A Novel Hybrid GWO-BFO Approach for Load Frequency Control Problem

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***Abstract* - This paper analyzed a competitive way to solve load frequency control problems by means of Grey wolf Optimization (GWO) technique. The technique is an original meta-heuristic motivated by grey wolves. The arrangement of pecking and method of hunting of the grey wolves is emulated in GWO. In this paper two units of thermal system with reheat turbines are taken into consideration. The values that are integral gain, tie line power, frequency coefficient are taken into notice as the adjustable parameters. These parameters are anticipated all the way through optimization method with the plan to decrease the Area Control Error (ACE).The projected method shows the effectiveness to resolve load frequency control problems at a variety of operating circumstances. The gains of GWO are also being compared with hybrid technique GWO-BFO and it shows that optimized values with hybrid technique are better to solve load frequency control problems.**

***Index terms* - Automatic generation control (AGC), Integral square error (ISE), Area Control Error (ACE), Grey wolf optimizer (GWO) and Bacterial Foraging Optimization (BFO)**

I. INTRODUCTION

Recent control system is a composite system. The complication of the structure is growing with each transient day owing to worried situation of the network and constant adding up of the utilities in distribution, transmission, generation area. The allotment of tall dispersed generating areas shows a probable menace to the control set-up. The idea of controlling the generation automatically is to maintain a balance among the generation and required demand. Though, the energetic operating circumstances with many contingencies create the structure weak for oscillatory insecurity. With the expansion of broad control scheme and mainly due to several interconnected systems the tie line power of restricted capability makes deep oscillation in scheme frequency [1]. Mainly there are two objectives of AGC:

1. To keep up the scheme frequency in so-called range i.e. (50-60) Hz
2. Tie line power should run in an adequate range.

Automatic generation control /Load Frequency Control/ (AGC) is defined as "the parameter of the control production of generators with in a given region in reply to variations in tie line power, scheme frequency, or the inter relation of these with each other, so as to keep the planned scheme frequency or set up exchange with added areas in determined restrictions" [2].

From earlier period, it has been experimental that noticeable hard work has been done in the region of neat control of load frequency of interconnected scheme to optimize the controller gain. A number of traditional as well as up to date optimization techniques viz. Artificial Neural Network (ANN), Particle Swarm Optimizations, Genetic Algorithm (GA), and Fuzzy Logic was used for the scheming of extra controller, which has the subsequent restrictions:

1. Controller gain optimization with traditional approach fascinated in local minima.
2. In old method large number of values cannot be controlled at the same time. However, the scheming of AGC structure need optimization of parameters more than one at a specific time instantaneously.
3. The optimization techniques discussed are not as much receptive to local minima and each gives likely explanation instead of explanation itself and it needs large amount of information for training use, which is a dreary job.

Grey wolf optimization (GWO) is a unmarked heuristic algorithm aggravated by the societal behaviour and hunting way has been projected by Mirjalili et.al.[38].With the help of GWO nonlinear functions can be resolved easily.

II. AGC MODEL

The two-area interrelated non reheat thermal power system is shown in the Fig 1. The main apparatus of the power scheme consist of governor, turbine, generator and load. The operating parameters of the interrelated power scheme must be assumed to be linear. The inputs of the control scheme are controller output u, change in load demand ΔP_L, and incremental tie line control ΔP_{tie} and the output are incidence difference Δf and area control area, ACE. The ACE signal is the area control error, which controls the steady state errors deviation of frequency and tie-power.
Mathematically ACE can be defined as:

$$ACE = B\Delta f + \Delta P_{tie} \quad (1)$$

Where B is the frequency bias parameter

i Area subscript
Δf_i Area iFrequency deviation (Hz)
ΔP_{Gi} Generation of area i (p.u.)
ΔP_{Li} Change in load area i (p.u.)
ACE_i Area control error of area i
B_i Frequency bias parameter of area i
R_i Governor speed regulation of the
T_{gi} Governor time constant of area i (s)
T_{ti} Turbine time constant of area i (s)
T_{pi} Generator and load Time constant
ΔP_{tie} Change in tie line (p.u.)
T_{12} Synchronizing coefficient

