

Application of Pattern Search Algorithm based Automatic Generation Control of an Interconnected Power System

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Abstract: This paper demonstrates the advantage of the selection of the Pattern Search algorithm (PS) in the design of a Proportional-Integral controller used in Automatic Generation Control for a two area non-reheat interconnected thermal system. The design problem involves the implementation of PS algorithm to find out the value of parameters of the controller of the proposed power system. Here we have implemented three objective functions by using ITAE, damping ratio of dominant eigenvalues and settling time with weight coefficients for the design problem to get an optimized parameter of the Proportional Integral controller. The robustness of the designed PI controller using the Pattern search algorithm has been demonstrated after comparing other PI controllers using various optimization techniques like Genetic Algorithm, Bacteria Foraging Optimization Algorithm for the system under study. Further, best objective function uses the PS optimization algorithm in PI/PID controller parameters, tuning is obtained in presence of physical constraints like governor dead band non linearity of the proposed two area power system. The modified model to test the sensitivity analysis of PI/PID controller by using different loading condition to show the PID controller performance of frequency and tie line power deviation improved better as compared to the PI controller of the same power system. Further, it is extended to multi-area multi-source power for effectiveness and robustness of the system under different disturbances to check the transient stability.

Keywords: Automatic Generation Control (AGC), two-area power system, PI/PID controller, Pattern Search (PS) algorithm. Governor dead band

1. Introduction

The objective of the interconnected power systems to maintain the continuous power supply with good quality to all the consumer in the system. There for it need the steady operation of an interconnected power systems, constant tie-line power exchange and constant frequency is required. An automatic generation controller (AGC) helps to keep frequency of the system and also tie-line power flow of each area in desirable limit. It also helps to reduce area control error-ACE due to the frequency and tie line power deviations at low value [1-2]. For this reason, an Automatic Generation Control output is considered to a linear combination of power interchange and frequency variation. Generally, AGC drives ACE to zero which infers that variation of frequency and tie-line power flows are made zeros [3-4]. Automatic Generator Control is showing controlling the control function making the difference between the generation of an area and the randomly changing the load of that area to zero. This makes the frequency of system and tie-line power flow to be in satisfactory limiting value. The different type of control strategies has been considered in AGC for maintaining the tie line power and frequency of the system at their desired value during normal and fault conditions. A classical PI and PID controller are the best choices of engineer' due to simplicity in structure, reliability, less cost, development

effort is very nominal and it needed lower user skill and also it overs simplified dynamic model. The may artificial intelligence optimizations are available in the present day for the optimization of PI and PID controller of AGC in interconnected power system In the literature survey on AGC with various control aspects affecting the smooth functioning of AGC has been carried out for frequency stability analysis [5]. Furthermore, researchers have attempted various AGC strategies using BES/SMES, FACTS devices, PV systems. Significant research work is being carried out to design an efficient AGC systems implementing control theory, Fuzzy logic, ANN and ANFIS approach [6-8]. It is also found that optimization method can be used to tune PI controller to improvise the performance of an Automatic Generator Controller. As a result, numerous optimization techniques have been implemented for comparative studies on the performance of AGC. The use of artificial intelligent techniques is not based on any model theory and arithmetic equations and hence, it is wide open to the knowledge of experts in problem formulation. On the other hand, various modern optimization techniques involve in models for any problem in the power systems [8-9]. For controller design, particle swarm optimization [10-11], multi-objective evolutionary algorithm, bacterial foraging and many more has been implemented to get an improvised performance of integral controller [12-17]. The PI controller based bacterial foraging optimization algorithm (BFOA) has

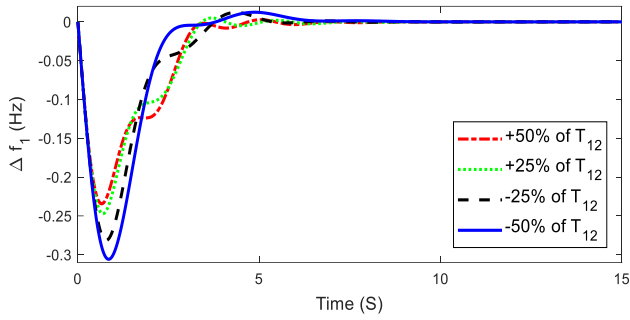


Fig.15.Frequency deviation in area-1 for change T_{12}

5.4 Analysis of Two Area Power System in Presence of Governor Dead Band

In this analysis, the simulation model of two area power system as shown in Fig-1 having remain same structure but only modification of the model is that a physical constraint of governor dead band considered in this system [9,22-23]. In the new power system model in presence of the governor dead-band non-linearity which is affect the dynamic performance of oscillation of power system. Some researcher has been attempted the effect of power oscillation in presence of this non linearity [9] and the transfer function G_g can be represented as follows

$$G_g = \frac{0.8 - \frac{0.2}{s}}{1 + sT_g}$$

TABLE IV:
THE SETTLING TIME, OVERSHOOT AND UNDERSHOOT OF FREQUENCY AND TIE LINE POWER DEVIATION OF PI AND PID CONTROLLER

PARAMETERS		PI CONTROLLER	PID CONTROLLER	PI CONTROLLER	PID CONTROLLER	PI CONTROLLER	PID CONTROLLER
J3		Case-1		Case-2		Case-3	
T_s (sec)	Δf_1	21.5	6.9	22.1	7.2	21.5	9.1
	Δf_2	22.1	6.7	22.5	7.1	20.5	9.2
	ΔP_{Tie}	23.5	7.1	24.2	8.5	20.6	9.2
Max. Overshoots (MOS)	Δf_1	0.010	0.003	0.005	0.001	0.004	0.001
	Δf_2	0.006	0.002	0.010	0.002	0.008	0.002
	ΔP_{Tie}	0.001	0.000	0.008	0.003	0.0083	0.0025
Max. Undershoots (MUs)(-ve)	Δf_1	0.032	0.018	0.031	0.011	0.035	0.009
	Δf_2	0.031	0.011	0.031	0.017	0.032	0.016
	ΔP_{Tie}	0.008	0.003	0.001	0	0.005	0

