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Advanced Fuzzy Logic Control system for Thermal Power Plant

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Abstract: An objective of this paper is too familiar with fuzzy logic and fuzzy modeling. Its incorporation in embedded systems could lead to enhanced performance, increased simplicity and productivity, reduced cost and time to- market, along with other benefits in power system. In this paper, we try to explain fuzzy logic control for AGC and comparing with other controlling methods like PID, Type-1 FLC. Where we calculate the comparison overshoot, undershoot and settling time in controlling system.
Keywords: Proportional Integral (PI), Automatic Generation Control (AGC), Fuzzy Logic control (FLC), Fuzzification, De-fuzzyfication.

I. INTRODUCTION

In the fuzzy logic controller is proposed to solve the load frequency control problem of single area power system and two area system and compared with a conventional PI controller. It is found that performance of type-1 FLC is better than the conventional PI controller in terms of peak overshoot, a number of oscillations and settling time but it is not sufficient for fulfilling the requirements of the future power system, so we have to design an advanced controller which gives fast response. To overcome the drawbacks of fuzzy logic controller used in the previous chapter, a new fuzzy logic controller approach is investigated in this Paper. This fuzzy approach handles all these problems of fuzzy controller easily and efficiently.

II. TYPE-2 FUZZY LOGIC CONTROLLER FOR AGC

A. Structure of Type-2 FLC

Generally, a controller design based on fuzzy logic for a dynamical system involves the following four main steps.

Understanding the system dynamic behavior and characteristics which define the states and input/output control variables and their variation ranges.

Establish applicable fuzzy sets and membership functions to form the degree of fuzzy membership function for every input/output variable and complete fuzzification.

Construct the fuzzy rule base, using the control rules that the system will operate under. Decide however the action will be executed by assigning strengths to the rules.

Determine de-fuzzification technique, combine the rules and de-fuzzify the output.

Hence, above discussion based fuzzy logic approach, a controller named type-2 fuzzy logic controller is investigated as shown in figure 1. It has two inputs, error and differential error and an output is integrated. Value of scaling factors K_e, K_{ce} and K_{pu} can be tuned by using IASE, PSO, GA or manually.

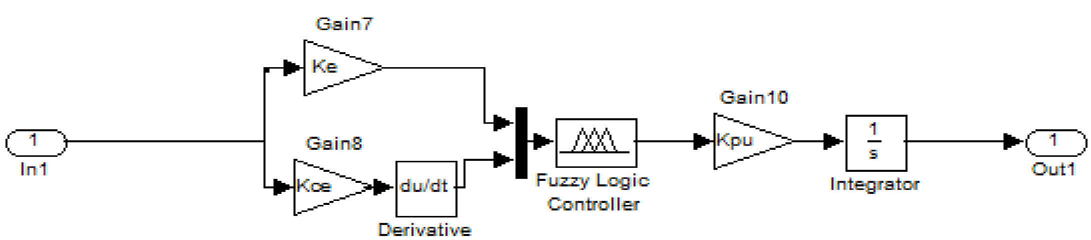

Figure 1 Type-2 fuzzy logic controller model

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B. Rule Base and Fuzzy Sets for type-2 Fuzzy Logic Controller

Similar to type-1fuzzy logic controller, type-2 FLC also based on 49 rules. These fuzzy logic rules are in “if and then” format. These rules can be placed in form of table (as in table 1). Here error and differential error are two inputs of fuzzy logic controller as given in figure 1.

TABLE 1
Fuzzy logic controller rule base

		differential Error						
		NB	**NM**	**NS**	**Z**	**PS**	**PM**	**PB**
Error	**NB**	PB	PB	PM	PM	PS	PS	Z
	NM	PB	PB	PM	PM	PS	Z	Z
	NS	PB	PM	PM	PM	Z	NS	NS
	Z	PB	PM	PM	Z	NS	NM	NB
	PS	PM	PM	NS	NS	NM	NB	NB
	PM	PS	PS	NS	NM	NB	NM	NB
	PB	NS	NS	NM	NM	NM	NM	NB

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Here we will use triangular membership function for input and output. Range of type-2 fuzzy logic controller is taken same as type-1 fuzzy logic controller, input error is taken from -0.8 to +0.8, differential error is -1.5 to +1.5 and output control action is taken from -0.015 to +0.015.