To model above components of power system the below transfer functions are used. Turbine transfer function is:

$$G_{(t)}\, s = \frac{1}{1+ s\, T_t} \qquad (2)$$

Governor transfer function:

$$G_{(g)}\, s = \frac{1}{1+ s\, T_g} \qquad (3)$$

Load and generator transfer function:

$$G_{(l)}\, s = \frac{K_p}{1+ s\, T_p} \qquad (4)$$

Where K_p = 1/D and T_p = 2H/fD

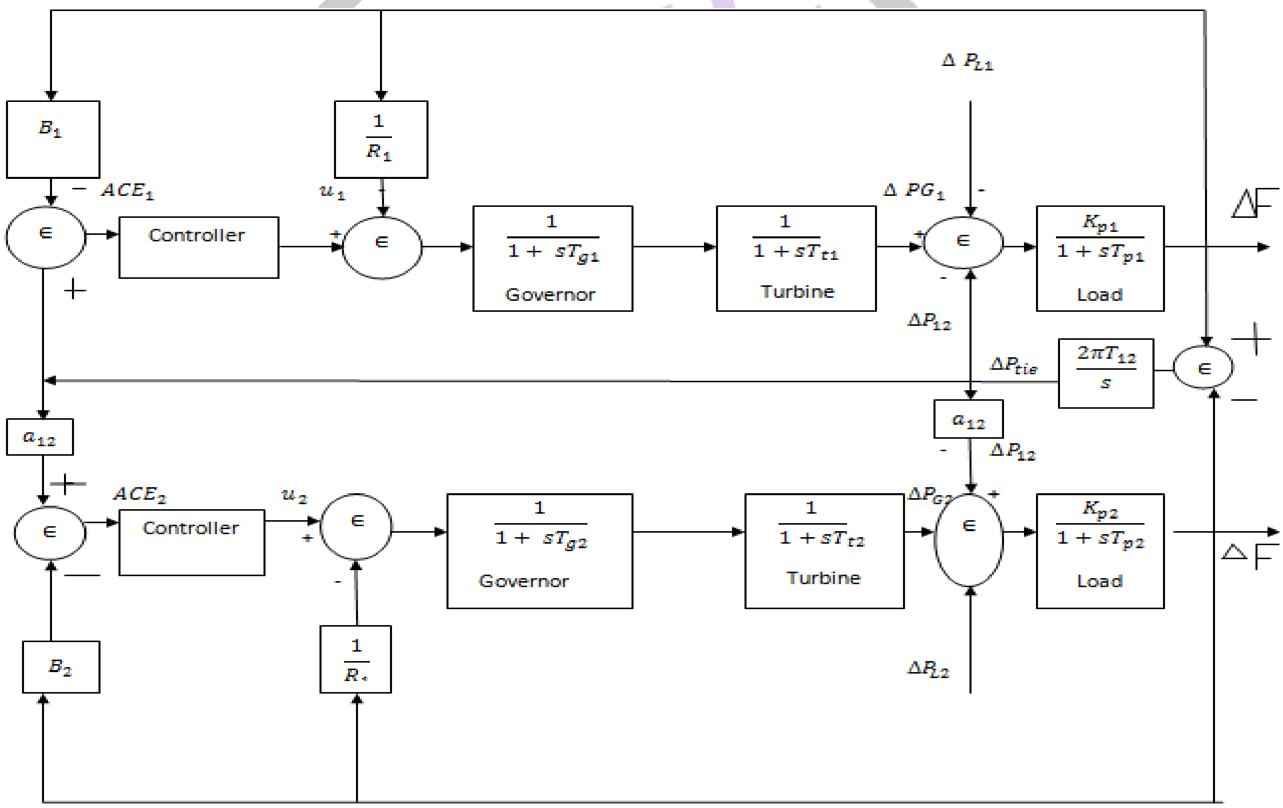

Fig 1 Two area interconnected thermal system

III. GREY WOLF OPTIMIZATION (GWO)

Grey wolf optimization (GWO) is explained to answer load frequency control problem. This technique is projected by Mirjalili et al., [42]. The technique was forced by the communal pecking arrangement and the hunting actions of apex predator's i.e grey wolves. The best among the pack are known as alpha (α). The next stage is secondary wolves that try to help out the best leaders, which are called beta wolves (β). The third stage is the Deltas (δ) grey wolves which are below alphas and betas, but are above omega. The last order of the wolf is omega (ω), which is at last position to all the other main wolves [41].

