International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 02, February-2017

Automatic Generation Control of an Interconnected Power System using Modified Classical Controller

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***Abstract*: This paper deals with automatic generation control (AGC) of an interconnected two area unequal thermal system. Performance of conventional PID controller are compared with newly introduce modified classical controller named as PID1 and PID2 controller. The performance of the proposed controller has been evaluated, which gives better dynamic response then the conventional PID controller over wide range of operating condition and system parameter variations.**

Keywords- Automatic Generation Control, Structure1 and2 Proportional plus Integral Plus Derivative Controller (PID 1 & PID 2).

1. INTRODUCTION:

The main objectives of automatic generation control are to regulate system frequency within acceptable range and to maintain the interchange of power between control areas as close as possible the schedule value by adjusting the output of selected generator. The power system loads are very sensitive to frequency. Any sudden load change in a control area of an interconnected power system will lead to frequency deviation as well as tie-line power deviation [1].

L.C. Saika, S. Debbarama, M. Pathak,[2].This paper deals with automatic generation control of an interconnected two area thermal system. Appropriate generation rate constraint area considered in the areas. Performance of several classical controller like integral (I),proportional plus integral controller (PI),proportional plus integral plus derivative (PID) are compared with classical controller which are newly introduced in AGC named as proportional plus integral plus double derivative . And it will give better dynamics than other controller. Selection of suitable value of governors speed regulation parameter (R) has been examined.

Wen Tan, [3] PID tuning of load frequency controllers for power systems is discussed in this paper. The tuning method is based on two degree of freedom internal model control design method. The performance of the resulting PID controller is related to two tuning parameter thus detuning is easy when necessary. Unified PID tuning technique dependent on two degree-of-freedom for LFC of power system is discussed. Also time domain act in addition to robustness of consequential PID controller is associated to two regulation constraints as well as its robustness is discussed. Simulation results shows improvement in damping of power systems. The additional degree-of-freedom cancels the impact of unwanted poles of disturbance reduction performance of system having closed-up.

F.C. Tacker, T.W. Reddoch, O.T. Pan, and T. D. Linthon [4]: It has discussed the LFC of interconnected power system and investigated the formulation of LFC through linear control theory. So comparison between these was made to the ability for motivation of the transients (GRC) was introduced in these studies, considering both discrete and continuous power system.

C. Fosha, O.I. Elgerd [4]: This paper records the development of a state variable model of the megawatt – frequency control problem of multi area electric energy systems. For application of theorems of modem optimal control theory the model is represented in mathematical form that considered before is developed. The results of this study allow the authors to explain the ways of greatly improving dynamic response and stability margins of the megawatt –frequency control systems.

C. Concordia and L.K. Kirchmayer [6] in this paper they has discussed the first attempt in case of LFC has to control the power system frequency by the help of the governer. This technique of governor control was not sufficient for the stabilization of the system. So, an extra supplementary control technique was introduced to the governor by the help of a variable proportional directly to the deviation of frequency plus it's integral. This scheme contains classical approach of Load Frequency Control (LFC) of power system.

2. MATERIALS AND METHODS:

2.1. Systems model

The multi-area power system consists of inter-connection of two unequal thermal systems as shown in Figure 1. Area-1 is having two units of thermal systems with reheater and area-2 having two units' thermal systems without reheater. Each area has three inputs and two outputs. The inputs are the controller inputs $\Delta P_{ref,}$ load disturbance $\Delta P_{D,}$ and tie-line power error $\Delta P_{tie.}$The outputs are the generator frequency ΔF and area control error (ACE) given by, $ACE=B\Delta F+\Delta P_{Tie}$, where B is the frequency bias parameter.

