International Journal of Engineering Science Invention
ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726
www.ijesi.org Volume 2 Issue 9‖ September 2013 ‖ PP.63-71

Comparative Study of Different Algorithm for the Stability in Multi Machine Power System

Deepkiran Tirkey[1] ,[2,]Ms.DhaneshwariSahu , [3,]UmaSankar Patel
ME, ScholarAssistant ProfessorAssistant Professor Dept of Electrical Engineering Dept of Electrical EngineeringDept of Electrical Engineering

ABSTRACT:*There are various method of problem solving for the optimal tuning of the parameters of the PID type stabilizer for the multi-machine power system. This paper presents a comparative study of algorithm such as Artificial Bee Colony, Iterative Particle swarm optimization, Gravitational Search Algorithm and many more. The problem of robustly tuning of PID based multiple stabilizer design is formulated as an optimization problem according to the objective function which is solved by a modified strategy of different algorithm technique that has a strong ability to find the most optimistic result. The results of these studies show that the different algorithms based optimized PID type stabilizers have an excellent capability in damping power system inter-area oscillations and enhance greatly the dynamic stability of the power system for a wide range of loading condition. Thus, because of the importance of the stability of the power systems, stabilizing control techniques have been used for the multi-machine power system with the help of intelligent methods.*

KEYWORDS: Power system stabilization, PID stabilizer, ABC algorithm, IPSOalgorithm, GSAtechnique, Genetic Algorithm.

I. INTRODUCTION

An electric Power System is a network of electrical components used for generation, transmission and distribution of electric power. Power system is alarge scale system and has strong non-linearity. In mathematics, a non-linear system is one that does not satisfy the super position principle or one whose output is not directly proportional to its input. High complexity, dynamic nature, nonlinearity characteristics and the time varying behaviour of power systems have created.Extensive challenges to stability of the power systems [3].The dynamic stability of power systems is an important issue for secure system operation. Stability of power systems is one of the most important aspects in electric system operation. This arises from the fact that the power system must maintain frequency and voltage levels in the desired level, under any disturbance, like a sudden increase in the load, loss of one generator or switching out of a transmission line, during a fault etc. By thedevelopment of interconnection of large electric power systems, there has been spontaneous system oscillations at very low frequencies in order of 0.2-3.0 Hz [2]. Once started, they would continue for a long period of time. In some cases, they continue to grow, causing system separation if no adequate damping is available. Furthermore, low frequency oscillations present limitations on the power-transfer capability. To improve system damping, the generators are equipped with Power System Stabilizer (PSS) that provides supplementary Feedback stabilizing signals in the excitation system.The conventional lead-lag compensators have been widely used as the Power system stabilizer. However, the tuning of the parameter of PSS is a complex exercise. The approaches used to the problem of PSS parameters tuning range from modern control theory, to the more recent one by using different random optimization techniques, such as Iteration Particle Swarm Optimization (IPSO) algorithm, artificial bee colony search, genetic algorithm, Gravitational Search Algorithm for achieving high efficiency and search global optimal solution in the problem space.

II. RESULT OF MULTI MACHINE POWER SYSTEM BY USING DIFFERENT ALGORITHM

A)ARTIFICIAL BEE COLONY (ABC) ALGORITHM

In the ABC model, the colony consists of three groups of bees: employed bees, onlookers and scouts. While this may be a correct math model, it neglects the male drone population. It is assumed that there is only one artificial employed bee for each food source. In other words, the number of employed bees in the colony is equal to the number of food sources around the hive. Employed bees go to their food source and come back to hive and dance on this area. The employed bee whose food source has been abandoned becomes a scout and

starts to search for finding a new food source. Onlookers watch the dances of employed bees and choose food sources depending on dances. The main steps of the algorithm are given below:
Initial food sources are produced for all employed bees

- Repeat
- Each employed bee goes to a food source in her memory and determines a neighbour source, then evaluates its nectar amount and dances in the hive
- Each onlooker watches the dance of employed bees and chooses one of their sources depending on the dances, and then goes to that source. After choosing a neighbour around that, she evaluates its nectar amount.
- Abandoned food sources are determined and are replaced with the new food sources discovered by scouts.
- The best food source found so far is registered.
- UNTIL (requirements are met)