III. DYNAMIC RESPONSE OF SINGLE AREA THERMAL SYSTEM USING TYPE-2 FLC

The above developed controllers have been used for load frequency control of single area thermal system. In starting, the performance of fuzzy logic controller (FLC) has been tested for a disturbance of 1% step change in load in single area thermal system. The above described single area thermal system has been implemented in Simulink/Matlab with FLC as shown in Figure 2. Simulation result as deviation in frequency of this system is given in figure 3; also the result is compared with PID and type-1 fuzzy logic controllers as shown in figure 11.

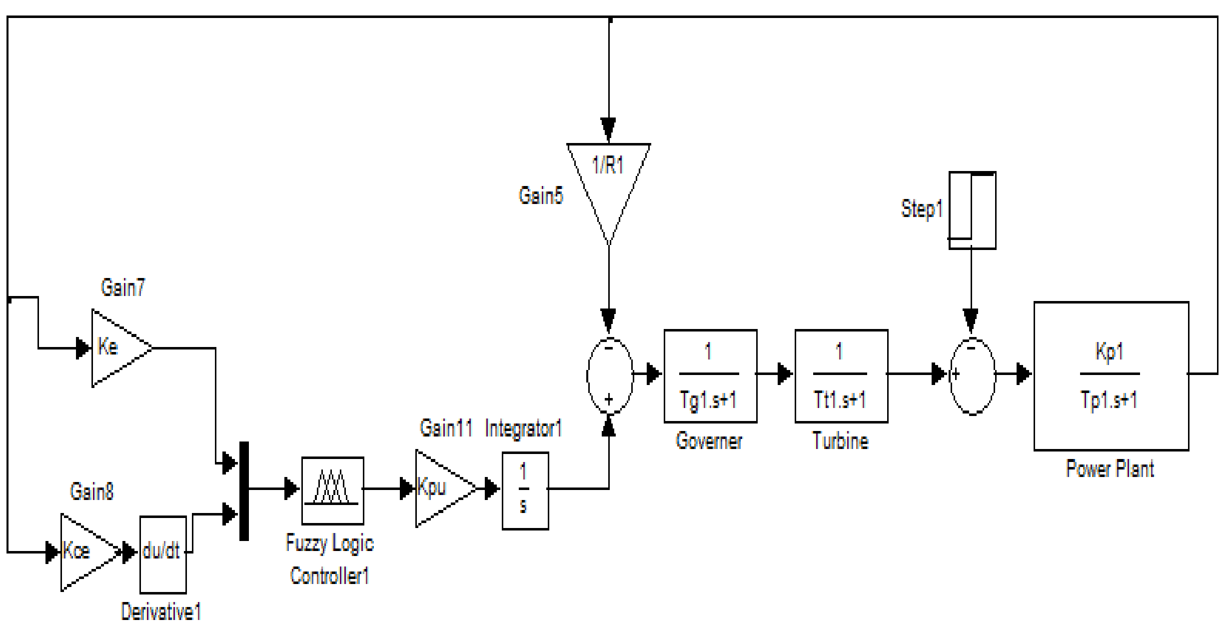

Figure 2 Implementation of Fuzzy logic controlled in single area Thermal System

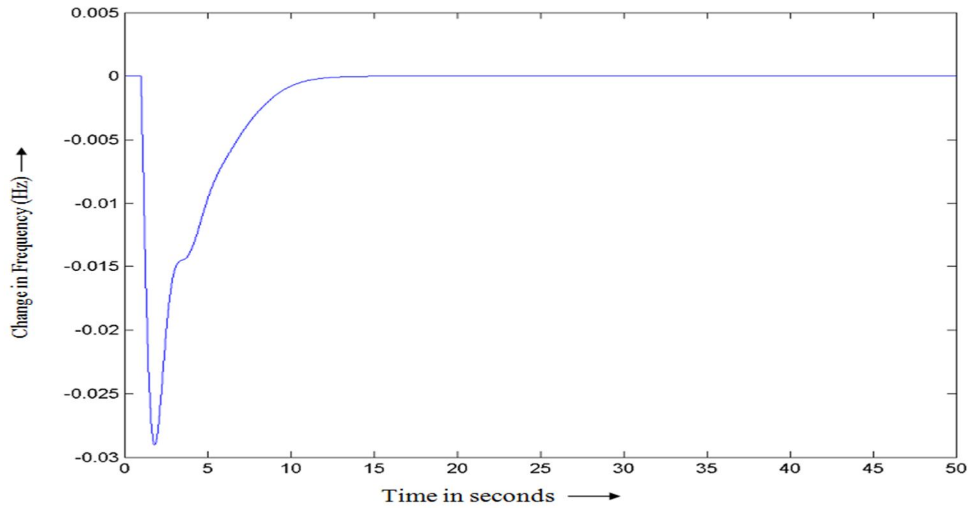

Figure 3 Deviation in frequency of single area Thermal System with type-2 FLC

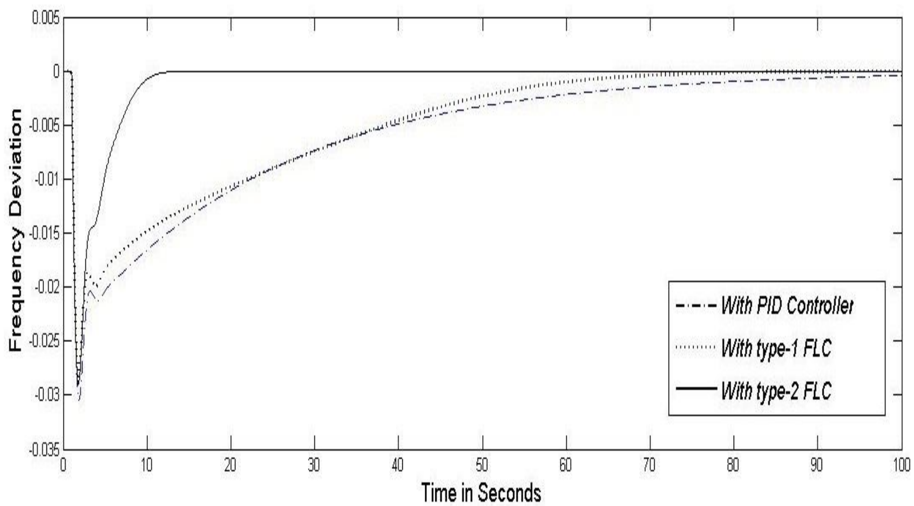

Figure 4 Comparison of frequency deviation for single area thermal with PID, type-1 and type-2 FLC

From the simulation results, It is found that type-2 fuzzy logic controller gave better results in terms of less deviation in frequency in first undershoot, overshoot, less settling time, and less oscillations as compared to type-1 fuzzy logic controller and conventional PID controllers which is given in table 2.

TABLE 2

Time analysis parameters of simulations of single area Thermal system

Parameters	**System With PI Controller**	**System With Type-1 Fuzzy logic Controller**	**System With Type-2 Fuzzy logic Controller**
Undershoot(Hz)	0.031	0.028	0.028
Overshoot(Hz)	0	0	0
Settling time(sec)	90	60	10

IV. DYNAMIC RESPONSE OF TWO AREA THERMAL SYSTEM USING TYPE-2 FLC

This section deals with a two area system simulation in Simulink/Matlab consisting of a thermal system as shown in Figure 5. Now the PID, type-1 fuzzy logic controller and type-2 fuzzy logic controllers have been tested and compared for 1% disturbance in area1, the simulation results shown in Figure 6 to 11.