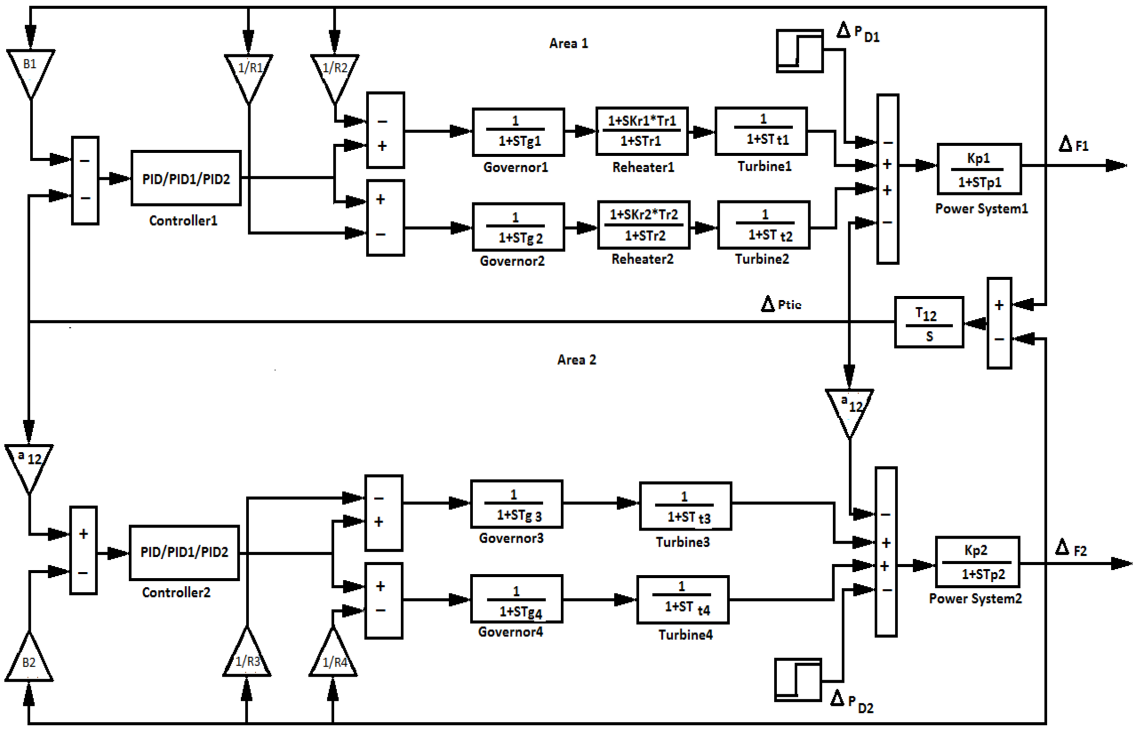

Figure1: transfer function model of a two unequal area thermal system.

2.2. System under study

Two unequal area thermal system of area capacity, Area1:2000MW, Area2:10000MW. While modelling interconnected areas of different capacities, a parameter $a_{12}=-P_{r1}/P_{r2}$ are considered in the two area system. Different controller like proportional plus integral plus derivative (PID), Proportional plus integral plus derivative with structure1 (PID1), proportional plus integral plus derivative with structure 2 (PID2) are investigated separately. The nominal parameters of PID are taken form [2].

Simulations were conducted on an Intel, core i-5 core CPU, of 2.4 GHz and 4GB RAM computer in the MATLAB8.3.0.532 (R2014a; The math work, Natick, Massachusetts, USA) environment.

2.3. Controller Structure

To control the frequency, PID/PID1/PID2 controllers are provided in each area. The structure 1and2of PID(PID1&PID2) controller are shown in fig.2(a) and 2(b), where K_P,K_I and K_D are proportional, integral and derivative gains respectively.

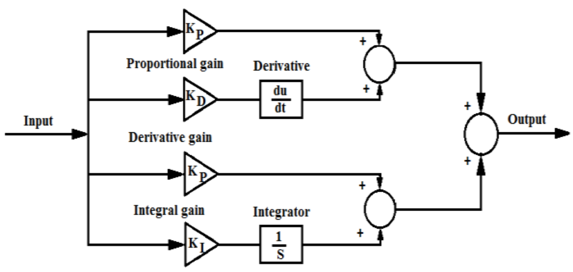

Figure 2 (a): Structure 1 of PID controller

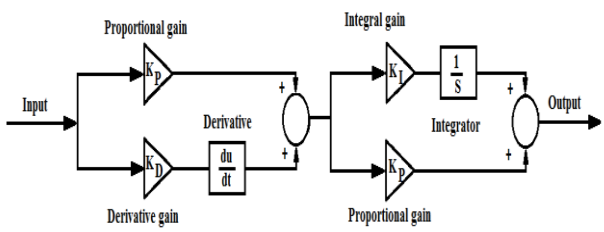

Figure 2(b): Structure 2 of PID controller

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 02, February-2017

3. RESULTS AND SIMULATIONS:

Table 1 shows different controller values of PID, PID structure 1 and PID structure 2 values.

Table 1.PID/PID1/PID2 controller parameters.