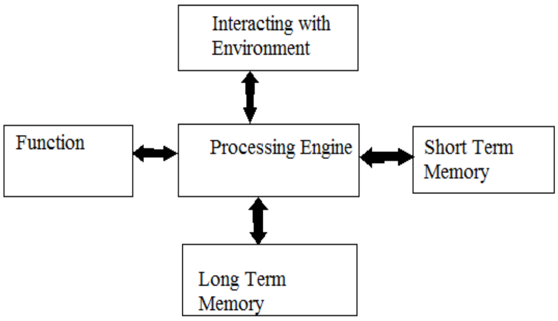

Fig.1 Artificial bee's colony Architecture

In ABC, a population based algorithm, the position of a food source represents a possible solution to the optimization problem and the nectar amount of a food source corresponds to the quality (fitness) of the associated solution. The number of the employed bees is equal to the number of solutions in the population. At the first step, a randomly distributed initial population (food source positions) is generated. After initialization, the population is subjected to repeat the cycles of the search processes of the employed, onlooker, and scout bees, respectively. An employed bee produces a modification on the source position in her memory and discovers a new food source position. Provided that the nectar amount of the new one is higher than that of the previous source, the bee memorizes the new source position and forgets the old one. Otherwise she keeps the position of the one in her memory. After all employed bees complete the search process; they share the position information of the sources with the onlookers on the dance area. Each onlooker evaluates the nectar information taken from all employed bees and then chooses a food source depending on the nectar amounts of sources. As in the case of the employed bee, she produces a modification on the source position in her memory and checks its nectar amount. Providing that its nectar is higher than that of the previous one, the bee memorizes the new position and forgets the old one. The sources abandoned are determined and new sources are randomly produced to be replaced with the abandoned ones by artificial scouts.

III XPERIMENT RESULTS

The power system stabilization using proposedABC optimization technique is evaluated. Table 1 shows the loading in three generators G_1, G_2, G_3.

Gen	Case 1		Case 2		Case 3	
	P	Q	P	Q	P	Q
G_1	0.71	0.25	2.19	1.06	0.34	1.10
G_2	1.62	0.07	1.92	0.55	2.00	0.56
G_3	0.84	-0.10	1.28	0.36	1.51	0.38

Table 1.Genarator Loading in PU

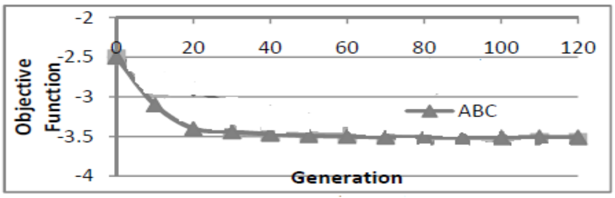

Fig.2 performance of an objective function of ABC algorithm

Figure 2 shows the objective function response of the ABC algorithm. It is observed that the convergence of the ABC is good and this technique is very significant. Now when the load disturbance is introduced in the power system at time 1 sec, then the power system undergoes a stabilization process by using ABC technique and the result shown below:-