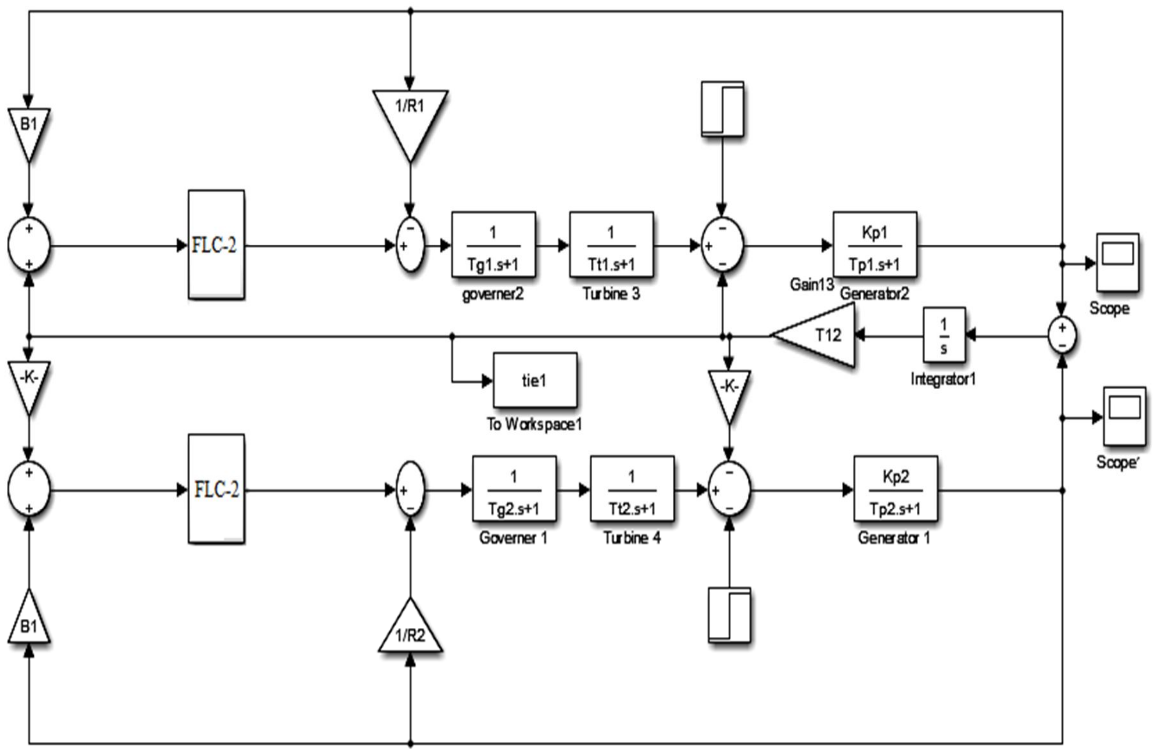

Figure 5 Simulation model of Fuzzy logic controlled two area Thermal System

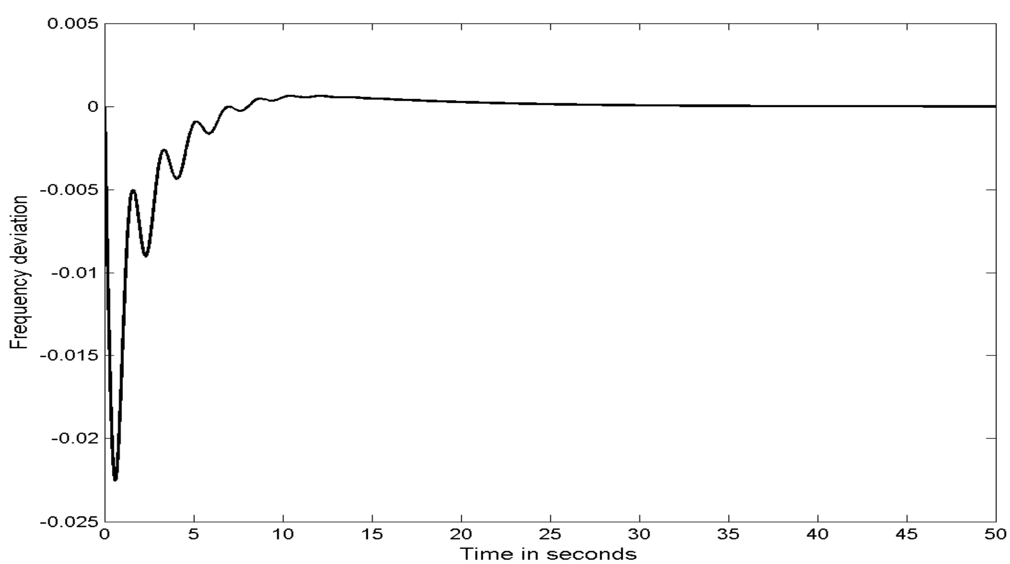

Figure 6 Deviation in frequency