Sl.No.	Controller	Gain	Area 1	Area 2
1	PID	KP	1.9999	1.6150
		KI	1.9999	0.4390
		KD	0.7201	1.6449
2	PID1	KP	1.7039	1.7789
		KI	1.9479	0.3080
		KD	1.9299	0.7699
		KP	1.9829	0.8520
3	PID2	KP	2.0003	0.5579
		KI	1.9811	0.9341
		KD	1.7381	0.9120
		KP	2.0111	0.4169

3.1. Step increase in demand of area 1(ΔP_{D1})

As the first test case, a step increase in load of 10% in area 1 is considered and the system dynamic response i.e. the frequency deviation of the area 1(Δf_1),the frequency deviation of area2 (Δf_2), tie line power deviation are shown in figures 3-5. It is clear from figures 3-5 that stability is improved and frequency error, tie-line power deviation gets reduced.

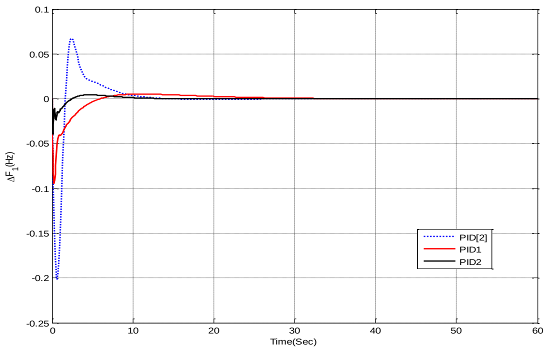

Figure 3.Frequency deviation of area-1 for 10% step increase in load demand in area -1.

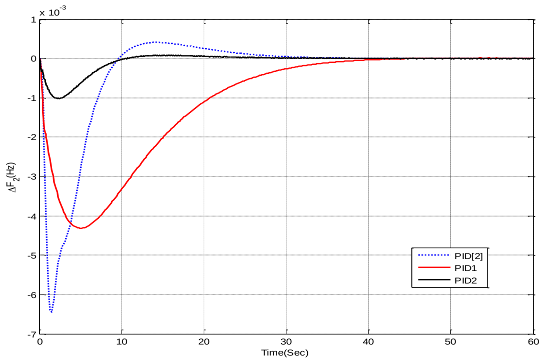

Figure 4. Frequency deviation of area-2 for 10% step increase in load demand in area -1.

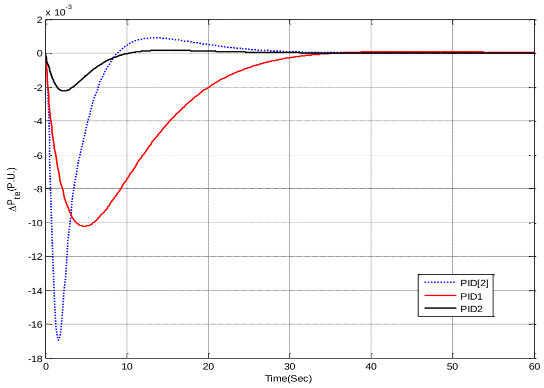

Figure 5.Tie-line power deviation for 10% step increase in load demand in area -1.

3.2. Step increase in demand of area 2(ΔP_{D2})

In this case, a step increase in load of 10% in area 2 is considered and the system dynamic response i.e. the frequency deviation of area1, the frequency deviation of area2, tie line power deviation is shown in figures 6-8. From these figures it can be seen that the under shoot, over shoot are also reduced which improves the stability.

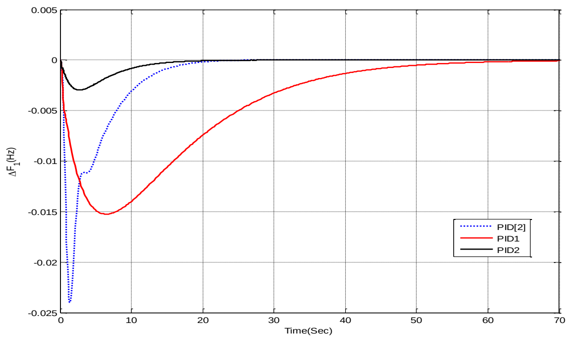

Figure 6. Frequency deviation of area-1 for 10% step increase in load demand in area -2.

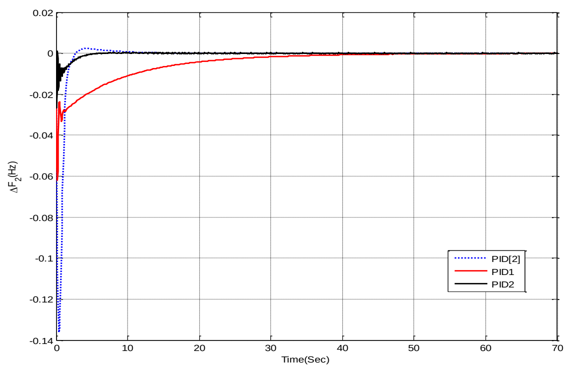

Figure 7. Frequency deviation of area-2 for 10% step increase in load demand in area -2.

