Improved Particle Swarm Optimization Algorithm Assisted AGC in interconnected Power System

Kajal Karna, G.Veeranna

Abstract: This paper allocates load frequency control in a two area interconnected power system using PID controller and different optimization techniques. Due to load deviation in any of two area or both area, the frequency of system gets affected which may cause serious problem in power system so we need load frequency control in order to balance the nominal value of frequency and tie line power interchange. Teaching learning-based-optimization (TLBO), harmony search algorithm (HS), sine-cosine algorithm (SCA) and improved particle swarm optimization (IPSO), the four optimization techniques are employed in this paper for tuning PID controller. IPSO is proposed algorithm here and compared with rest three techniques. Furthermore, the performance analysis is done with cost function integral square error (ISE) considering 1% step load change in either one area at a time. The maximum overshoot, maximum undershoot and settling time period are observed from simulation results. It is found that IPSO manifested as the best optimization techniques and has shown good performance during transient period with less overshooting and settling time period. By using MATLAB/SIMULATION, we get all the results and it is presented in this paper.

Keywords – Automatic Load frequency control (ALFC), Area error control (ACE), interconnected power system, TLBO, HS, SCA and IPSO.

I. INTRODUCTION

Isolated power system causes instability due to continuously changing of load thereby system frequency gets affected so we need interconnected area in order to meet demand but it is very difficult to manage generation and demand at a time therefore requirement of power generation control automatically.The main goal of power utility is to keep continuous supply to Customers within acceptable limit. There are specially two control mechanism – if we balance reactive power (Acceptable voltage level) this is called automatic voltage regulation (AVR) whereas if we balance real power then it is called automatic generation control (AGC).

AGC helps to reduce transients deviation in large power system, maintainfrequency by balancing load and demand , maintain proper way of tie line power interchange andalso it helps to make steady state error zero [1].

The different control mechanism on AGC is explained in ref [2] and [3].In ref [4], the use of controller PI and PID for AGC and AVR is shown. PID controller is proved better than PI controller as it gives significant results during transient states. Ref [5] and [6], in this paper different physical constraints and non linarites is considered in AGC which play important role in controlling inputs to turbine. In ref [7], the fractional order PID is applied to amplify transient response of the two area systems. This paper shows the comparison between FOPID and IOPID (integral power of PID) and found that IOPID is best controller than all conventional controllers. Similarly, different controllers for AGC are defined in [8], [9],[10] and [11]for single sources as well as multi source. ALL the conventional controllers hold satisfactorily result for some operating points only beyond that they will not perform so FUZZY logic controller is designed in sense to achieve ethical output by upgrading close loop work of I/PI/PID. Among all controller used in AGC, Fuzzy-PID controller sustains best as it can be applied to all nonlinearities. Ref [13], this paper representing the two area control with FUZZY logic controller including SMES. SMES is superconducting magnetic energy storage device which is useful when there is demand for large power and to maintain continuous supply. It controls real as well as reactive power and also stabilizes frequency so called frequency stabilizer. It is also worthwhile in improving dynamic performance. Flexible AC transmission system plays as major role by increasing stability of power system which is explained in ref [15]. FACTS controller are capable of controlling the power in fast manner. Thyristor control series compensator (TCSC) is used in this paper which helps to control line current in transmission line and it magnifies system stability. In given paper [28], the comparison of different FACTS devices like TCSC, TCPS and SSSC is revealed. Among all these FACTC devices, SSSC is proved best as it has presented more desirable performance.
Many researchers have advocated different optimization techniques to improve operating points of controllers.Ref[19], in this article differential evolution algorithm has been carried out for tuning of I, PI and PID controllers to get optimal controller parameters. In this interconnected two area,