Case-1: Step increase in load in area-1

To studies the dynamic performances of the PI and PID controller of the proposed new power system model in presence of governor dead band non linearity which employing PS algorithm using the best objective function (J_3) as compared to objective function of J_1 and J_2 . As in Case-1, a step increase in load is same as in Case-A taken in the previous analysis and the system dynamic responses of PI/PID controller are shown in Figs. 16-21. It is clear that system responses in PID controller better performance as compared to PI controller of the same system in term of settling time, overshoot and undershoot of frequency deviations and tie line power the system

The proposed modified simulation model is run in same procedure as in the previous analysis under condition of a step load disturbance of 0.1p.u considered in the area-1 of the system. The optimization processes are continuing with minimum 50 times run and the best global value of objective function becomes as final value obtained in PI and PID controller parameters. The best values of control parameters of the proposed power system by considering the objective function (J_3) are obtained as shown in Table-III.

TABLE III
CONTROLLER PARAMETERS IN THE MODIFIED POWER SYSTEM IN PRESENCE OF GOVERNOR DEAD BAND NON-LINEARITY

TUNING PARAMTERS			J3	J3
PI Controller	KP	Proportional Gain	-0.3221	-0.4743
	KI	Integral Gain	0.2974	0.3104
PID Controller	KP	Proportional Gain	0.6954	0.2286
	KI	Integral Gain	0.8701	0.8835
	KD	Derivative Gain	0.6943	0.5261

The corresponding performance indexes settling time, maximum overshoots and maximum undershoot of frequency deviations and tie lie power with the above varied system conditions are given in Table IV. To study the dynamic performance of the proposed modified model in presence of governor dead band non linearity by considering the three step load disturbances as in case-1, case-2 and case-3 just like in absence of governor dead band of the same system.

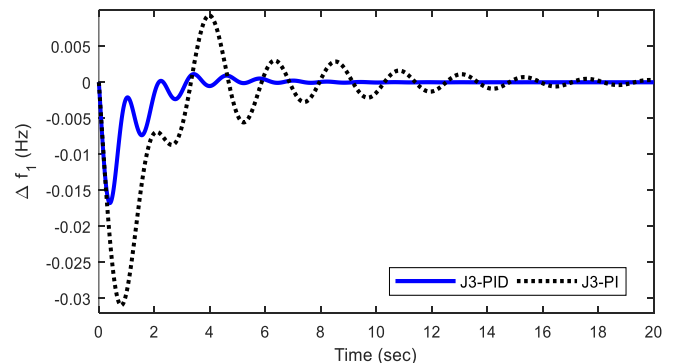


Fig.16. Variation of frequency in area-1 in presence of physical constraint

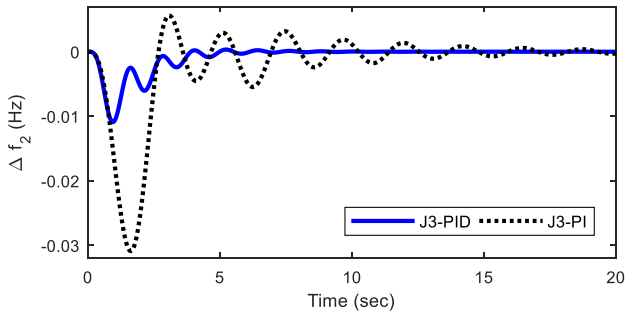


Fig.17. Variation of frequency in area-2 in presence of physical constraint

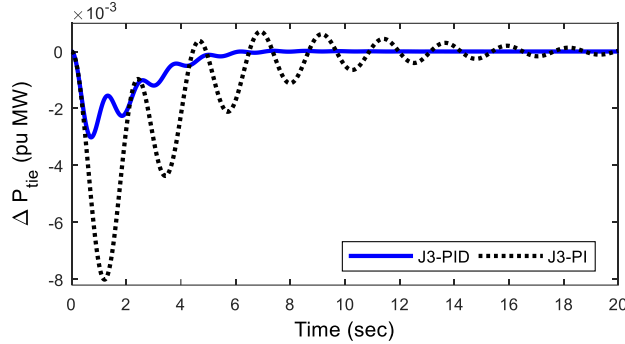


Fig.18. Variation of Tie line power with governor dead band physical constraint

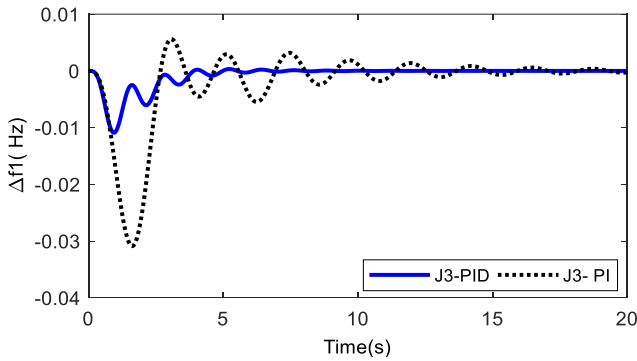


Fig.19. Variation in frequency as in Case-2 in presence of physical constraint

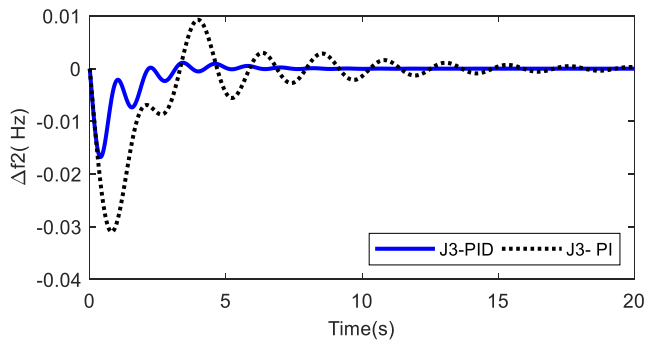


Fig.20. Variation in frequency as in Case-2 in presence of physical constraint

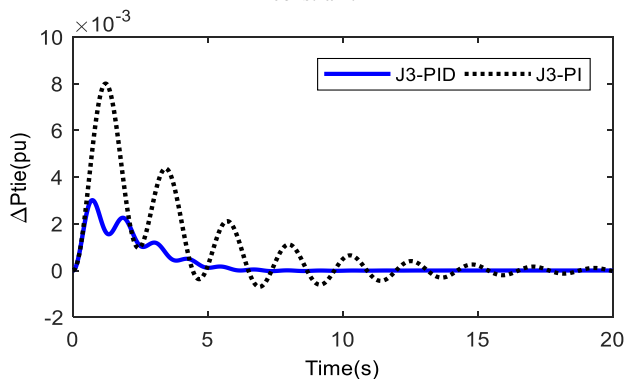


Fig.21. Variation in tie line power as in Case-2 with governor dead band physical constraint