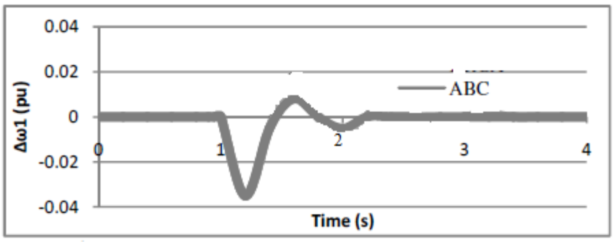

Fig.3 System response under fault condition Δω1

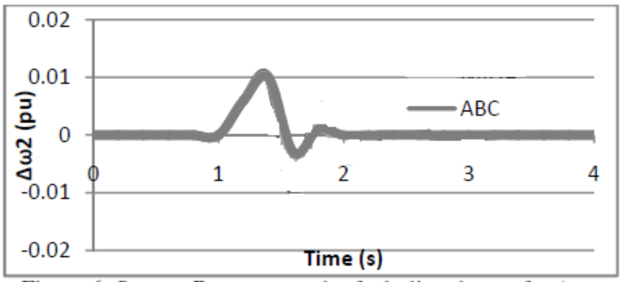

Fig.4 System response under fault condition Δω2

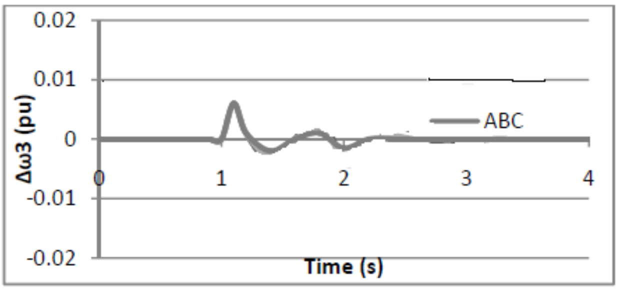

Fig.5 System response under fault condition Δω3

The controller parameters are adjusted in order to stabilize the system. Δω1, Δω2 and Δω3 are the deviations that occur in power system because of the introduction of 5 % load disturbance areprovided in figure 3, 4 and 5 respectively. From thefigure, it can be observed that initially the system is stable until 1 second, after that the system becomes unstable because of load disturbances. The proposed ABC technique takes only 2.2 seconds for stabilizing the system[4].

B) ITERATION PARTICAL SWARM OPTIMIZATION (IPSO) ALGORITHM

The IPSO algorithm is employed to tune nonlinear parameters (V_s^{max} and V_s^{min}) and PID type PSS parameters for the two-area multi-machine power system. The goal of optimal tuning of stabilizer parameters task is to maximize low frequency oscillation damping; *i.e.*: minimize the settling time and overshoots in system response. Minimizing the overshoot is equivalent to increasing system damping. However; we are confronted with a necessary compromise between swiftness of response and allowable overshoot. To achieve robustness and avoiding conservation in the design, the max overshoot is selected to be worst over there operating regimes (heavy, nominal & light loading).The salient feature of this objective function is that it needs the minimal dynamic plant information. The design problem can be formulated as the following constrained optimization problem, where the constraints are the PSS parameters bounds:

Minimize subject to:-

$T_{wi}^{min} \le T_{wi} \le T_{wi}^{max}$

$K_{pi}^{min} \le K_{pi} \le K_{pi}^{max}$

$K_{Ii}^{min} \le K_{Ii} \le K_{Ii}^{max}$

$K_{Di}^{min} \le K_{Di} \le K_{Di}^{max}$

$V_s^{min} \le V_s \le V_s^{max}$

$-V_s^{min} \le -V_s \le -V_s^{max}$

Typical ranges of the optimized parameters are[0.1-20] for $T_w$and[0.01-50] for PID controller parameters (*KPi*, *KI*iand *KDi*) and[0.05-0.5] for V_s^{max} and -V_s^{min}. The IPSO approach was implemented in MATLAB software and used to solve this optimization problem and search for the optimal set of stabilizers parameters. To evaluate the effectiveness and robustness of the proposed optimization technique numerous operating conditions and the system configurations, simultaneously are considered. The optimal tuning of the PSS parameters is carried out by evaluating the fitness function as given above for four operating conditions.

Table 1 Optimal parameter settings of the proposed stabilizers

Method	Gen	T_W	K_P	K_I	K_D	V_{max}	V_{min}
IPSO	G_1	9.78	32.2	1.01	6.56	0.098	-0.096
	G_2	9.51	31.7	1.97	5.67	0.094	-0.097
	G_3	9.67	33.39	2.01	4.83	0.097	-0.087
	G_4	9.78	36.6	1.62	4.43	0.091	-0.094

Optimized multiple stabilizers parameter set values corresponding to the best fitness achieved by each algorithm based on the objective function as given in above Equations using the IPSO methods are listed in Table 2