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multisource are applied – Gas plant, Thermal plant and Hydro plant. Gas plant is specially used for peak load as its generation is high. These multisource is used and manage continuous supply to load. This project contemplates HVDC-Link connected in parallel as it helps to cut out oscillation in frequency. It is being reported from this project that DE gives excellent outputs than feedback controllers. Ref [21] and [22] describing PSO technique in two area load frequency control for tuning of controllers (PID). PSO technique is better than DE and gives adequate results as well. Ref [23], Firefly optimization technique is assisted here in this paper and this one better techniques than DE and PSO.in this project, UPFC is utilized for enhancing power stability. UPFC is series shunt converters which is connected through DC-Linkand controls real as well reactive power. This project has used multi sources –Gas plant, Thermal plant and Hydro plants with nonlinearity's GRC and GDB. In ref [24] Bat algorithm is declared for LFC multi area power system using cascaded PD-PID controller. Later the Hybrid is BFOA –PSO is allocated for AGC and it gives more accurate results than single algorithm as well. Similarly in ref [25], Bacteria Foraging Optimization techniques is applied for two area system and in ref [29] manipulating interconnected system with Artificial Neural network and Genetic algorithm and compared both algorithm whereas Genetic algorithm assigned as best here.This project has used multi sources –Gas plant, Thermal plant and Hydro plants with nonlinearity's GRC and GDB. In ref [24] Bat algorithm is proposed for AGC multi area power system using cascaded PD-PID controller. Later the Hybrid of BFOA –PSO is allocated for AGC and it gives more accurate results than single algorithm as well. Similarly in ref [25], Bacteria Foraging Optimization techniques is applied for two area system and in ref [29] manipulating interconnected system with Artificial Neural network and Genetic algorithm and compared both algorithm whereas Genetic algorithm assigned as best here.

After doing all the literature survey, it is perceived easily that the performance investigation on automatic generation control depend on structure of controller and its controlling strategies by using different optimization techniques. The main role of optimization to give optimal parameters and some optimization techniques have their drawback. For this authors are developing latest techniques which helps to eliminate the drawback. Here in this article, IPSO is formulated for tuning of controller so that it can give superiority over TLBO, SCA and HS in two area interconnected system.

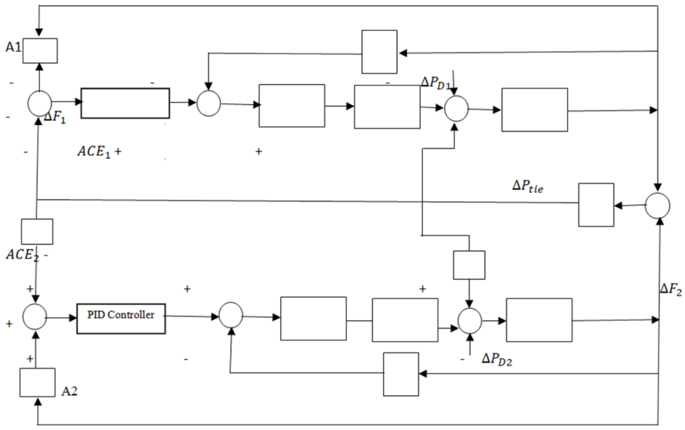

Fig.1. Transfer function block diagram of two area interconnected system

II. TWO AREA UNDER ANALYSIS

The present work under research is related to automatic generation control in which IPSO is proposed algorithm for tuning of PID controller to get optimal control parameter. Furthermore, IPSO technique is compared with TLBO, HS and SCA by considering 1% step load change in one area at a time. These all optimization techniques are employed with objective function integral square error (ISE) in order to optimized parameters of controller. We have considered simple two area interconnected power system having single sources thermal plant. Each area error is given as input to controllers. The main intention of this project is to get better performance in transient states whenever there is load perturbation in system and the proper way of exchanging of tie line power interchange. The transfer function block diagram of interconnected system under study is presented above.

To make it more realistic, we have considered unequal two area given in Fig.1 by assuming different values of time constants and all the parameters .The given system consists of single sources as thermal plant in each area. PID controller is used for controlling purpose whereas B_1 and B_2 area frequency biasing constant. ACE_1 and ACE_2 are area control errors of area-1 and area-2 respectively.R_1 and R_2 are regulation parameters, ΔF_1 and ΔF_2 are frequency deviation in each area, ΔP_{tie} is tie line power interchange, K_{P1} and K_{P2} is power system gain Hz/puMW and T_g and T_t are governor time constant and thermal time constant. Similarly ΔP_1 and ΔP_2 are step load change in each area (1% change is supposed in one area at a time).