Case 3: Step load change in area-1 and area-2

In this Case 3, the performance of PI and PID controller can be studied under the disturbances same as in Case-C of the proposed power system. The system responses under this condition are shown in Figs. 22-24 which are clear that the proposed controllers are robust and perform satisfactorily performances in PID controller as compared to PI controller subjected to load disturbance changes in both areas simultaneously.

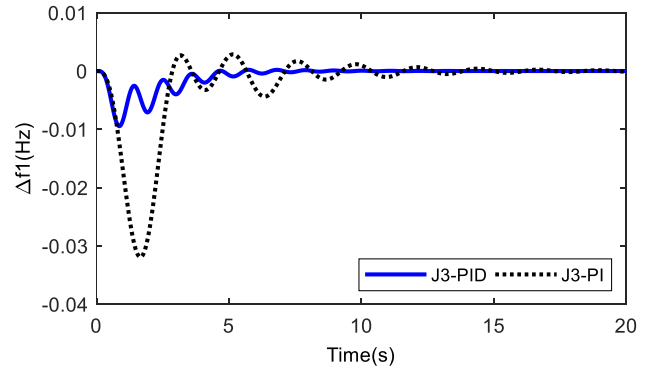


Fig.22. Variation of frequency as in Case-3 with governor dead band physical constraint

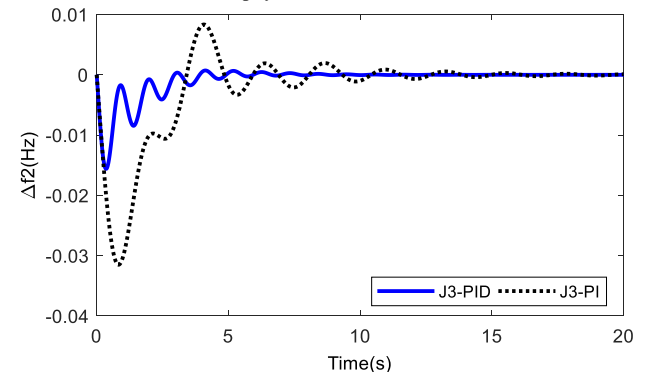


Fig.23. Variation of frequency as in Case-3 with governor dead band physical constraint

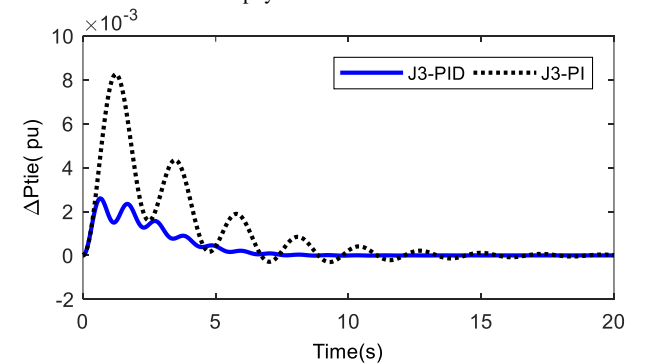


Fig.24. Variation of tie line power as in Case-3 with governor dead band physical constraint

5.5 Sensitivity Analysis

It is further investigated the sensitivity analysis under extensive changes in operation condition and also change in system parameters to test the robustness of the proposed new power system in presence of physical constraint of governor dead band. In this analysis only operating loading condition changes from nominal value to $\pm 50\%$ and $\pm 25\%$ in step of the power system of PI and PID controller. The PI and PID controller parameter obtained under $+50\%$, -50% , $+25\%$ and -25% of nominal loading by using PS optimization algorithm with objective function is considered in presence of perturbation same as in Case-1. The

optimized controller of PI and PID parameters are obtained as in the given Table-V. The Figure 25-36 shows that the system responses of PID controller gives better performances as compared to PI controller of the same system under operating loading condition changes from nominal value to $\pm 50\%$ and $\pm 25\%$ in step of the proposed power system. The table-VI shows depict undershoot, overshoot and settling time of $\Delta f_1, \Delta f_2$ and ΔP_{tie} for PI and PID controllers of the proposed power system. It is clear that settling time, overshoot and undershoot is improved better in PID controller as compared to PI controller of the same power system.

TABLE V

OPTIMIZED CONTROLLER PARAMETERS UNDER FOUR NOMINAL LOADING CONDITIONS

TUNING CONTROL PARAMETERS		+25%	+50%	-25%	-50%
PI	KP	-0.4972	-0.4761	-0.4654	-0.4568
	KI	0.2344	0.1974	0.1257	0.1258
PID	KP	0.2361	0.6012	0.1750	0.3442
	KI	0.576	0.8833	0.9031	0.8865
	KD	0.5601	0.7453	0.4972	0.5672