of area-1 of a two area Thermal System with type-2 FLC

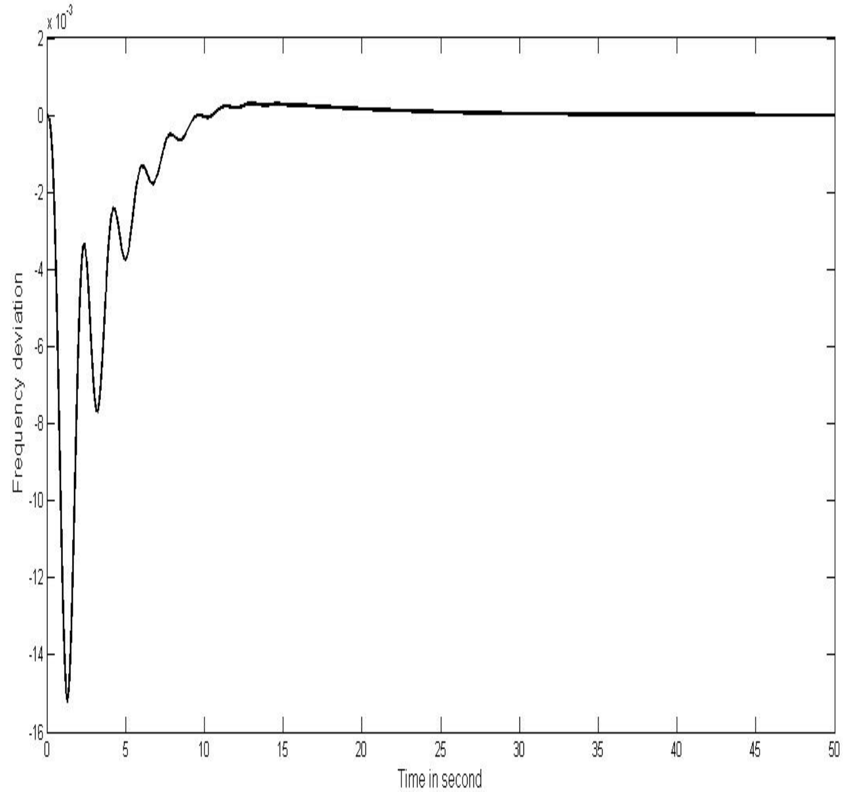

Figure 7 Deviation in frequency of area-2 of a two area Thermal System with type-2 FLC