A. Objective function

The inputs error called as ACE to controller of each two area is given below:

$$e_1(t) = ACE_1 = B_1\Delta F_1 + \Delta P_{tieline}$$

$$e_2(t) = ACE_2 = B_2\Delta F_2 - \Delta P_{tieline}$$

To minimize area control error (ACE), we have to minimize the objective function as given –

$$J = \int_0^t (ACE_1^2 + ACE_2^2)\ dt$$

Where t is the simulation time

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III. RECOMMENDED TECHNIQUE

The method which is proposed for this project is improved particle swarm optimization technique (IPSO) where 1% load perturbation is supposed in each area.

A. *Improved particle swarm optimization (IPSO) technique*

IPSO is very convenient in solving complex networks (computational) problems. This algorithm is modification of PSO techniques so it is also population based algorithm but it has no limit of population size. This technique has multiple solving point and easy to implement, its convergence rate is high and accurate and marvelously solving the realistic power system. The multiple techniques is possible to apply on PSO in order to get modified form of IPSO. PSO algorithm is not applicable to high dimensional as the population size is large. Thereby population size is one of the important elements. As population number is large, we need to make convergence rate fast and accurate as well by considering some factors in PSO algorithm such as selection, crossover and mutation. These operators helps to get better position and velocity than PSO algorithm. After doing these modification, IPSO removes problems of local minimum and slow convergence rate. The mutation factors helps to mutate the parameter inertia weight and maintain diversity in the swarm. Ipso eliminates local convergence by considering the following equation in PSO.

B. *Flowchart of IPSO*

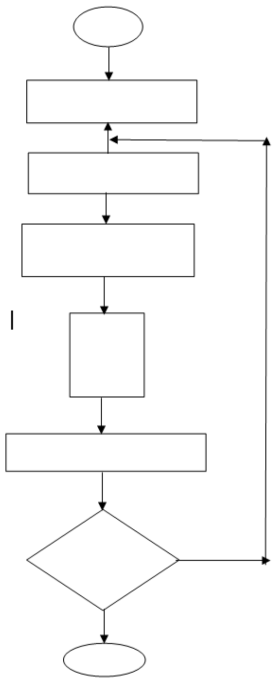

Fig.2 Flowchart of IPSO

The position of particle is use to updated by adding velocity to its position in order to updated position in PSO technique.

$Xi^k + Vi^k$ For I = 1, 2…N

Where

$$Vi^k = w\,Vi^k + c_1 r_1 * (pbest_i^k - X_i^k) + c_2 r_2 * (gbest_i^k - X_i^k)$$

$$w = (w_{max} - w_{min}) * iter\ /iter_{max}$$

IV. SIMULATION RESULTS AND DISSCUSSION

Two cases have been assumed here in this project for the performance analysis in both area of interconnected system.