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Vol. 6 Issue 02, February-2017

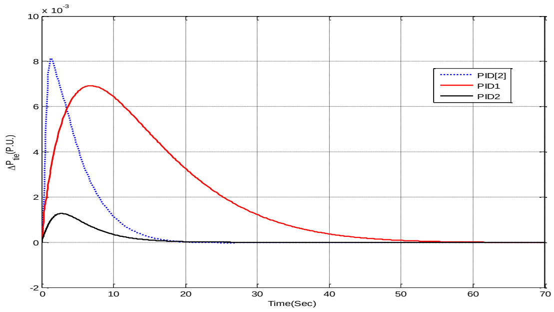

Figure 8.Tie-line power deviation for 10% step increase in load demand in area -2.

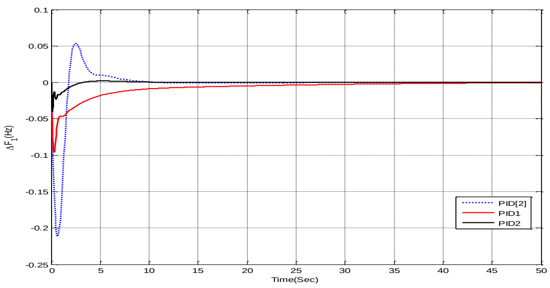

Figure 9. Frequency deviation of area-1 for 10% step increase in load demand in both areas.

3.3 Step increase in demand of the first and second area simultaneously

In this case a step increase in load of 10%in area 1 and area2 simultaneously are considered and system dynamic response is shown in figure(9-11) it is clear from figure(9-11) the best dynamic performance is obtained by PID structure 1 and PID structure 2 compared to the conventional PID controller in terms of settling times in frequency and tie-line power deviations.

Hence it can be concluded that the design structure 1 and structure 2 of PID controllers are robust perform satisfactorily under different operating condition.

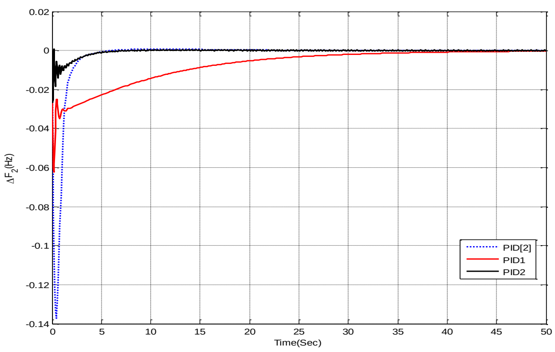

Figure 10.Frequency deviation of area-2 for 10% step increase in load demand in both areas.

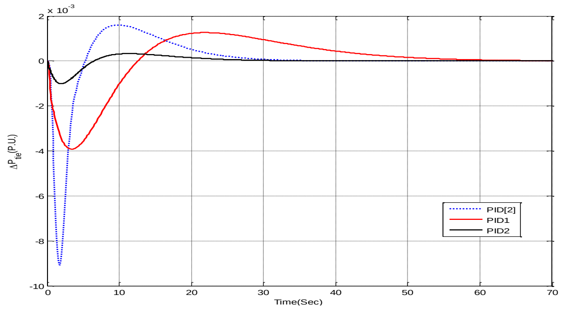

Figure 11.Tie-line power deviation for 10% step increase in load demand in both areas.

4. CONCLUSION:

In this paper, an attempt has been made to use different structure of Proportional plus Integral plus Derivative controllers (PID1&PID2) in AGC for two unequal area thermal system, which provides much better performances than conventional PID controller. Simulation result emphasis that the designed structured 1 and 2 of PID controller gives the better response and the system gets stable in terms of frequency deviation and tie line power deviation within shortest settling time. It has the potentiality of implementation in real time environment.

APPENDIX:

The nominal parameters of the system investigated are as follows : Two-unequal –area thermal system F=60HZ,Pr1=2000MW,Pr2=10000MW,B1=0.4249, B2=0.4249,R1=2.4,R2=2.4,R3=2.4,R4=2.4,Tg1=0.08,Tg2 =0.085,Tg3=0.085,Tg3=0.085,Tg4=0.085,Tt1=0.35,Tt2=o. 35,Tt3=0.35,Tt4=0.35,Kr1=0.5,Kr2=0.5,Tr1=10,Tr2=10,K p=120,T12=0.0866,Tp1=20,Tp2=20

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