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Performance Evaluation of Load Frequency Controller

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Abstract

Frequency deviation control is a major issue in a power system. With increase in complexity of the network and frequently changing load, make it more significant issue. For stable operation of the power system within the stability limit, the frequency deviations must be controlled. Controlling frequency by installation of prime mover governor is a very simple mechanism to control the frequency deviations. If the frequency of the system is not controlled within the fraction of time, the stability may be jeopardized. Many intelligent techniques are available in the literature to control the frequency deviations such as fuzzy control, particle swarm optimization and neural network control etc. Fuzzy logic frequency controller is proposed in this paper.

Keywords:

Frequency deviation;
Load deviation;
Fuzzy controller;
Integral controller;
Performance.

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1. Introduction

Power system is a very big network having number of generating stations. There are many points in this network where power transfer between two or more area is done. For instance India has five regional grids, 1) Eastern Region, 2) North-East Region 3) Northern Region, 4) Western Region and 5) Southern Region. These regions are interconnected to its neighboring areas through tie-lines for power sharing. For power regulation between these areas, LFC (load frequency control) is implemented. The objective of the LFC is to retain the frequency almost stabilized. This paper uses transfer function based model of the various components. Figure 1 is the

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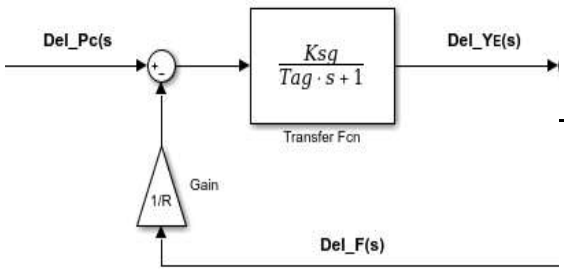

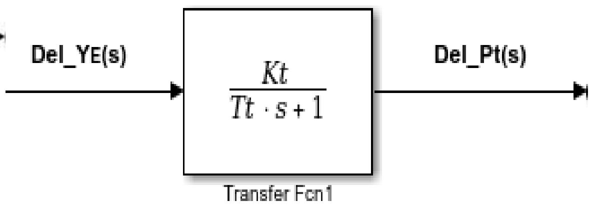

Figure 1. Speed Governor Model Figure 2. Generator Load Model

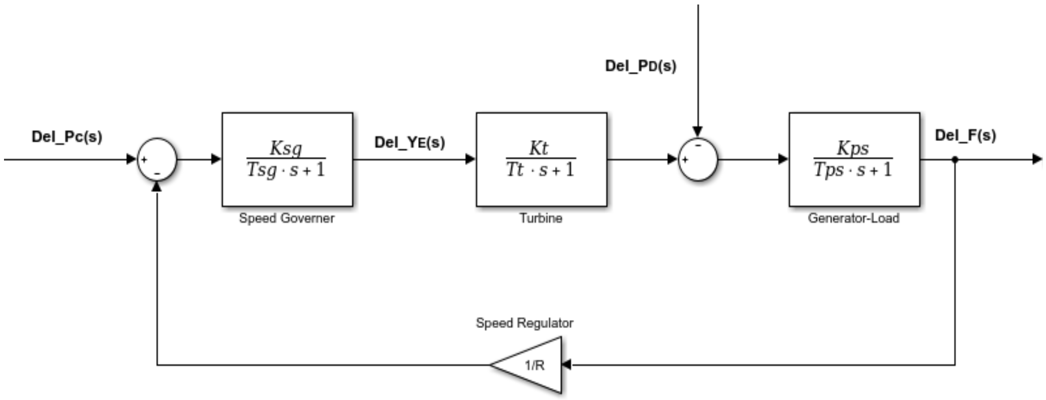

Figure 3. Complete LFC Block Diagram

representation of the turbine speed governor while in figure 2 generator load model is done. Figure 3 shows the diagram of LFC for standalone area.

2. Load Frequency Control

In [1], author has shown that the frequency and tie-line power are affected by speed governor dead-band. The dynamic model of multi-area system is designed in [2, 3]. In [4], author has used linear quadratic regulator concept for LFC. In [5], the author used particle swarm optimization technique, to control the frequency of multi area system. In [5], it is suggested that the fix gain for the PID and integral controller doesn't produce much better results so; the gain must be varied in accordance with the operating conditions. Different controllers have been proposed in [6], in order to enhance the proportional integral controller performance including gain selection for the proportional integral derivative based controller. In [7], self-adaptive gain control has been proposed. In [8], the authors has used artificial neural network for designing a controller to control the frequency of the system. In [9], author has optimized the fuzzy logic based PID controller and produced better result than non-optimized fuzzy logic based PID controller [61-75].