In the arithmetical representation grey wolves, alpha (α) is measured as the best explanation. So, the next top answer is beta (β) and followed by delta (δ). The applicant explanations which are absent are considered as omega (ω). Optimization process is explained by Alpha, beta, and delta. The omega wolves come under these wolves [40]. The grey wolves surround victim throughout the process. The surrounding actions can be obtained as : [38]

$\vec{D}= |\vec{C} .\vec{X}_p \text{ (t)} - \vec{X} \text{ (t)}$ (5)

$\vec{X} \text{ (t+1)} = \vec{X}_p \text{ (t)} - \vec{A}. \vec{D}$ (6)

IV. IV.GWO FLOWCHART

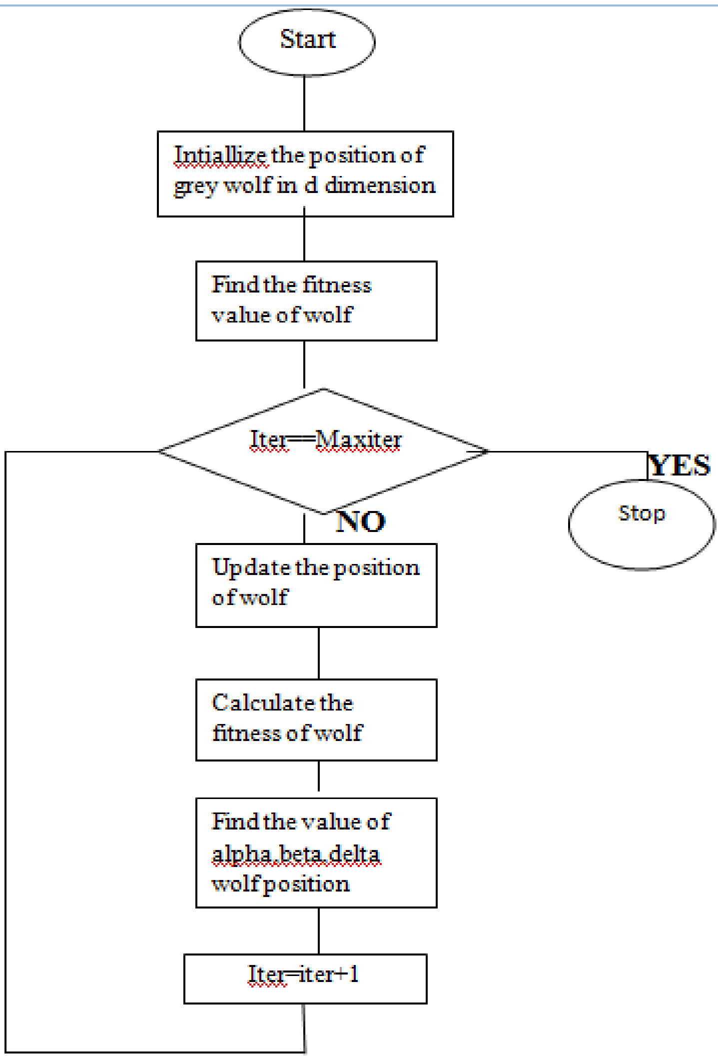

Fig 2 Flowchart of GWO

Where t represents present iteration, $\vec{A}$ and $\vec{C}$ are coefficient vectors, $\vec{X}_p$ is the prey position and $\vec{X}$ is the grey wolf position.

$\vec{A} = 2\vec{a}.\vec{r}_1 - \vec{a}$ (7)

$\vec{C} = 2. \vec{r}_2$ (8)

The components of $\vec{a}$ are decreased linearly from 2 to 0 over the course of iterations and r_1, r_2 are random vectors in [0,1]. The process is classically followed by alpha, beta and delta, which has better information concerning the possible place of victim. The new values must adjust their places according to best optimized values. The up to date position can be obtained as [42]:

$\vec{D}_\alpha = |\vec{C}_1 . \vec{X}_\alpha - \vec{X} |$ (9)

$\vec{D}_\beta= | \vec{C}_2 . \vec{X}_\beta - \vec{X} |$ (10)

$\vec{D}_\delta= | \vec{C}_3 . \vec{X}_\delta - \vec{X} |$ (11)

$\vec{X}_1 = \vec{X}_\alpha - \vec{A}_1. (\vec{D}_\alpha)$ (12)

$\vec{X}_2 = \vec{X}_\beta - \vec{A}_2. (\vec{D}_\beta)$ (13)

$\vec{X}_3 = \vec{X}_\delta - \vec{A}_3. (\vec{D}_\delta)$ (14)

$\vec{X} \text{ (t+1)} = \frac{X_1 + X_2 + X_3}{3}$ (15)

The ‘A’ is an random value in the[-2a, 2a] range. When |A.|<1, the grey wolves are required to hit the victim. Attacking the victim is the exploitation capability and finding for prey is the exploration capability. The random values of ‘A’ are used to force the search agent to go away from the victim. When |A.|>1, the grey wolves are imposed to move away from the prey [38].