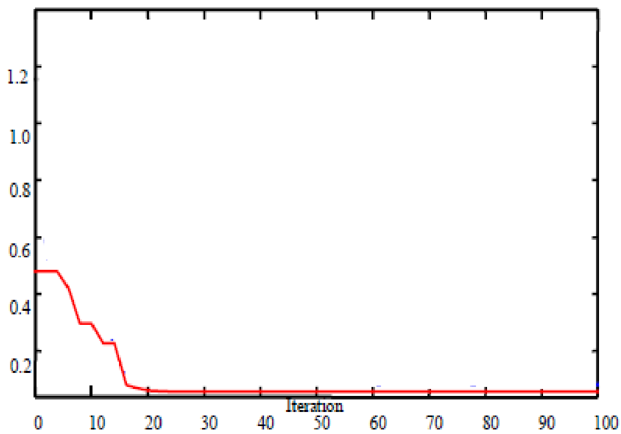

Fig.6 Fitness convergence of IPSO

The performance of the IPSO based optimized multiple PID type stabilizer is quite prominent in comparison with the other PSSs and the overshoots and settling time are significantly improved with the proposed stabilizer. To illustrate robustness of the proposed method, some performance indices based on the system performance characteristics are defined as:

$$\text{IAE} = 10^4 \times \int_0^{tsim} (|\Delta\omega_{12}| + |\Delta\omega_{13}| + |\Delta\omega_{14}| + |\Delta\omega_{34}|)\, dt$$

$$\text{ITAE}=10^4 \times \int_0^{tsim} t.(|\Delta\omega_{12}| + |\Delta\omega_{13}| + |\Delta\omega_{14}| + |\Delta\omega_{34}|)\, dt$$

$$\text{ISE}=10^4 \times \int_0^{tsim} (\Delta\omega_{12}^2 + \Delta\omega_{13}^2 + \Delta\omega_{14}^2 + \Delta\omega_{34}^2)\, dt$$

$$\text{FD}=(OS \times 4000)^2 + (US \times 1000)^2 + T_s^2$$

Where, *OS*, *US* and *T*sare mean overshoot, mean under-shoot and mean settling time of four relative speed deviations of $\Delta\omega_{12}$, $\Delta\omega_{13}$, $\Delta\omega_{14}$and $\Delta\omega_{34}$. It is merit mentioning that the lower the value of these indices is, the better the system response in terms of the time-domain characteristics. The inter-area and local mode of oscillations with the above stabilizers for deferent operating conditions as given in Table 3 is shown in Figs. 7-9, respectively.

Table 2. Four operating conditions(pu)

Operating Condition	G_1		G_2		G_3		G_4	
	P	Q	P	Q	P	Q	P	Q
Case1(Base Case)	0.7778	0.1021	0.7777	0.1308	0.7879	0.0913	0.7778	0.0918
Case2(20% inc.for system load in case 1)	1.084	0.3310	0.7778	0.4492	0.7879	0.1561	0.7778	0.2501
Case3(20% dec.for system load in case 1)	0.7778	0.0502	0.2333	0.0371	0.7989	0.0794	0.7778	0.0704
Case4(Loss of a line between buses)	0.7778	0.1021	0.7777	0.1308	0.7989	0.0903	0.7778	0.0981