Equation 1 shows the variation in the frequency w.r.t. change in load.

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

If the system is having only one generating unit then, the load frequency control can be accomplished in a very simplified manner but in complex system where more than one area are sharing some load then it becomes a complicated task to achieve the goal [10-25]. In this paper, control of the frequency in multi area system is done by fuzzy logic controller. The response is

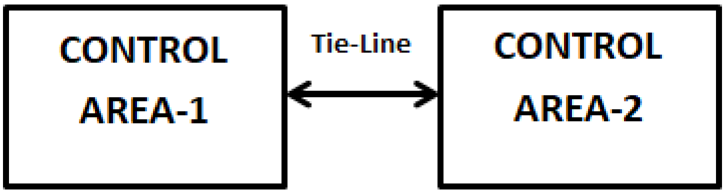

Figure 4 Tie-Line Power Transfer in Two Areas

compared with an integral type load frequency controller. The Fuzzy Logic controller produces much better result in very small time as compared to the integral type controller [26-38].
Figure 4 shows the tie-line power exchange of two areas. The transferred power is given by equation 2, change in power at the tie-line is going by equation 3 and 4.

$$P_{tie,1} = \frac{|V_1||V_2|}{X_{12}} \sin(\delta_1^0 - \delta_2^0) \tag{2}$$

$$\Delta P_{tie,1} = 2\pi T_{12}\left(\int \Delta f_1\, dt - \int \Delta f_2\, dt\right) \tag{3}$$

$$\Delta P_{tie,2} = 2\pi T_{21}\left(\int \Delta f_2\, dt - \int \Delta f_1\, dt\right) \tag{4}$$

3. Fuzzy Logic controller (FLC):

Lotfi Zadeh had given the concept of fuzzy logic in 1965, who was Professor in University of California Berkeley. In fuzzy logic the input from the real world is firstly fuzzified in to fuzzy membership function and rules are applied in the rule base to compute the fuzzy output functions and finally to produce a crisp output the de-fuzzification is done [37-49]. Fuzzy logic controller is designed by selecting input output membership functions. Different types of membership function are available in MATLAB fuzzy tools such as triangular, trapezoidal and Gaussian etc. In fuzzy logic controller, a rule based system design for input and output to produce certain controlling argument for a controller. The input is firstly normalized for processing and then output of fuzzy logic controller is de-fuzzified to produce a control signal. The fuzzy controller is loaded with certain fuzzy rules, these fuzzy rules are “if-then” statements which are designed to take a decision corresponding to the input characteristics for example, if certain condition satisfied then fuzzy controller produce yes or one output, if that condition is not satisfy then fuzzy controller will produce no or other output [48-60]. Fuzzy inference system is the Kernel of fuzzy logic controller, which emulates the human decision making capabilities depending upon the fuzzy rules [76-83]. To produce output, there are two types of fuzzy inference system (FIS); 1)Sugeno type FIS and 2) Mamdani type FIS.