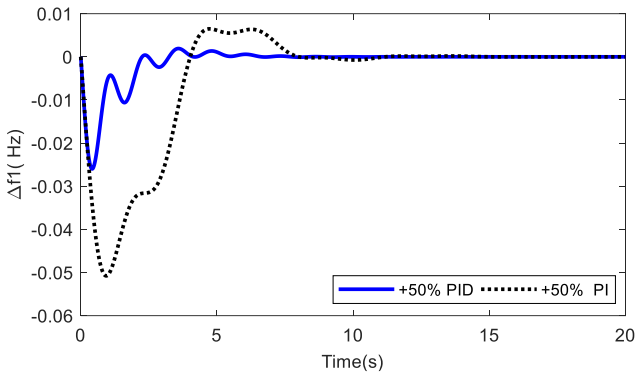


Fig.25. Deviation of frequency in area-1 for condition same as Case-1

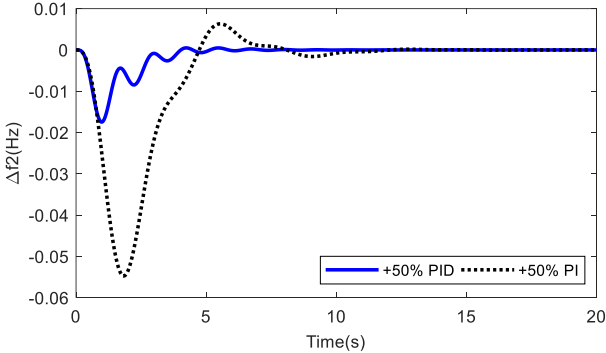


Fig.26. Change in frequency in area-2 for the condition same as Case-1

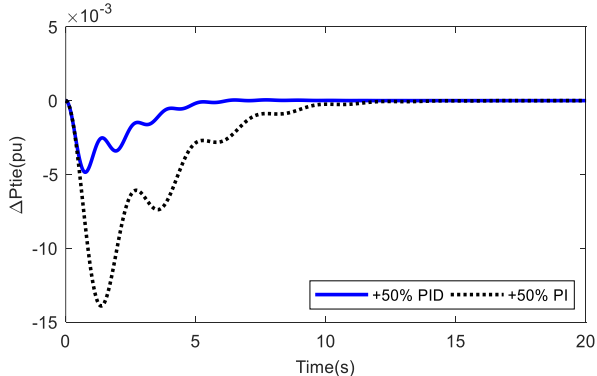


Fig.27. Change in tie line power for the condition same as Case-1

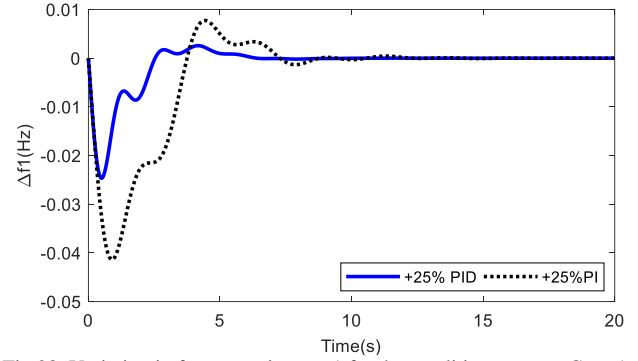


Fig.28. Variation in frequency in area-1 for the condition same as Case-1

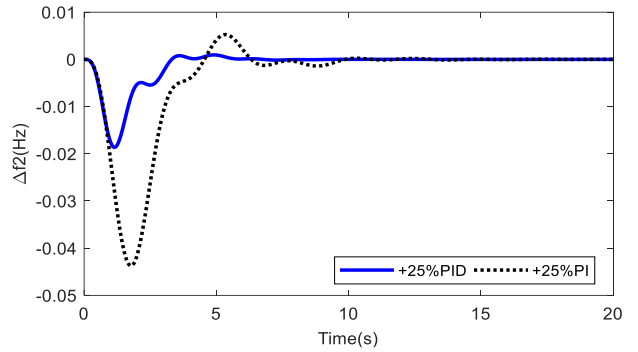


Fig.29. Variation in frequency of area-2 for the condition same as Case-1

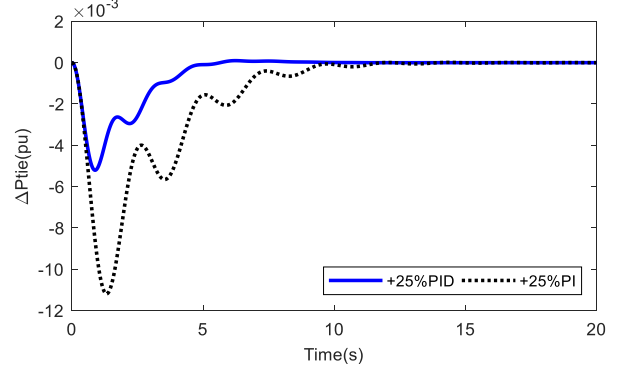


Fig.30. Variation in tie line power for the condition same as Case-1

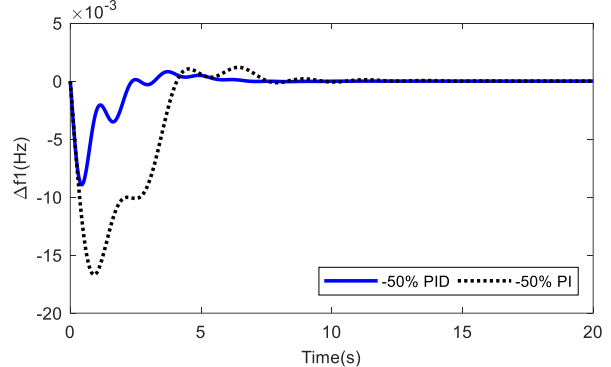


Fig.31. Variation in frequency of area-1 for the condition same as Case-1

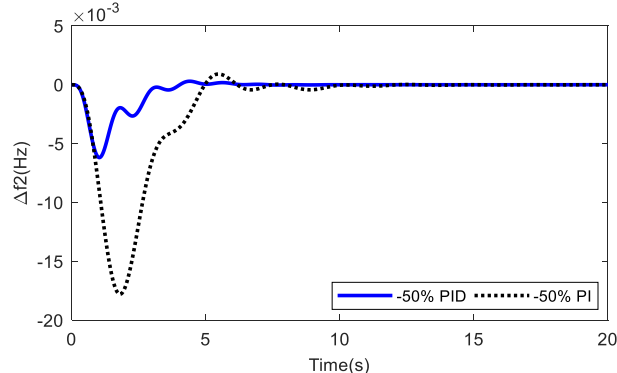


Fig.32. Variation in frequency of area-2 for the condition same as Case-1

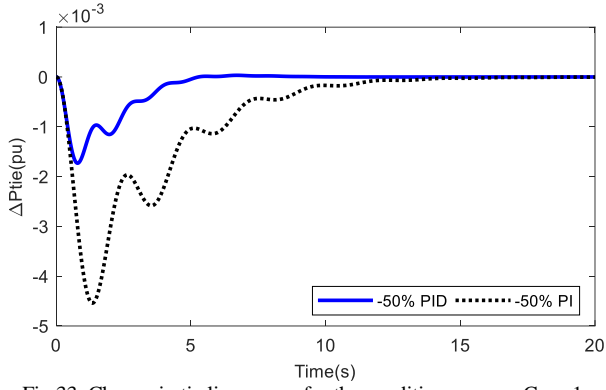


Fig.33. Change in tie line power for the condition same as Case-1

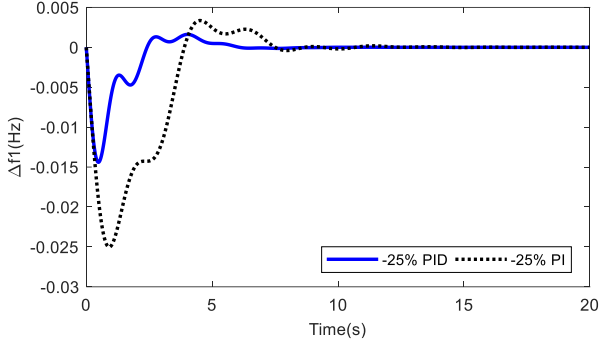


Fig.34. Change in frequency of area-1 for the condition same as Case-1

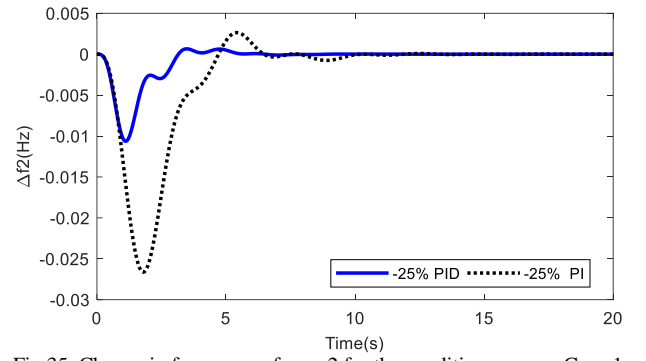


Fig.35. Change in frequency of area-2 for the condition same as Case-1

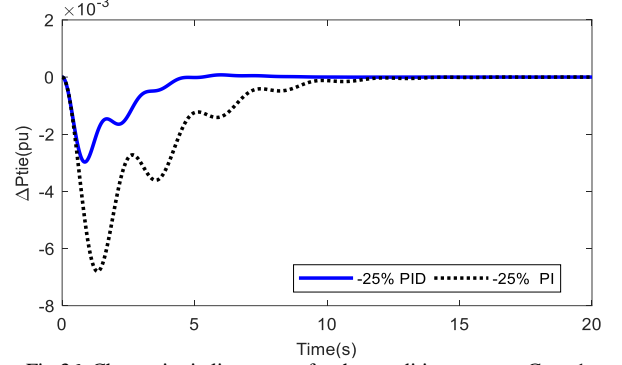


Fig.36. Change in tie line power for the condition same as Case-1

TABLE VI:

DEPICTS UNDERSHOOT, OVERSHOOT AND SETTLING TIME OF Δf_1 , Δf_2 And ΔP_{tie} FOR PI AND PID CONTROLLERS

PARAMETERS		+25%	+50%	-25%	-50%	+25%	+50%	-25%	-50%
J3		PI Controller				PID Controller			
T_s (sec)	Δf_1	12.7	11	12.1	12.4	8.1	7.2	8.1	7.5
	Δf_2	13.1	13	11.9	12.3	7.3	7.7	7.0	7.1
	ΔP_{Tie}	14.2	13.8	14.1	15.8	7.7	7.1	8.2	7.9
Max. Overshoots (MOS)	Δf_1	0.008	0.008	0.004	0.004	0.003	0.005	0.002	0.002
