International Journal of Innovative Research in Science and Engineering
Vol. No.3, Issue 06, June 2017
www.ijirse.com
ISSN (O) 2454-9665
ISSN (P) 2454-0663

LOAD FREQUENCY CONTROL WITH THERMAL AND NUCLEAR INTERCONNECTED POWER SYSTEM USING PID CONTROLLER

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ABSTRACT

In this paper, Zigler Nicolas (ZN) based optimal proportional-plus-integral controller is designed for load frequency control of a two area thermal power and nuclear power system. The design is determined an optimization problem and a minimizing the error function, is derived for increasing the performance of convergence to the solution. To optimize the parameters of the PI controller, fuzzy logic technique and the particle swarm optimization algorithm are also used. The results show that the ZN based PI is providing better performance than Fuzzy based PI for dynamic responses of the power system.

Keywords— Automatic Generation Control (AGC),Area Control Error (ACE), Particle Swarm optimization (PSO) algorithm.

NOMENCLATURE

1. f   Nominal system frequency.
2. i   Subscript referred to area i (1, 2, 3).
3. Pri Area rated Power.
4. H   Inertia constant.
5. ΔPtie i-j Incremental change in tie power of tie i- j (p.u).
6. ΔPgi change in power generation in area i.
7. Δfi Frequency deviation in area i,
8. ΔPDi Incremental load change in area i (p.u).
9. Di ΔPdi/Δfi.
10. Ri Governor speed regulation parameter in area i.

I.INTRODUCTION

Automatic generation control is one of the most important issues in power system design. The main purpose of AGC is used for fast minimization of area frequency deviation and mutual tie-line power flow deviation of areas for stable operation of the system. The overall performance of AGC in any power system is depends on the proper design of speed regulation parameters and gains of the controller. The AGC action is guided by the Area Control Error (ACE) which is a function of systemfrequency and tie line flows. Here the ACE represents a

ISSN (O) 2454-9665
ISSN (P) 2454-0663

mismatch between area load and generation by taking account into any interchange agreement with the neighbouring areas [1].

In the load frequency control problem, frequency and tie-line power should be kept as near scheduled value as possible, which is difficult to achieve due to fluctuating nature of the load. The frequency and the interchanged power are kept at their desired values by means of feedback of the area control error (ACE) integral, containing the frequency deviation and the error of the tie line power, and controlling the prime movers of the generators. The controllers so designed regulate the area control error to zero. For each area, a bias constant determines the relative importance attached to the frequency error feedback with respect to the tie-line power error feedback.

(a) The steady-state frequency error following a step load change should vanish. The transient frequency and time errors should be small.

(b) The static change in the tie power following a step load in any area should be zero, provided each area can accommodate its own load change.

(c) Any area in need of power during emergency should be assisted from other areas.