V. GWO-BFO HYBRID TECHNIQUE

GWO has given the gains of integral controller and these inputs have been given to the hybrid technique in order to get the optimized values with GWO-BFO. After applying hybrid technique the gains of integral controller is obtained and it has been seen that values are coming out to be better as compare to that of GWO technique.

The hybrid flowchart of GWO-BFO has been shown below by which gains of integral controller is obtained and optimized values are obtained in order to control load frequency problems in two area interconnected thermal system.

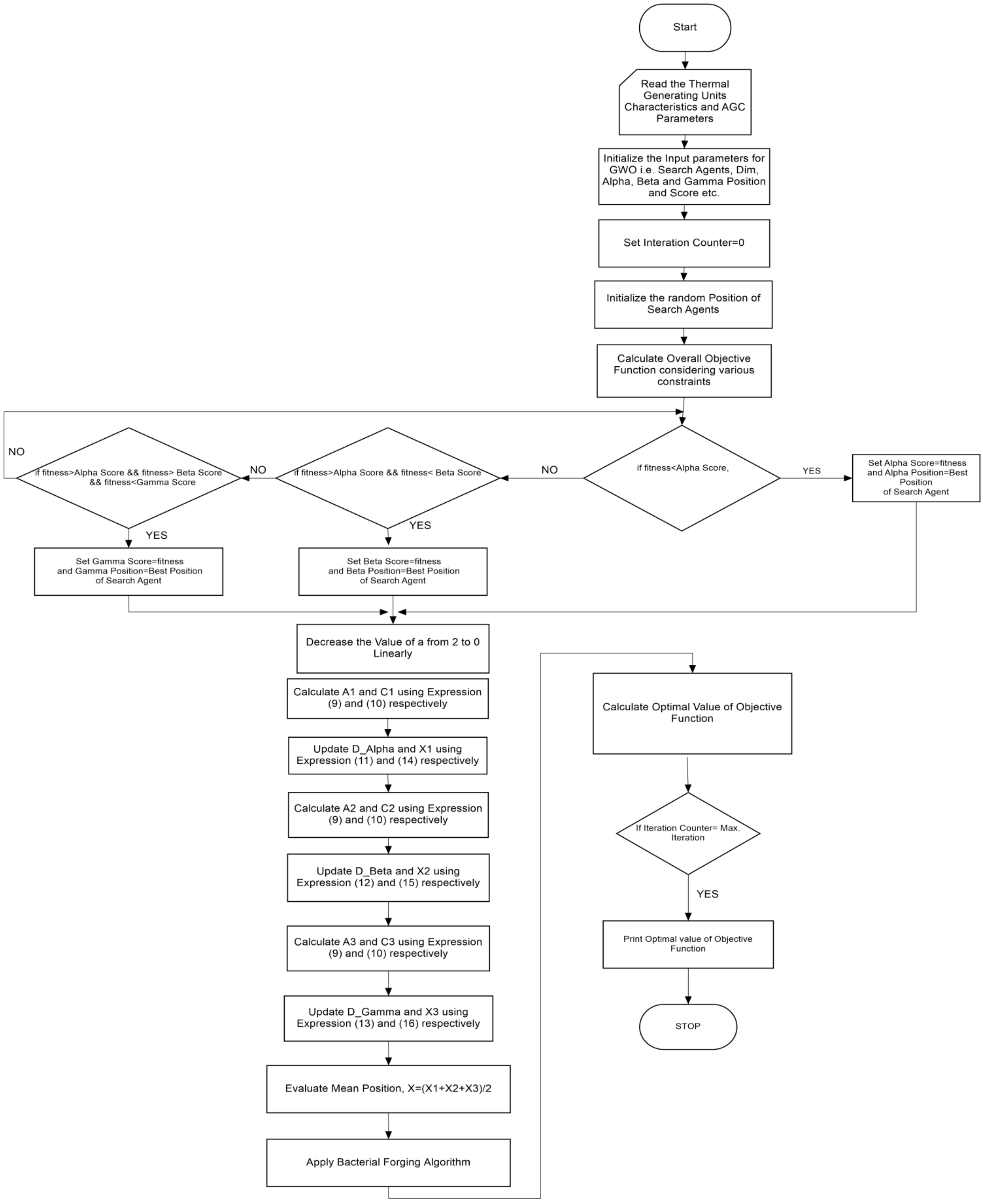

Fig 3 Flowchart of GWO-BFO (Hybrid technique)

VI. SIMULATION RESULTS

To demonstrate the usefulness of the projected optimization technique different frequency plots of Area 1 and 2 is obtained. The Simulink implementation of two area interrelated network has been implemented in Matlab and optimized values of Ki1 and Ki2 is obtained with Tie line power.

