.

5.8.4 SYSTEM WITH RANDOM LOAD DISTURBANCE PATTERN

To examine the efficacy of the proposed controller, random step load disturbances are injected to Area-1. after 10 seconds of operation. Fig. 5.13 shows the random step load disturbance pattern which is random both with respect to magnitude and time period [31]. The frequency deviation of Area-1 is illustrated in Fig. 5.14.

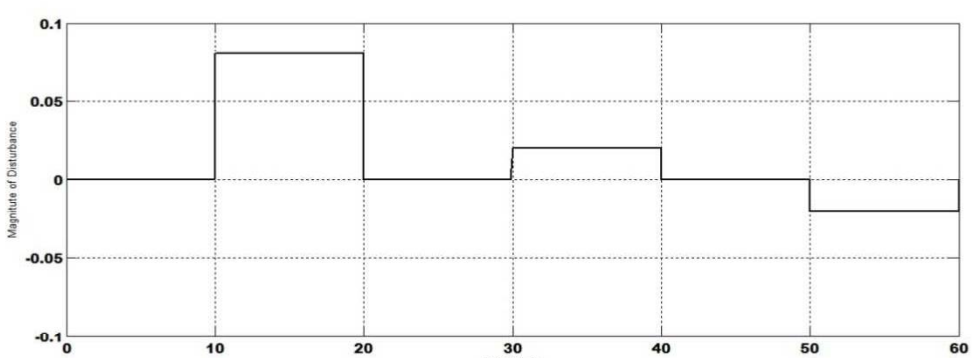
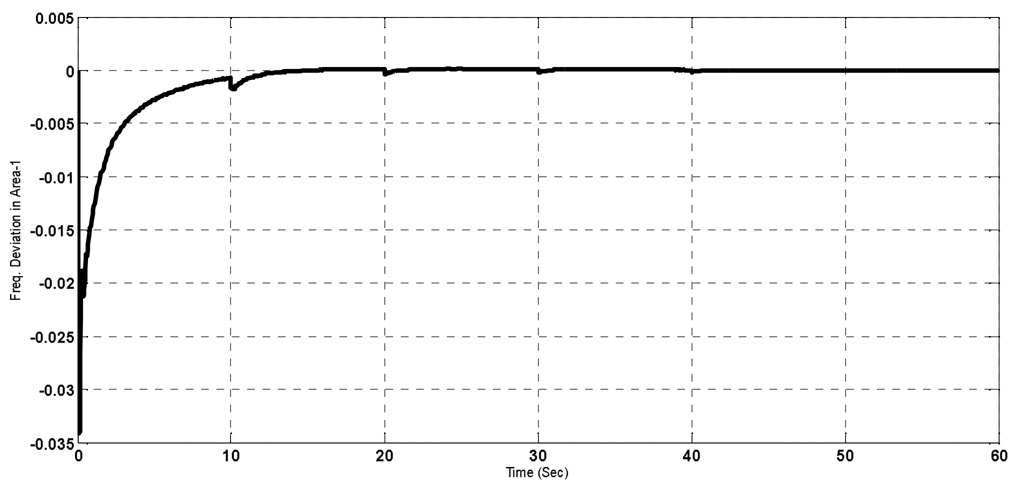


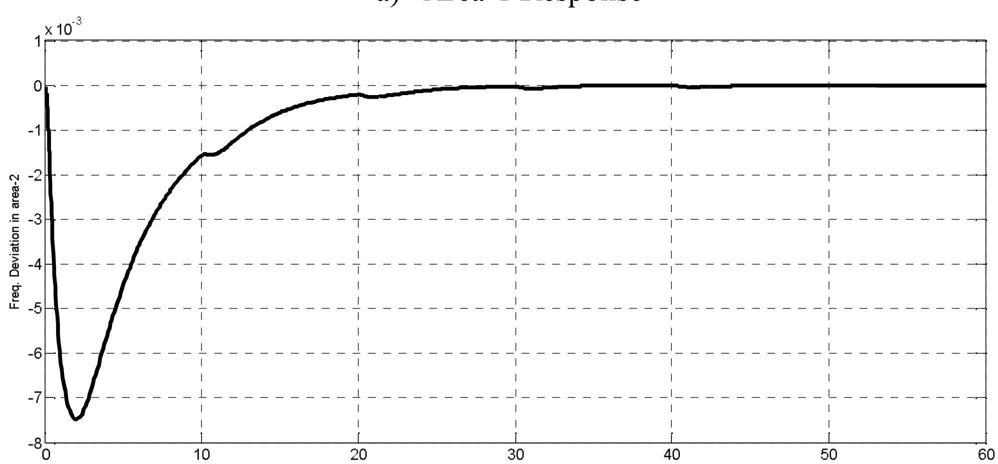
Figure 5.13 Pattern of Random step load disturbance

+50%	180	30

The switching system shown in Fig. 5.11 is incorporated in Area -1 of the two Area AGC model under restructured scenario and the response of the system is captured with parameters of the transfer function changing after 10 seconds in the range depicted in Table 5.9. The Figure 5.12 depicts the behavior of the dynamic system with changing transfer function model of the generator in Area-1.



a) Area-1 Response



b) Area-2 Response

5.8.3 SYSTEM WITH DYNAMICALLY CHANGING GENERATOR MODEL

The controller is tested on dynamic model of AGC with parameters of generator varying with time. The transfer function of the generator model may vary with time with changes in the parameters of the transfer function. The general transfer function of the generator model is given by $K_p / T_p s+1$. Fig. 5.11 shows the arrangement for changing the parameters of the transfer function while the simulation is in progress.

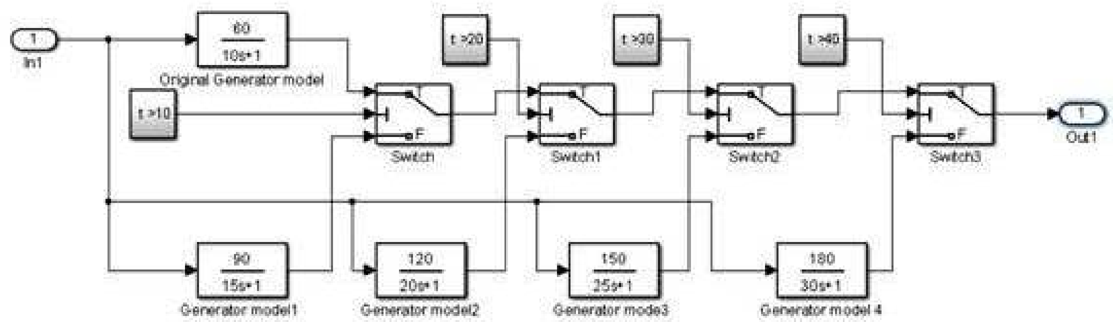


Figure 5.11 Switching Model for Parametric variation in Generator model

The system is tested with the parameters (K_p and T_p) varying in the range from -50% to + 50 % of their nominal values as per Table 5.9

Table 5.9 Variations in Generator model transfer function

% Change	K_p	T_p
-50%	60	10
-25%	90	15
Nominal	120	20
+25%	150	25