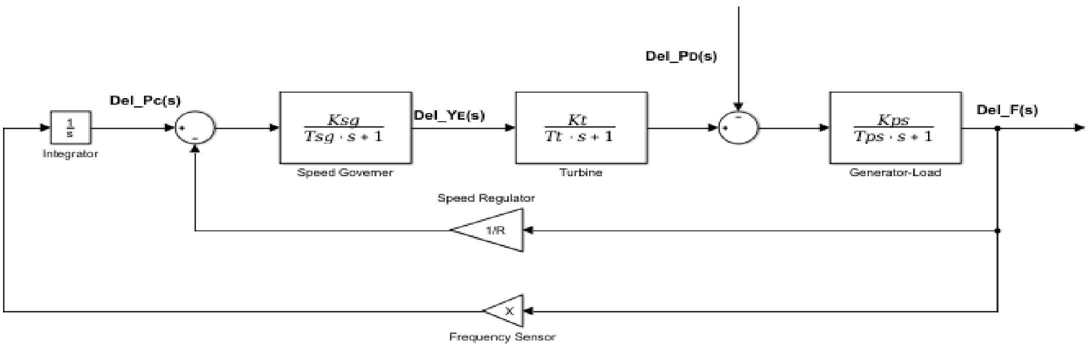

Figure 5. Single Area Frequency Control with Integral Controller

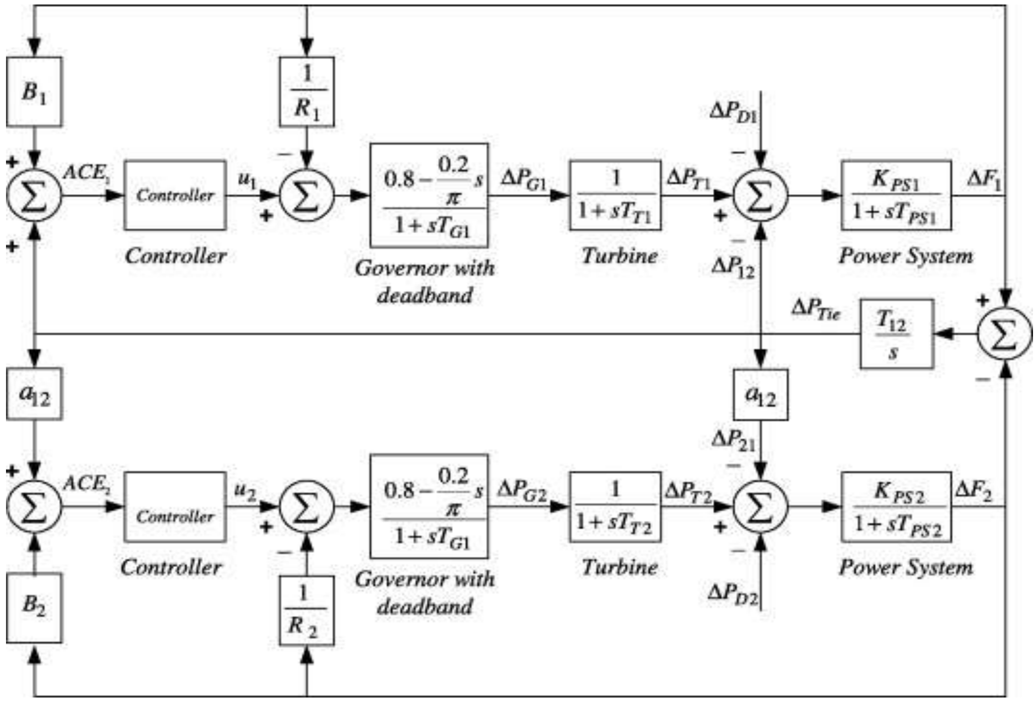

Figure 6. Two Area Frequency Control.

Figure 5 shows the single area frequency control with integral controller and figure 6 shows the two area frequency control.

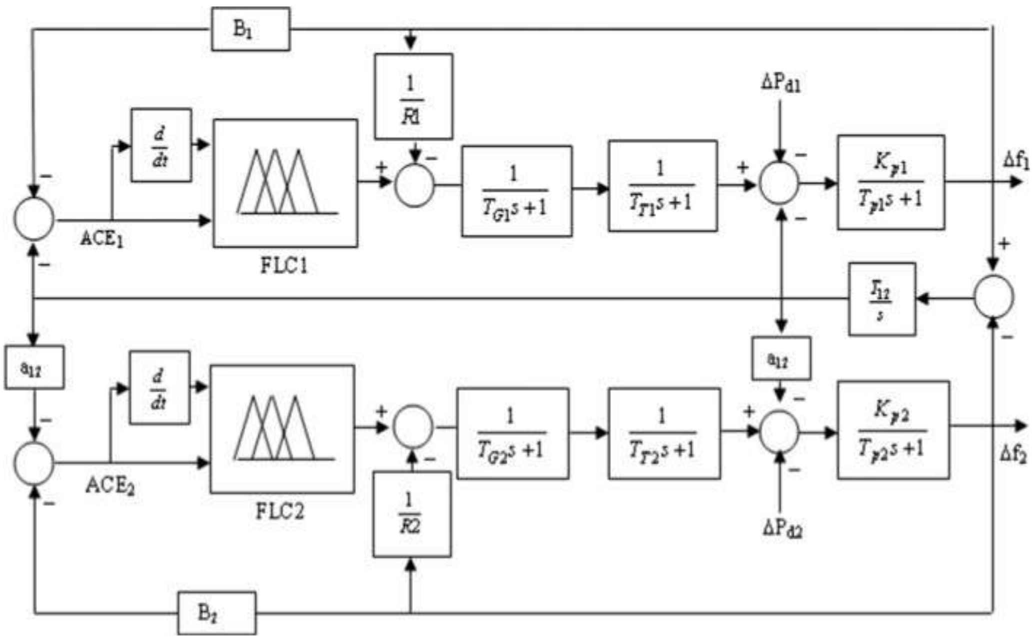

Figure 7. Load Frequency Controller based on Fuzzy Logic Controller

3. Results and Analysis

Results produced by the integral controller having higher settling time as well as high value of peak overshoot as it is very much clear from the figure 8 and 9.