Table 1 Optimized values of integral controller with GWO and GWO-BFO

Optimum Parameters	GWO	GWO-BFO
Ki1	0.2753	0.2749
Ki2	0.0453	0.0443

VII. SIMULATION GRAPH

After putting the values of ki1 and ki2 in simulink model the frequency plots of area 1 and area 2 with tie line power is obtained with GWO-BFO technique:

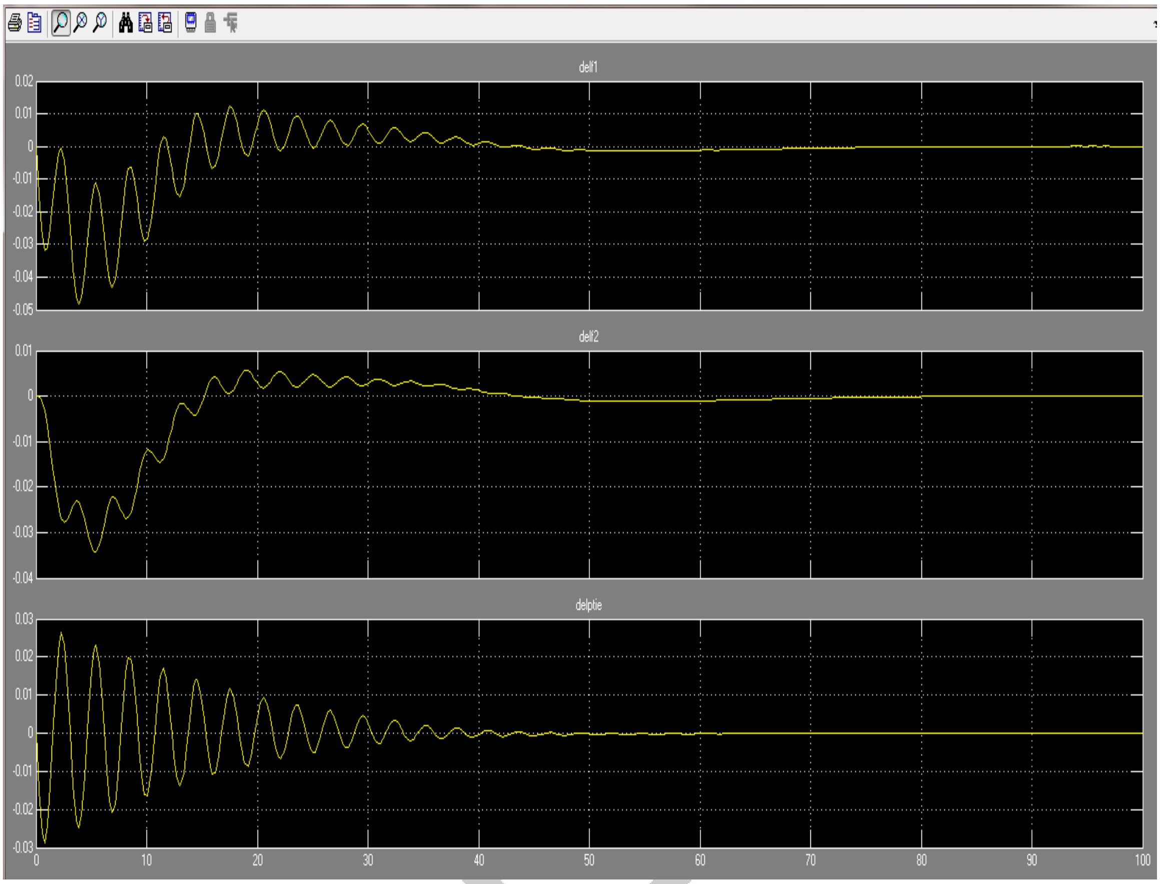

Fig 4 Frequency response of area 1, 2 and tie line with (GWO-BFO) Hybrid Technique

The nominal system parameters are:
F=60Hz, Pr_1=Pr_2=2000MW, pd_i=1000 MW
H1=H2=5sec, Tt_1=Tt_2=0.3sec, Tg_1= Tg_2= 0.8 secs
Ptiemax=200 MW, Kr1, Kr2=0.50, D1=D2=8.33*10-3 puW/Hz, Bi= βi(1=1,2)

VIII. CONCLUSION

GWO is one of the recently obtained meta-heuristic procedures. In this paper GWO and GWO-BFO are used to explain load frequency control problem for two area thermal system. The simulation conclusion shows that gains of hybrid technique GWO-BFO are better to resolve Load frequency problem in power scheme. The algorithm is planned in MATLAB (R2009b) software package.

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