II. SINGLE AREA THERMAL POWER GENERATION MODEL

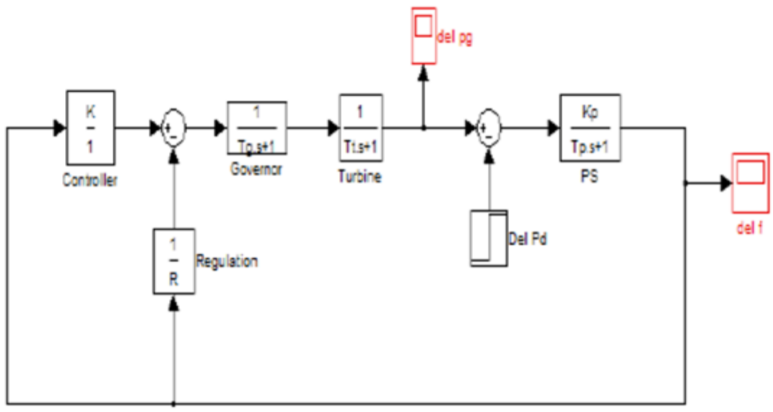

Fig.1 Single area thermal powergeneration model

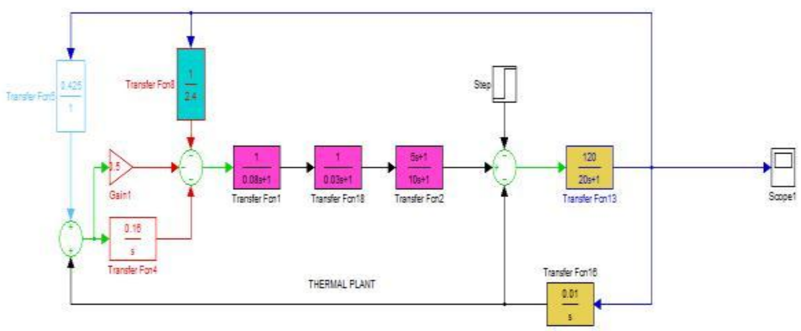

Fig.2Agc Model Of Thermal Power Plant With Continuous PIController

ISSN (O) 2454-9665
ISSN (P) 2454-0663

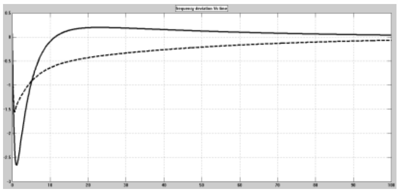

Fig.3 Time response of F1 for 1% load disturbance in area- 1(Thermal power plant) with and without controller.

TABLE- I

COMPARATIVE STUDY OF SETTLING TIME & PEAKOVERSHOOTS(in sec)

Type of controller		Peak Overshoot		Settling time	
Without controller		-0.3		infinite	
With controller					
Kp	Ki	Due to Kp	Due to Ki	Due to Kp	Due to Ki
0.40	0.128	0.22	0.18	220	220
0.45	0.144	0.20	0.19	220	230
0.50	**0.160**	**0.20**	**0.20**	**200**	**200**
0.55	0.176	0.25	0.20	180	240
0.60	0.192	0.18	0.21	220	210

III. NUCLEAR TURBINE GOVERNOR SYSTEM

The Mathematical model considered for Nuclear unit with tandem-compound turbines, one HP section and two LP sections with HP re heater is shown in fig 3.

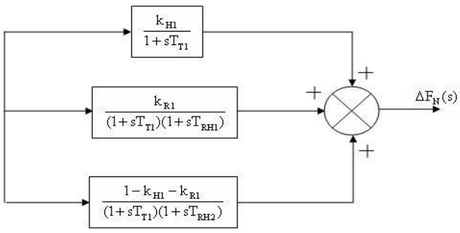

Fig. 4 Isolated model of Nuclear Power System for LFC

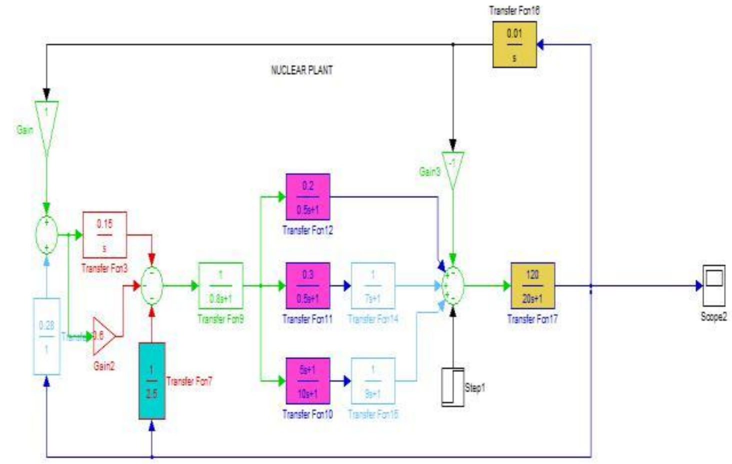

Fig.5 AGC Model of Nuclear plant with continuous PI controller.

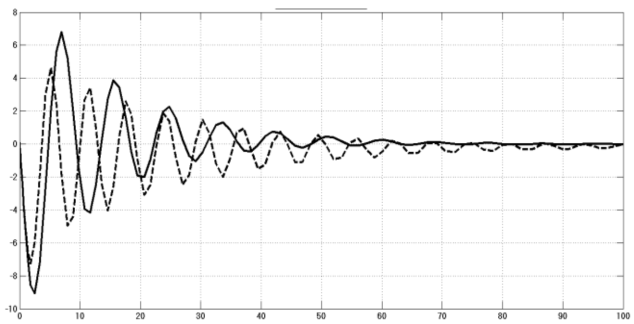

Fig.6 Time response of F1 for 1% load disturbance in area-2(Nuclear power plant) with and without controller.