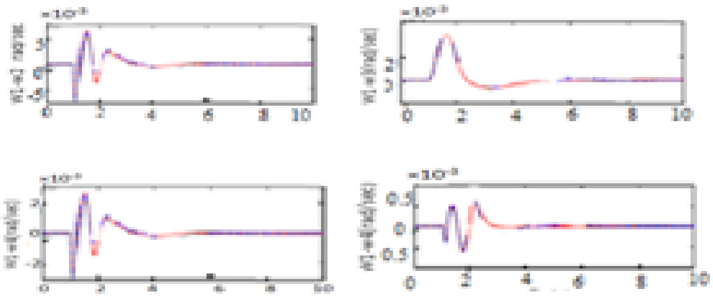

Fig.7 Inter-area and local mode of oscillation forcase1

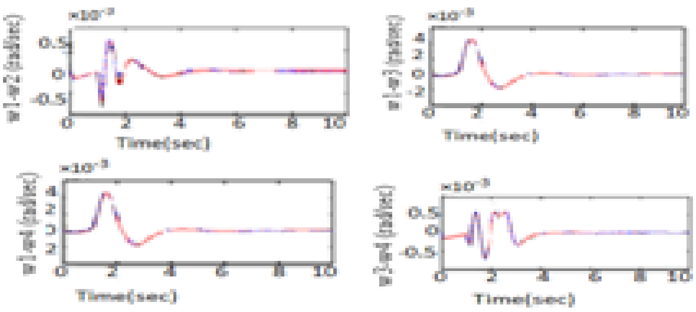

Fig.8 Inter-area and local mode of oscillation forcase2

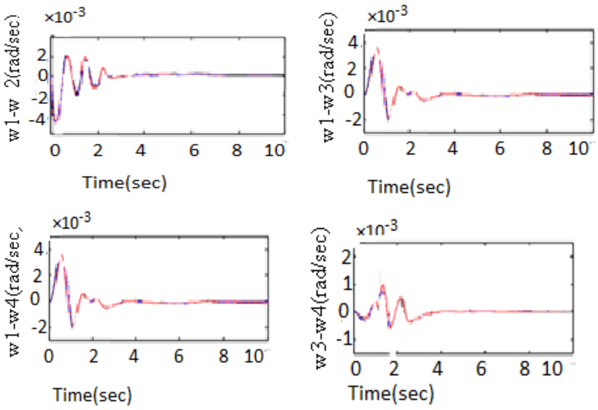

Fig.9 Inter-area and local mode of oscillation forcase 3

Evaluation of these Table reveals that the using the proposed IPSO the speed deviations of all machines are greatly reduced, has small overshoot, undershoot and settling time.Numerical results of performance robustness for all system loading cases with three PID type stabilizers by applying a three-phase fault of 100 ms duration at the middle of one of the transmission lines between buses.The effectiveness of the proposed strategy was tested on a two-area four machine power system under different operating conditions. The nonlinear time-domain simulation results demonstrate the effectiveness of the pro-posed PID type stabilizers and their ability to provide good damping of low frequency oscillations. The system performance characteristics in terms of 'ITAE', 'IAE', 'ISE' and 'FD' indices reveal that the proposed IPSO algorithm is superior, accurate and computational effort[6].

C) GRAVITIONAL SEARCH ALGORITHM

In GSA, the swarms, called agents, are a collection of masses which interact with each other by the Newtonian laws of gravity and the laws of motion. The swarms share information using a direct form of communication, through gravitational force to guide the search toward the best position in the search space process. The high performance and the global search ability of GSA in solving various nonlinear functions infers from the results of experiments undertaken previously. In GSA, the effectiveness of the swarms is measured by their masses. All the swarms are likely to move toward the global optima attract each other by the gravity force, while this force causes a global movement of all swarms toward the swarms with heavier masses. The heavy masses correspond to best solutions of the problem. In other words, each mass place represents a solution, and the algorithm is navigated by properly adjusting the gravitational and inertia masses. By lapse of time, the masses will be attracted by the heaviest mass which it represents an optimum solution in the search space. Thus, in GSA, all swarms move to a new place by updating their direction and distance determined by their velocities. Consequently, the swarms are likely to move toward the global optima by changing the velocities over the time. This algorithm is an iterative process similar to the other swarm intelligence based approaches. It starts with *N* agents (masses) in a *d*-dimension space, where *N* and *d* denote the size of population and the number of optimization parameters, respectively. The *i*th agent is represented by:

$X_i = \left(x_i^1, \ldots, x_i^d, \ldots, x_i^n\right) for\, i = 1, 2, \ldots, N$

Where,$x_d^i$is the position of agent *i* in dimension *d* and *n* is the search space dimension.