Case -1 is 1% step load change in A1

And

Case-2 is 1% step load change in A2

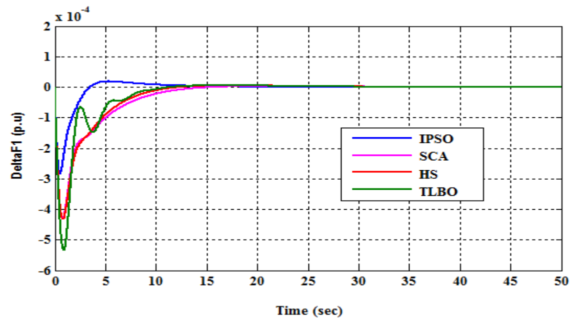

Fig.3 Frequency change in A1 for case-1

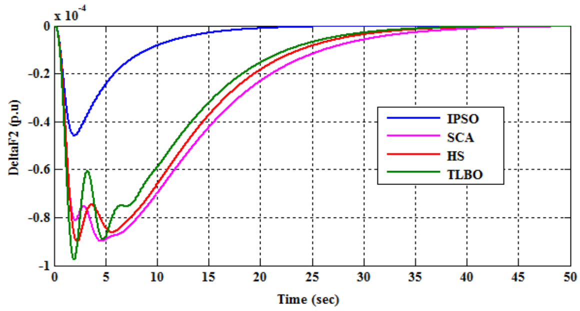

Fig.4 Frequency change in A2 for case-1

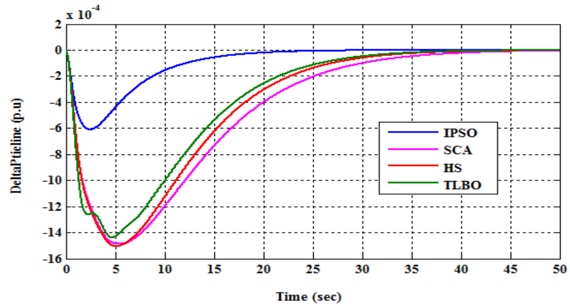

Fig.5 Change in Tieline power for case-1

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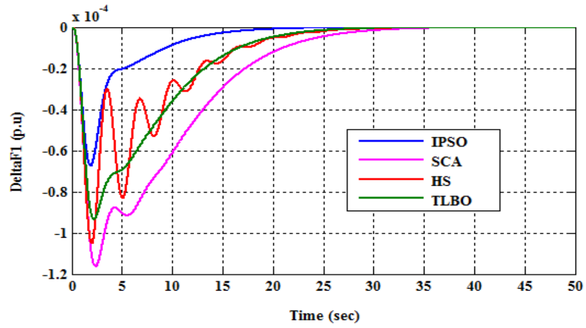

Fig.6 Frequency change in A1 for case-2

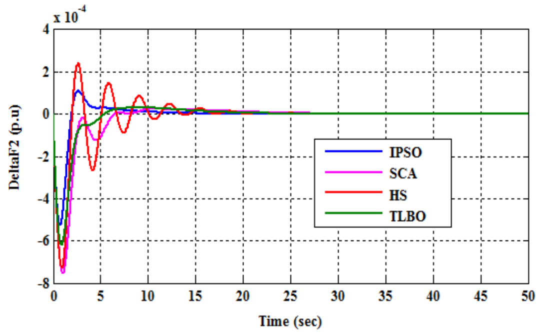

Fig.7 Frequency change in A2 for case-2

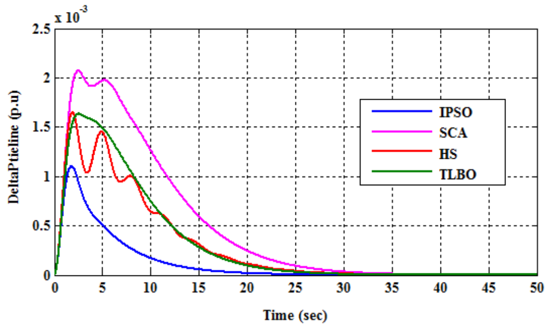

Fig 8 Change in Tie line power for case-2

Table-1 PID controller's parameters for case-1

PID Controller	**TLBO**		**HS**		**SCA**		**IPSO**	
	A1	***A2***	***A1***	***A2***	***A1***	***A2***	***A1***	***A2***
P I D	0.36 0.24 0.15	1 1 0.7	0.35 0.22 0.44	0.28 0.7 0.48	0.42 0.2 0.42	0.98 0.03 0.61	1 1 0.9 98 6	0.06 73 0.01 17 0.61 43

Now we can analyze the performance of PID controller in two area interconnected system by appointing different optimization techniques different from above graphs and tables. Figure 3-5 and Figure 6-8 represents case-1 and case-2 as represented above.

a. **SCA Techniques** –SCA technique is not having good performances when comparing to others techniques but sometime its nature is same as HS techniques as it has same maximum overshot period during frequency change for case-1 in A2.While talking about case-2, it has almost same nature as case-1.Tieline power interchange is negative for case-1, it means that power will be transferred to A1 from A2 as it denotes load increased in area-1 by 1%.