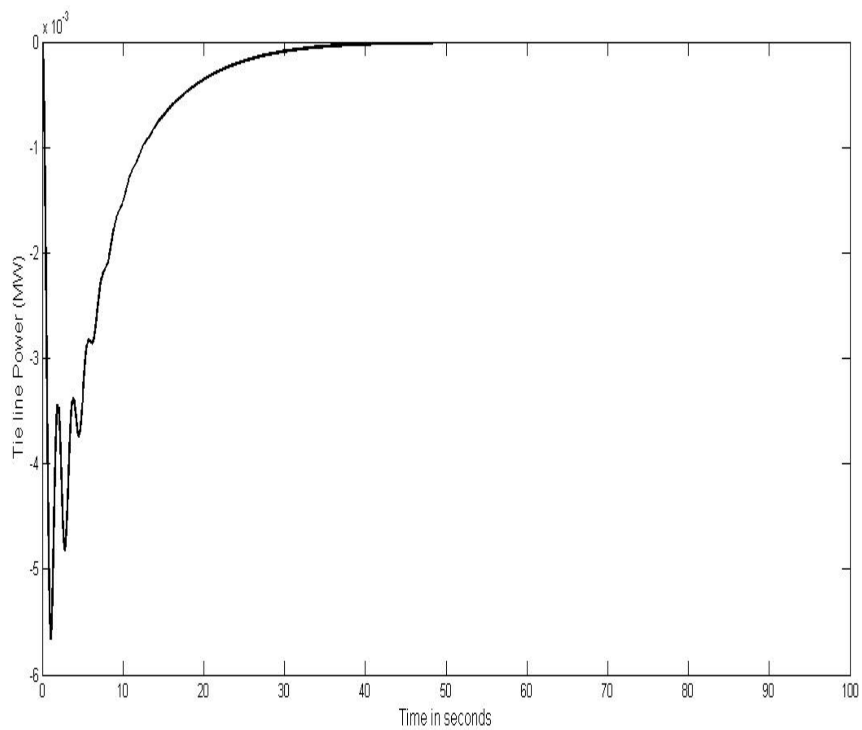

Figure 8 Deviation in tie line power of a two area Thermal System with type-2 FLC

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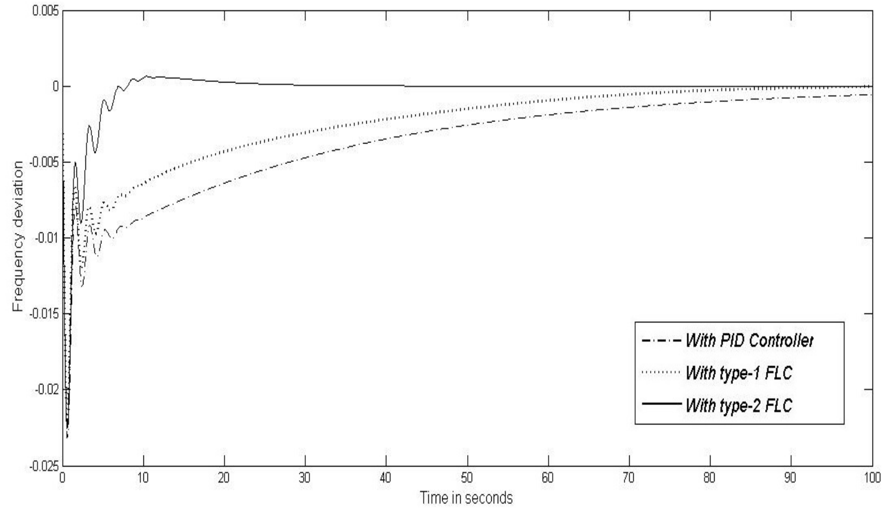

Figure 9 Comparisons of deviation in frequency of area-1 of a two area Thermal-Thermal System