The gravitational constant *G*(*t*)is an important control parameter in determining theperformance of GSA and adjusting its accuracy. Thus, itis generally reduced with iteration *k* as follows:

$G(k) = G0 \exp(\alpha\, k / K_{max})$

where, G0 is the initial value, α is a constant and Kmax isthe maximum iteration number. From the above clarification the

Control parameters used in the GSA algorithm are thenumber of population size N, the value of initial Gravitational constant G0, α and the maximum iterationnumber (generation).

Using the above concepts, the whole GSA algorithm can be described as follows:

1. Initialize the control parameters of GSA algorithm (N, $G0$, d, α and K_{max})
2. For each individual, the position and velocity vectorswill be randomly initialized with the same size as theproblem dimension within their allowable ranges.
3. Evaluate the fitness of each agent.
4. Update the G, $f_{best}$and $f_{worst}$of the population according to equations:-

$$f_{best}(k)=\min_{j=[1,\dots,N]} fj(k)$$
$$f_{worst}(k)=\max_{j=[1,\dots,N]} fj(k)$$
&
$$G(k) = G0 \exp(\alpha\, k / K_{max})$$

5. Compute M and a for each agent.
6. Update velocity and position for each agent using Equations respectively:-

$$v_i^d(k+1) = r_i v_i^d(k) + a_i^d(k)$$
$$x_i^d(k+1) = x_i^d(k) + v_i^d(k+1)$$

7. Repeat steps 2-6 until a termination criterion is Satisfied.

Here, an Integral of the Squared Time of the Squared Error (ISTSE) of the speed deviations is taken as the objective function (fitness) into account which is given by:

$$F=\sum_{i=1}^{NP}\int_{t=0}^{t=tsim} t^2(\Delta\omega)^2 dt$$

where, $\Delta\omega$shows the rotor speed deviation, $t_{sim}$is the time range of the simulation and NP is the total number of operating conditions for which the optimization is carried out.The optimization of the coordinated stabilizerParameters is carried out by evaluating theObjective cost function as given in above Equation, whichconsiders a multiple of operating conditions are given inTable3.The upper and lower limits of the optimized parameters as given in the literature are given in Table 4. Results of the PSS parameter set values based on the objective function F,by applying a three phase-to-ground fault for 100 ms at generator terminal at t=1 sec using the proposed GSA, are given in Table 5.

Table3. Operating Conditions

Case No.	P	Q	x_e	H
Case1(Base Case)	0.8	0.4	0.3	3.25
Case2	0.5	0.1	0.3	3.25
Case3	1	0.5	0.3	3.25
Case4	0.8	0.4	0.6	3.25
Case5	0.5	0.1	0.6	3.25
Case6	1	0.5	0.6	3.25
Case7	0.8	0	0.6	3.25
Case8	1	-0.2	0.3	3.25
Case9	0.5	-0.2	0.6	3.25
Case10	1	0.2	0.3	0.81

Table4. The upper and lower limit of the optimized parameters

Parameter	T_W	K_P	K_I	K_D	V_s^{max}	V_s^{min}	K_A
Lower limit	1	1	1	1	0.05	-0.5	50
Upper limit	20	50	50	50	0.5	-0.05	200

Table 5. Optimal Stabilizer Parameters

Method	T_W	K_P	K_I	K_D	V_{max}	V_{min}
GSA	19.81	25.31	1.231	0.978	0.098	0.078

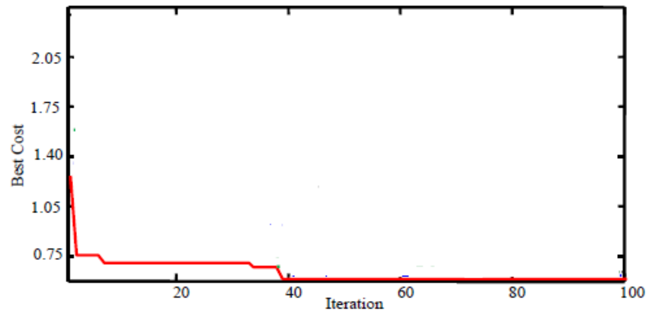

Fig 10. Fitness Convergence of GSA Technique

The system response using the proposedcoordinated PSS and GSA technique for operationconditions is depicted in Figure 11.It is evident that the system low frequency oscillationdamping using the proposed GSA tuned coordinated stabilizer has small overshoot, less settling time. Thisdemonstrates that the overshoot, undershoot, settling timeand speed deviations of machine is greatly reduced byapplying the proposed coordinated stabilizer [5].