	Δf_2	0.005	0.007	0.003	0.002	0.001	0.002	0.001	0.001
	ΔP_{Tie}	0.001	0.014	0.000	0.000	0.002	0.001	0.001	0.001
Max. Under shoots (MUs)(-ve)	Δf_1	0.041	0.051	0.025	0.017	0.024	0.025	0.013	0.008
	Δf_2	0.045	0.057	0.027	0.018	0.018	0.018	0.011	0.0065
	ΔP_{Tie}	0.0112	0.014	0.007	0.004	0.005	0.004	0.003	0.001

5.6 Extension to Multi-area Multi-source Power System

The study is further extended to a multi-area multi source power of transfer function model interconnected by transmission line as shown in Fig. 4. Each area comprises reheat thermal, hydro and gas generating units. The nominal parameters of the system are given in reference [24]. The PI and PID controllers considered in each unit of the anticipated model of the multi area power system. The objective function J2 and J3 of the two-area power system is same objective function considered in multi area multi source power system. The control inputs of each unit of the power system U_T , U_H and U_G with PID structure are obtained as:

$$U_T = K_{P1}AEC_1 + K_{I1} \int AEC_1 + K_{D1} \frac{dAEC_1}{dt} \quad (16)$$

$$U_H = K_{P2}AEC_1 + K_{I2} \int AEC_1 + K_{D2} \frac{dAEC_1}{dt} \quad (17)$$

$$U_G = K_{P3}AEC_1 + K_{I3} \int AEC_1 + K_{D3} \frac{dAEC_1}{dt} \quad (18)$$

The optimization was repeated 50 times using tuned PS algorithm and the best final solution among the 50 runs is chosen as proposed PI and PID controller parameters. The best final tuning controller parameters corresponding to the minimum objective function as shown in Table VII. The performance index in terms of settling time, peak overshoot, minimum damping ratio and ITAE value for under objective functions J2 with PID and J3 with PI and PID controllers of the power system are shown in Table VIII under 1% step load perturbation in area-1 of the system.