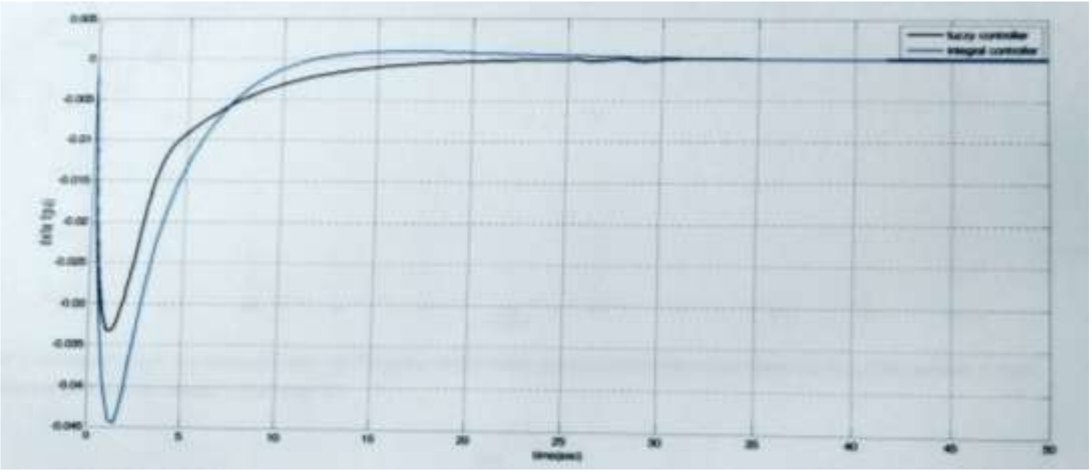

Figure 8. Integral Vs Fuzzy Controller output for Single Area System

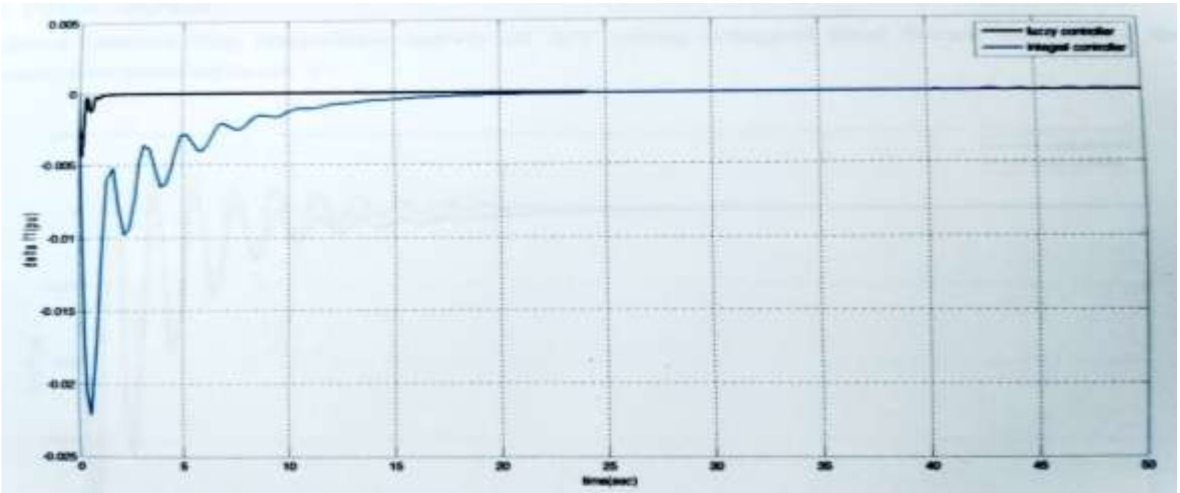

Figure 9. Integral Vs Fuzzy Controller for Two Area System

Table 1 Fuzzy Rules used

$\frac{dACE}{dt}$ → / ACE ↓	LP	MP	SP	Z	LN	MN	SN
LN	Z	SN	MN	MN	LN	LN	LN
MN	SP	Z	SN	MN	LN	MN	MN
SN	MP	SP	Z	SN	LN	MN	SN
Z	LP	MP	SP	Z	MN	MN	SN
SP	LP	MP	SP	SP	MN	SN	Z
MP	LP	MP	MP	MP	SN	Z	SP
LP	LP	LP	LP	MP	Z	SP	MP

4. Conclusion

In this paper, MATLAB simulation of LFC based on fuzzy controller and integral controller for single and two areas network is done. The dynamic performance of the both controllers is compared. The output of fuzzy logic controller is much better than the integral controller. The FLC has lower settling time and lesser peak overshoot. The characteristics of the FLC can be enhanced by hybrid controller design. In hybrid control, fuzzy technique with artificial intelligence technique can produce better results. Hybrid neuro fuzzy controller can be designed for the more constraints to simulate more complex structure i.e., more than two area systems, to investigate the behavior of the controller.

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