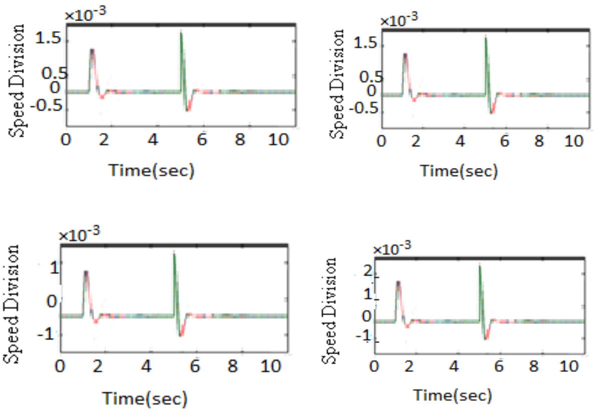

Fig 11. System response of a GSA based Stabilizer

III. CONCLUSION

Recently, Optimization algorithms have been widely used for the stabilization of the power system. There are various techniques for this purpose. Here we discuss about three important algorithm viz. Artificial Bee Colony, Iteration Particle Swarm Optimization and gravitational Search Algorithm. All of them have their own criterion of searching a best result. ABC Algorithm, with the help of Bees and their ways of Searching food has been taken and find an optimal point by an objective function with the use of PID type stabilizer. In IPSO technique, how the swarm floating on a river for the searching of their food has been taken into account and in GSA technique, the search space of a problem is assumed as a multidimensional system with different solutions to the problem. Gravitational search algorithm (GSA) is constructed based on the law of gravity and the notion of mass interactions. The GSA algorithm uses the theory of Newtonian physics and its searcher agents are the collection of masses. Using the gravitational force, every mass in the system can see the situation of other masses. The gravitational force is therefore a way of transferring information between different masses.

REFERENCES

[1] M. Ouassaid, A. Nejmi, M. Cherkaoui, and M. Maaroufi, "A New Nonlinear Excitation Controller for Transient Stability Enhancement in Power Systems" World Academy of Science, Engineering andTechnology, Vol.8, 2005.

[2] M. Anderson, A.A. Fouad, "Power System Control

[3] and Stability", Ames, IA, Iowa State Univ. Press, 1977.

[4] P. Kundur, "Power System Stability and Control", Mc

[5] Graw-Hill Inc., New York, 1994.

[6] V.Ravi, Dr.K.Duraiswamy,"effective Optimization Technique for power system stabilization using Artificial Bee Colony"Internatinal conference on computer communication and informatics (ICCI-2012).

[7] H.Shayegi,A.Ghasemi,"Optimal Tuning Of PID Type Stabilizer and AVR Gain Using GSA Technique "International journal on Technical and Physical Problems Of Engineering".Vol 4, ISSN 2077-3528,2012

[8] HosseinShayeghi, Ali Ghasemi, HeidaraliShayanfar,"PID Type Stabilizer Design for Multi Machine Power System Using IPSO Procedure". Computer Science and Engineering: Vol. 1,No.(2),PP 36-42,2011
[9] K. R. Padiyar, "Power System Dynamics, Stability and Con-trol". Second Ed., 2008
[10] E. Rashedi, H. Nezamabadi-pour, S. Saryazdi,
[11] "GSA: A Gravitational Search Algorithm", Information
[12] Sciences, Vol. 179, pp. 2232-2248, 2009
[13] AliasgharRahmaniHosseinbadi,MohammadYazdanpanah and Ali ShokouhiRostami," A New Search Algorithm For Solving Travelling Salesman Problem Based On Gravity".World Applied Science Journal,Vol.16.pp. 1387-1392,2012.