To study the dynamic performance of the system under 1% step load perturbation (SLP) in area 1 is considered at time $t = 0$ sec. The system dynamic performances of as shown in Fig 37-39 for the objective function J3 of PI/PID controller compared with the objective J2 of PID controller under this condition. It is clear that from the Fig 37-39 that settling time, overshoot of frequency deviation ΔF_1 , ΔF_2 and tie line power ΔP_{tie} are improved better in case of objective function (J3) used in PID controller as compared the objective function (J2) of same PID controller of the same power system. It is also demonstrated that both J2 and J3 objective function based PID controller is superior performance as compared to J3 of PI controller in term of overshoot and settling time of frequency and tie line power.

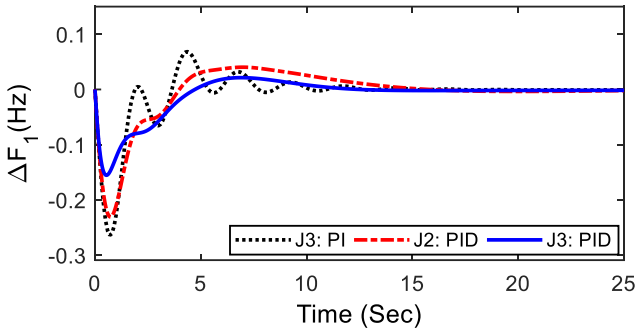


Fig. 37. Change in frequency of area-1 for 10 % change in area-1

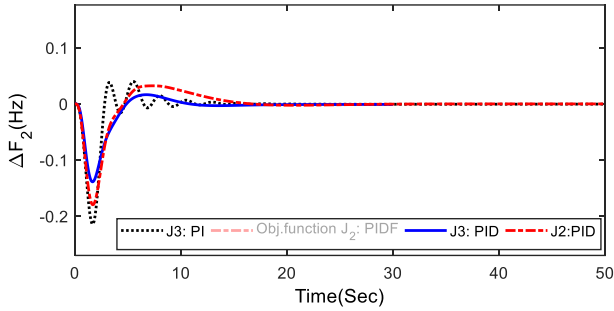


Fig. 38. Change in frequency of area-2 for 10 % change in area-1

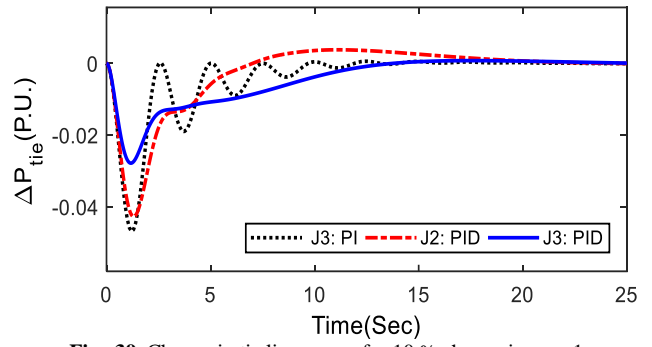


Fig. 39. Change in tie line power for 10 % change in area-1

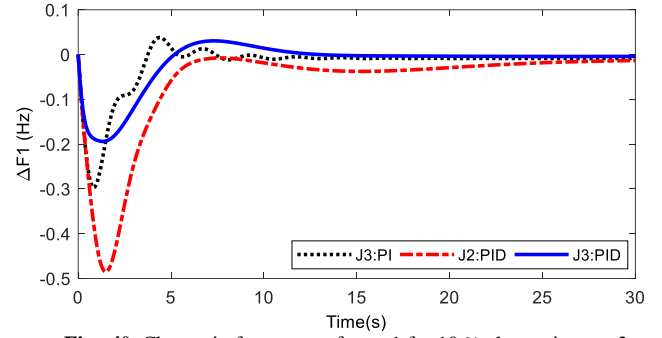


Fig. 40. Change in frequency of area-1 for 10 % change in area-2

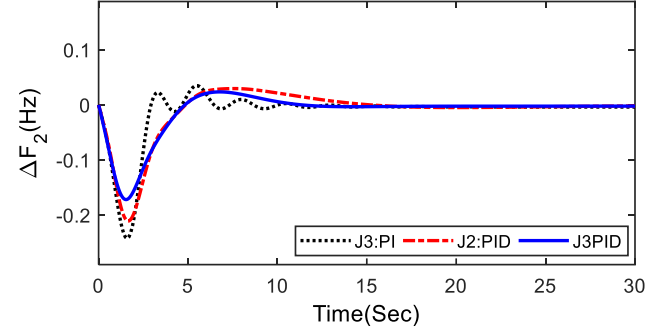


Fig. 41. Change in frequency of area-2 for 10 % change in area-2

Similarly, the dynamic responses of frequency and tie line power deviation responses of the system for a 1% step load perturbation (SLP) in area 2 occurring at time $t = 0$ sec are shown in Figs. 40-42.

TABLE-VII: PI(J3) AND PID(J3) CONTROLLER PARAMETERS OF MULTI AREA MULTI SOURCE POWER SYSTEM.