TABLE-II

COMPARATIVE STUDY OF SETTLING TIME &PEAKOVERSHOOTS(in sec)

Type of controller		Peak Overshoot		Settling time	
Without controller		-0.3		infinite	
With controller					
Kp	Ki	Due to Kp	Due to Ki	Due to Kp	Due to Ki
0.48	0.120	6.5	6.1	68	65
0.54	0.135	6.4	6.2	65	70

ISSN (O) 2454-9665
ISSN (P) 2454-0663

0.60	**0.150**	**6.4**	**6.4**	**65**	**65**
0.66	0.165	6.8	6.6	73	72
0.72	0.180	6.3	6.8	70	210

IV. TWO AREA CONTROL

A three area system consists of three single area systems,connected through a power line called tie-line, is shown in the figure-2. Each area feeds its user pool, and the tie line allows electric power to flow between the areas.

Information about the local area is found in the tie line power fluctuations. Therefore, the tie-line power is sensed, and the resulting tie linepower signal is fed back into both areas. It is conveniently assumed that each control area can be represented by anequivalent turbine, generator and governor system. Symbol used with suffix 1 refer to area 1 and those with suffix 2 refer to area 2.

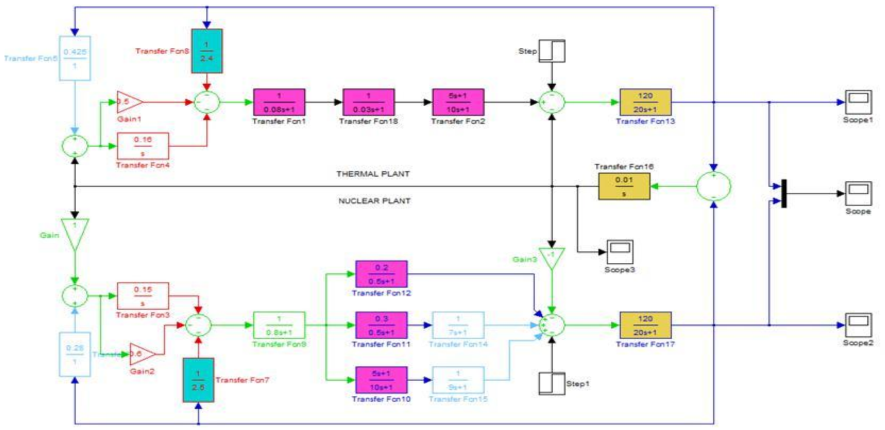

Fig. 7 AGC Model of Thermal and Nuclear interconnected power plant with continuous PI controller

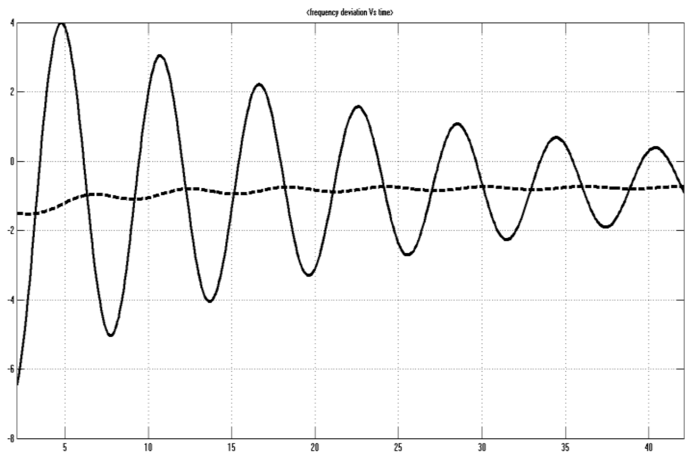

Fig.8 Time response of Ptie for 1% load disturbance in both area(Thermal and Nuclear interconnected power plant) without controller.