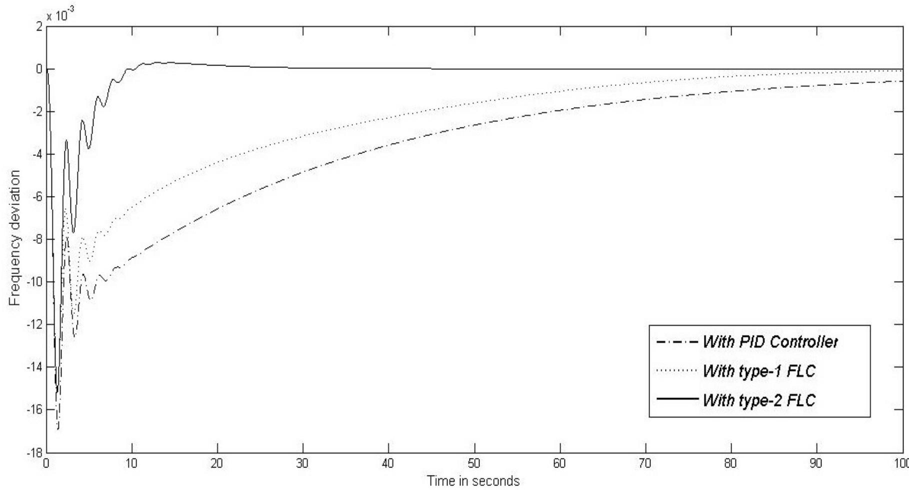

Figure 10 Comparisons of deviation in frequency of area-2 of a two area Thermal-Thermal System

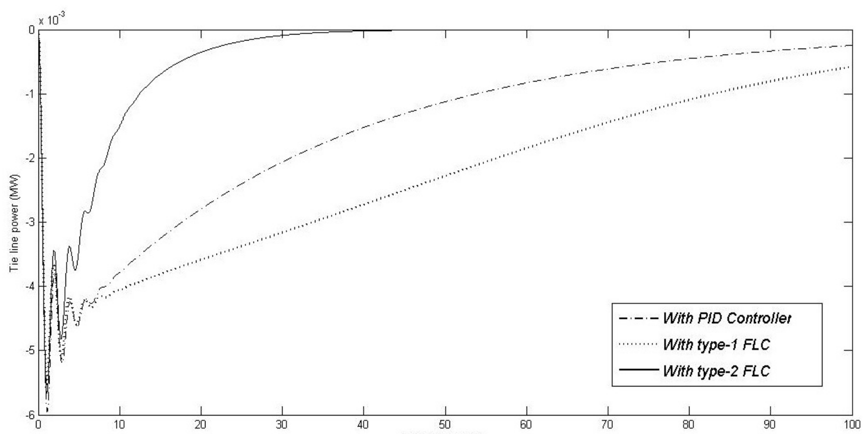

Figure 11 Comparison of deviation in tie line power of a two area Thermal System

From the simulation results, It is found that type-2 fuzzy logic controller gave better results in terms of less deviation in frequency in first undershoot, overshoot, less settling time, and less oscillations as compared to type-1 fuzzy logic controller and conventional PID controllers which is given in table 3 to 5.

TABLE 3

Time analysis parameters of simulations of area1 for Thermal-Thermal system when 1% disturbance in area1

Parameters	**System With PI Controller**	**System With Type-1 Fuzzy logic Controller**	**System With Type-2 Fuzzy logic Controller**
Undershoot(Hz)	0.023	0.022	0.022
Overshoot(Hz)	0	0	0.001
Settling time(sec)	100	60	30

TABLE 4

Time analysis parameters of simulations of area 2 for Thermal-Thermal system when 1% disturbance in area1

Parameters	**System With PI Controller**	**System With Type-1 Fuzzy logic Controller**	**System With Type-2 Fuzzy logic Controller**
Undershoot(Hz)	0.017	0.015	0.015
Overshoot(Hz)	0	0	0.001
Settling time(sec)	110	70	30

TABLE 5

Time analysis parameters of simulations of tie line for Thermal-Thermal system when 1% disturbance in area1

Parameters	**System With PI Controller**	**System With Type-1 Fuzzy logic Controller**	**System With Type-2 Fuzzy logic Controller**
Undershoot(Hz)	0.0060	0.0055	0.0055
Overshoot(Hz)	0	0	0
Settling time(sec)	120	130	30

V. CONCLUSION

In this paper, a type-2 fuzzy logic controller has used to solve the load frequency control problem of single area power system and two area system. A simulation study of single and two area systems with conventional PID controller, type-1 fuzzy logic controller, and a type-2 fuzzy logic controller is proposed and compared their performance. Hence, the performance of the type-2 fuzzy logic controller is found superior in terms of peak overshoot, number of oscillations and settling time.