Controller/Objective function Parameter	PI (J_3)	PID (J_2)	PID (J_3)
KP1	-1.8611	-1.7251	-1.6845
KP2	1.7566	-0.6001	0.1976
KP3	-0.1011	-0.6218	-1.5679
KP4	-1.4680	-1.3679	1.1053
KP5	1.9015	-0.1007	0.8104
KP6	0.5994	-0.1984	-0.5890
KI1	-0.7896	-1.1102	-0.7991
KI2	1.1002	-1.1924	-1.0236
KI3	-1.8721	-1.1145	-1.6047
KI4	-0.2912	-1.5993	-0.4912
KI5	1.0717	-0.8967	1.5381
KI6	-1.0123	-1.1893	-1.1503
KD1	-	-0.2986	-1.7825
KD2	-	-1.8891	-0.0227
KD3	-	-1.1178	-1.5172
KD4	-	-0.8911	-0.3873
KD5	-	0.4113	-1.5704
KD6	-	-1.3762	-1.1946

TABLE 6: PERFORMANCE INDEX WITH DIFFERENT OBJECTIVE FUNCTIONS AND CONTROLLER STRUCTURE

Performance index Controller/Objective function	T _s (sec)			Peak Overshoot			ζ	ITAE
	ΔF_1	ΔF_2	ΔP_{tie}	ΔF_1	ΔF_2	ΔP_{tie}		
PI: J3	17.5	21.4	23.6	0.0714	0.0642	0.0037	0.4581	5.1204
PID: J2	16	19	21.5	0.0468	0.0538	0.0045	0.1784	6.8362
PID: J3	13	16.5	19.7	0.3105	0.0351	0.0005	0.1233	3.4728

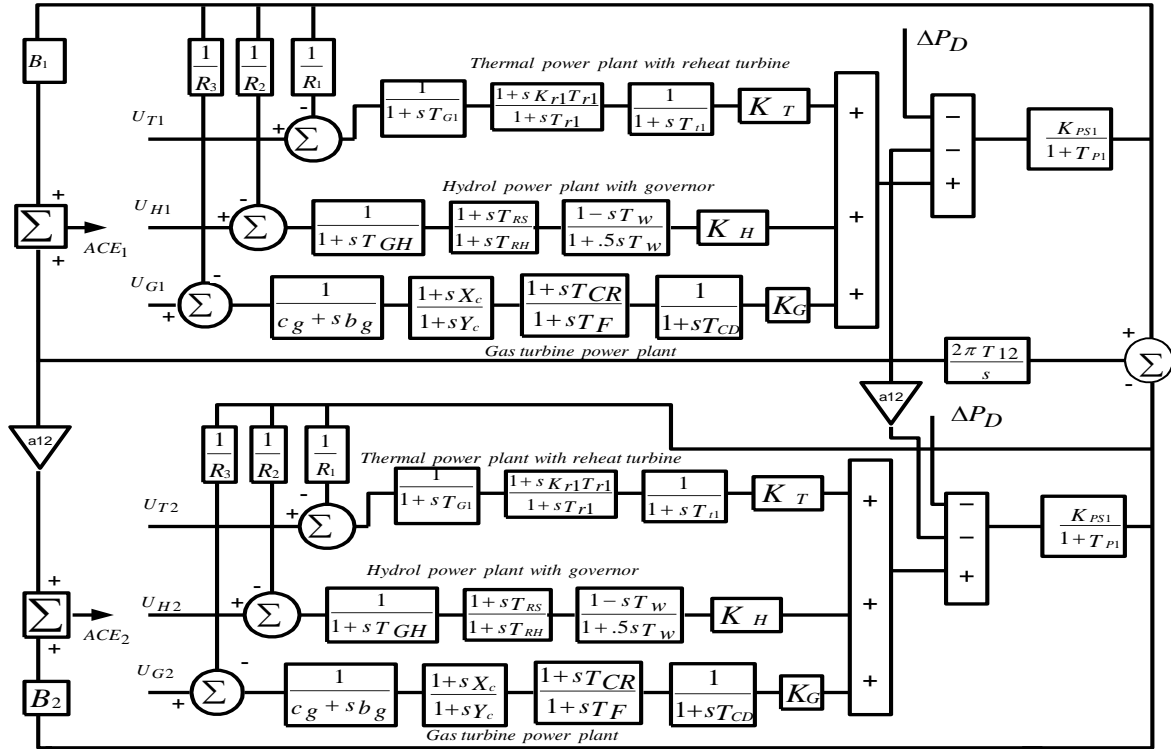


Fig.23. Multi Machine Multi sources two area power system

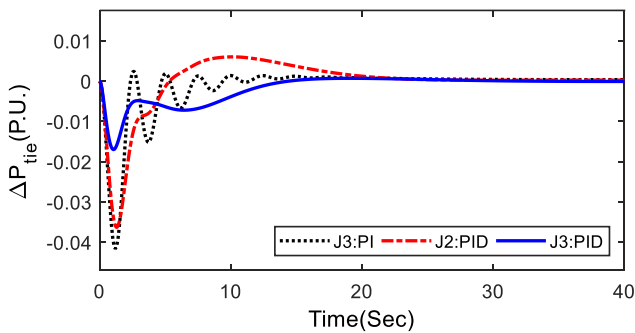


Fig. 42. Change in tie line power for 10 % change in area-2

Similarly, the dynamic frequency and tie line power deviation responses of the system for a 1% step load perturbation (SLP) in area 2 occurring at $t = 0$ sec are shown in Figs. 40-42. It is clear from Figs. 40-42 that settling time and overshoot of frequency deviation ΔF_1 and ΔF_2 , tie line power ΔP_{tie} gives the better transient performance in objective function (J3) used with PID controller as compared to objective function (J2) used of same PID controller but however the objective function used in J2 and J3 in PID controller better performance as compared to objective function(J3) used in PI controller of the same multi machine power system.

6. Conclusion

This article depicts the advantages of employing a pattern

search algorithm technique to optimize proportional-integral controller used in AGC of an interconnected two area power system. The proper tuning of the parameters of PI controller with heuristic optimization techniques involves to choose of suitable objective function of given power system. Various types of objective functions employing ITAE, damping ratio of dominant eigenvalues and settling time with appropriate weight coefficients are used to improve the robustness of the chosen controller. The improved dynamic performance is seen using new objective functions in the proposed control strategy. The advantage of this designed approach can be found on comparison of the results of PI controller with BFOA, GA under different perturbation of change in step load of the system. The proposed approach is further extended by considering the physical constraints of governor dead band in the power system. It is clear that by physical constraint nonlinearity included the system becomes a more accurate power system and the change in performance index is quite prominent from the analysis. We also investigated the sensitivity analysis, demonstrated to show the robustness of the system and we observed that in presence of governor dead band nonlinearity with PID tuning controller superior performance is achieved compared to PI controller under different range of nominal loading condition ($\pm 25\%$ and $\pm 50\%$) of the system. Lastly, it is further extended to multi-area multi-

source power system to check the effectiveness of the analysis of the system and it is observed that transient performance in objective function (J3) used with PID controller is achieved compared to objective function (J2) used of same PID controller but however the objective function used in J2 and J3 in PID controller better performance as compared to objective function(J3) used in PI controller of the same multi machine power system.