b. **HS Techniques –** HS techniques is better than SCA in overall performance after analysis all cases but sometime it has same performance values as SCA also .SCA has less maximum overshoot period during frequency change in A1 for case-1 while going to case-2,it has less undershoot period thanSCA. Tie line power deviation is negative for case-1 and positive for case-2, negative sign denotes load increases in A1 and it will take power from A2 and vice versa for positive sign.

c. **TLBO –** Coming to TLBO techniques, overshoot period is least compared to others techniques during frequency change in A1 for case-1. It offers less settling time period compared to SCA and HS techniques for both cases. If we talk about tie line power then TLBO less negative tie line power for case-1 that it will require less power from A2 but having same tie line power as HS in case-2.

d. **IPSO –** This technique has largest overshoot period during frequency deviation in A1 for case-1 otherwise it has better performance compared to others techniques having lowest overshoot, undershoot, tie line power deviation and settling time periods for case-1 as well as case-2.

Table-2PID controller's parameters for case-2

PID	**TLBO**		**HS**		**SCA**		**IPSO**	
	A1	***A2***	***A1***	***A2***	***A1***	***A2***	***A1***	***A2***
P I D	0.27 0.44 0.55	0. 22 0. 35 0. 45	0.61 0.3 0.28	0.4 7 0.3 8 0.1 2	0.12 0.5 0.78	0.1 0.23 0.22	0.097 5 0.498 4 0.602 0	0.4 893 0.9 390 0.6 241

Table-3 Max overshooting, max undershooting and settling for case-1

	Del F1 (p.u) * 10^{-4}		**Del F2 (p.u) *10^{-4}**		**Del Ptie(p.u)* 10^{-4}**	**Del F_1**	**Del F_2**	**Del P_{tie}**
	Max over shoot	***Max under shoot***	***Max over shoot***	***Max under shoot***	***Max deviation***	***$t_{settling}$ (sec)***	***$t_{settling}$ (sec)***	***$t_{settling}$ (sec)***
SCA	0.08	-4	_	- 0.9	14.9	12	38	38
TLBO	0.1	-5.3	_	- 0.98	14.2	8	32	31
HS	0.05	-4.3	_	- 0.9	15	11	34	34
IPSO	0.178	-2.62	_	- 0.45	6	9	18	20

Table-4 Max overshooting, max undershooting and settling for case-2

	Del F1 (p.u) * 10^{-4}		Del F2 (p.u) *10^{-4}		Del Ptie(p.u)* 10^{-4}	DelF_1	Del F_2	Del P_{tie}
	Max over shoot	***Max under shoot***	***Max over shoot***	***Max under shoot***	***Max deviation***	$t_{settling}$ ***(sec)***	t_{settli} ***(sec)***	t_{settli} ***(sec)***
SCA	_	- 1.18	0.3	- 7.3	21	28	16	25
TLBO	_	- 0.93	0.3	- 6.2	16.3	23	12.5	23
HS	_	- 1.06	2.3	- 7.3	16.3	26	18	25
IPSO	_	-0.625	0.268	- 5.12	11.2	19	10	20

V. CONCLUSION

This paper explores different techniques (IPSO, TLBO, HS and SCA) for interconnected system where IPSO is proposed algorithm here. The load frequency control has done with all techniques and compared to each other's. As we have main aiget better performance during transient's periods, the performance analysis of PID controller is done byconsidering 1% step load change in either one area at a time (A1 and A2). IPSO is blessed with best performance during transient's periods and gives good results as shown in above graphs and tables. It is being suggested to go for the hybrid optimization techniques and other controllers like PIDA considering WECS Variation to get more good performance for future work.

APPENDIX

The parameters of the system are taken as follow:

B_1 = 20.6, B_2 = 16.9,
R_1 = 20, R_2 = 16,
Tg_1 = 0.2, Tg_2 = 0.3,
Tt_1 = 0.5, Tt_2 = 0.6,
Kp_1 = 1.67, Kp_2 = 1.11
T_{P1} = 16.67,T_{P2} =8.89

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