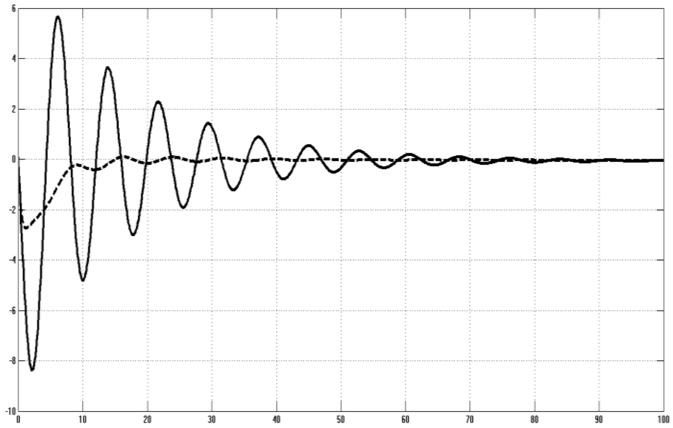

Fig.9 Time Response ofPtie For 1% Load Disturbance In bothArea (Thermal And Nuclear Interconnected Power Plant) With Controller.

TABLE-III

COMPARATIVE STUDY OF SETTLING TIME &PEAKOVERSHOOTS(in sec)

Type of controller	Peak Overshoot		Settling Time	
	Thermal	Nuclear	Thermal	Nuclear
Without controlller	-1.9	3.2	infinite	infinite
With PI controller	0	5.8	38	70

V. THE SYSTEM MODEL BASED ON SAME FREQUENCY

In the traditional model, each area within a system is assumed to be operating at a different frequency and tie line power exchanges between the areas is computed as the product of the tie line constant and the angular difference between the areas. For hydro-hydro, interconnections, traditional approach turned to be unsuccessful [6]. In reference [6], a model has been proposed. In this model the entire system is assumed to operate on same frequency. The frequency is determined by integrating net accelerating /decelerating power. Since all the areas of same frequency, the difference between frequencies cannot be used for calculating the tie line power deviations. For this purpose power balance equation given by (1) is used.

$$P_{tie} + P_{gi} - P_{di}(f) = Hdf/dt (1)$$

Where P_{tie} is the tie power, P_{gi} is total power generation in area i, $P_{di}(f)$ is the total area load, Hi is the inertia constant, and Hdf/dt is the accelerating or decelerating power and f_{sys} is the system frequency. The proposed model is justified one and the same is recommended in [9].

VI. CONCLUSION

The real time simulation uses the discrete model of the AGC. Hence discrete controller for the AGC is derived from the continuous controller by discritization of the continuous controller using Tustin transformation, or trapezoid approximation method and the closed loop stability is checked by taking the bode of the closed loop of AGC model for different sampling time periods ,the dynamic response plot for 1% load disturbance in area-1 is quite appreciable for the hybrid model (continuous model with discrete controller) as compared to continuous model for the frequency deviation in area 1 and in tie line power. When discrete controller is prototyped and the real time simulation is performed to observe the results, the dynamic response plot for 1% load disturbance in area-1 of the real time model is quite appreciable as compared to non-real time model. The peak magnitude, oscillations and settling time are quite low as compared to non-real time model. Real time simulation is good technique of prototyping the controllers for various applications in the lab.

VII. APPENDIX

TABLE-III, SYSTEM PARAMETERS OF THE POWER PLANT

$$R_1 = R_2 = R_3 = 2.4Hz/p.u.MW$$
$$Tg_1 = Tg_2 = 0.08s$$
$$Kr_1 = Kr_2 = 0.5$$

$$Tt_1 = Tt_2 = 0.3s$$
$$a_{12} = a_{13} = a_{23} = 1$$
$$Kp_1 = Kp_2 = Kp_3 = 120Hz/p.u.MW$$
$$Tp_1 = Tp_2 = Tp_3 = 20s$$
$$D_1 = D_2 = D_3 = 8.33*10^{-3}\,p.u.MW/Hz$$
$$T_{12} = T_{13} = T_{23} = 0.086\,p.w.MW/rad.$$
$$P_{tie,\max} = 200MW$$
$$T_R = 5s$$
$$T_W = 1.0s$$
$$Kp = 1.0$$
$$Ki = 5.0$$
$$Kd = 4.0$$
$$f = 50Hz$$

ISSN (O) 2454-9665
ISSN (P) 2454-0663

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