APPENDIX.

Parameters of power System model for two area system.	Values
$B_1 \cdot B_2$	$B_1 = B_2 = 0.045$ p.u. MW/Hz
R_1, R_2	$R_1 = R_2 = 2.4$ Hz/p.u
T_{G1}, T_{G2}	$T_{G1} = T_{G2} = 0.08$ (s)
T_{T1}, T_{T2}	$T_{T1} = T_{T2} = 0.3$ (s)
K_{PS1}, K_{PS2}	$K_{PS1} = K_{PS2} = 120$ Hz/p.u. MW
T_{PS1}, T_{PS2}	$T_{PS1} = T_{PS2} = 20$ (s)
T_{12}	$T_{12} = 0.545$ pu
a_{12}	$a_{12} = -1$

References

- [1] N. Jaleeli, L. S. VanSlyck, D. N. Ewart, L. H. Fink and A. G. Hoffmann, "Understanding automatic generation control," in IEEE Transactions on Power Systems, vol. 7, no. 3, pp. 1106-1122, Aug. 1992
- [2] P. Kundur, Power System Stability and control, TMH, 8th reprint 2009.
- [3] O.I. Elgerd, Electric energy systems theory. An introduction. New Delhi: Tata McGraw-Hill; 1983
- [4] C. E. Fosha and O. I. Elgerd, "The Megawatt-Frequency Control Problem: A New Approach Via Optimal Control Theory," in IEEE Transactions on Power Apparatus and Systems, vol. PAS-89, no. 4, pp. 563-577, April 1970
- [5] D.K. Chaturvedi, P.S. Satsangi, P.K. Kalra, Load frequency control: a generalized neural network approach, Elect. Power Energy Syst. 21 (6) (1999) 405–415.
- [6] H.L. Zeynelgil, A. Demiroren, N.S. Sengor, The application of ANN technique to automatic generation control for multi-area power system, Electr. Power Energy Syst. 24 (5) (2002) 345–354.
- [7] S.R. Khuntia, S. Panda, Simulation study for automatic generation control of a multi-area power system by ANFIS approach, Applied Soft Computing, 12 (1) (2012) 333-341.
- [8] Junfeng Zhao, Jian Li and Cuirong Huang, Multi-objective Optimization Model of Hydrodynamic Sliding Bearing Based on MOPSO with Linear Weighting Method, IAENG International Journal of Computer Science, Volume 48, Issue 3: September 2021
- [9] Gonggui Chen, Xilai Zhao, Yi Xiang, Xianjun Zeng and Hongyu Long, Research on Multi-objective Active Power Optimization Simulation of Novel Improved Whale Optimization Algorithm, IAENG International Journal of Applied Mathematics, Volume 51, Issue 3: September 2021.
- [10] S.P. Ghosal, Optimization of PID gains by particle swarm optimization in fuzzy based automatic generation control, Electr. Power Syst. Res. 72 (3) (2004) 203–212.
- [11] H. Gozde, M.C. Taplamacioglu. Automatic generation control application with craziness based particle swarm optimization in a thermal power system, Int. J. Elect. Power Energy Syst. 33 pp.8–16, 2011
- [12] Mostafa, Mohamed & Attia, Mahmoud & Mekhamer, S. & Mostafa, Mahmoud, "Application of Different Optimization Techniques to Load Frequency Control with WECS in a Multi Area System", Electric Power Components and Systems, 2018
- [13] S. Mishra, "Maiden application of bacterial foraging-based optimization technique in multiarea automatic generation control," 2012 IEEE Power and Energy Society General Meeting, San Diego, CA, USA, 2012
- [14] J. Nanda, S. Mishra, L.C. Saikia, Maiden application of bacterial foraging-based optimization technique in multiarea automatic generation control, IEEE Trans. Power Syst. 24 (2) (2009) 602–609.
- [15] S. Panda, Multi-objective PID controller tuning for a FACTS-based damping stabilizer using non-dominated sorting genetic algorithm-II, Int. J. Elect. Power & Energy Sys., 33 (2011) 1296-1308.
- [16] H. Golpîra, H. Bevrani and H. Golpîra, Application of GA optimization for automatic generation control design in an interconnected power system, Energy Conversion and Management 52 (2011) 2247–2255.
- [17] Elmenfy, Tawfiq A Genetic Algorithm for Optimum Design of PID Controller in Load Frequency Control", 2012 World academy of Science, Engineering and Technology, Vol 6
- [18] E.S. Ali, S.M. Abd-Elazim, Bacteria foraging optimization algorithm-based load frequency controller for interconnected power system, Elect. Power and Energy Syst. 33 (2011) 633–638
- [19] Rout UK, Sahu RK, Panda S. Design and analysis of differential evolution algorithm based automatic generation control for interconnected power system, Ain Shams Eng J (2012).
- [20] M. F. AlHajri and M. E. El-Hawary, "Pattern search optimization applied to convex and non-convex economic dispatch," 2007 IEEE International Conference on Systems, Man and Cybernetics, Montreal, QC, Canada, 2007, pp. 2674-2678,
- [21] K. Ogatta, Modern control engineering. NJ, USA: Prentice Hall; 1990
- [22] Saikia LC, Nanda J, Mishra S. Performance comparison of several classical controllers in AGC for multi-area interconnected thermal system. Int J Electr Power Energy Syst 2011; 33:394–401.
- [23] Panda S, Yegireddy NK, Automatic generation control of multi-area power system using multi-objective non-dominated sorting genetic algorithm-II, Int J Electr Power Energy Syst 2013;53:54-63.
- [24] Parmar K.P.S., Majhi S., Kothari DP., Improvement of Dynamic Performance of LFC of the Two Area Power System: An Analysis using MATLAB, Int. Journal of Comp App. 40(10) (2012) 28-32

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