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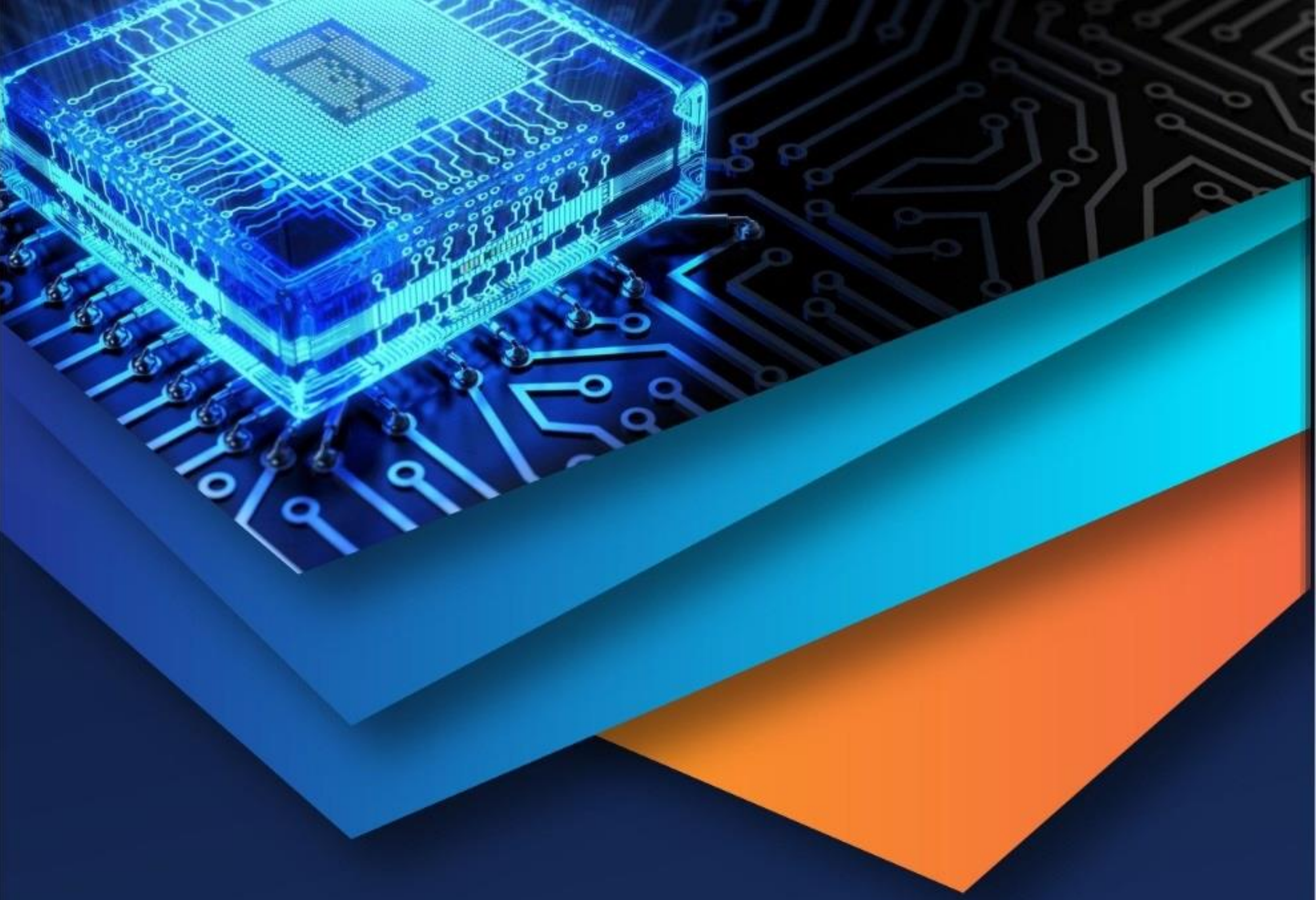

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