AGC IN UNREGULATED ENVIRONMENT USING BACTERIAL FORAGING OPTIMIZATION

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Abstract- Automatic Generation Control (AGC) is an integral part of Energy Management System. This paper deals with the automatic generation control of interconnected Thermal-Hydro and Thermal-Thermal unregulated system with Bacterial foraging technique.

Keywords- Automatic Generation Control, Bacterial Foraging Technique, Unregulated Area, Tie Line frequency Control.

I. Introduction

An interconnected power system consists of control areas which are connected to each other by tie lines. In a control area, all the generators speed up or slow down together to maintain the frequency and relative power angles to scheduled values in static as well as dynamic conditions. In an interconnected power system, any sudden small load perturbation in any of the interconnected areas causes the deviation of frequencies of all the areas and also of the tie line powers.

The main objectives of Automatic Generation Control (AGC) are:

I. To maintain the desired megawatt output and the nominal frequency in an interconnected power system.
II. To maintain the net interchange of power between control areas at predetermined values.

1.1 AGC with Optimization techniques

The AGC problem has been augmented with the valuable research contributions from time to time, like Automatic generation control regulator designs incorporating parameter variations/uncertainties, load characteristics, excitation control and parallel AC/DC transmission links. The microprocessor-based regulator, self-tuning regulator, and adaptive regulator designs have been presented. The most recent advancement in this area is the application of artificial intelligence techniques such as neural networks, fuzzy logic, genetic algorithms etc. to tackle the difficulties associated with the design of regulators with nonlinear models and/or insufficient knowledge about the system.

However, the implementation of Automatic generation control strategy based on a linearized model on an essentially nonlinear system did not necessarily ensure the stability of the system. Hence attention was paid to consider the system nonlinearities. The destabilizing effect of governor dead-band non-linearity on conventional Automatic generation control system was studied and it was shown that governor dead-band non-linearity tends to produce continuous oscillations in the area frequency and tie line power transient response. The successful operation of interconnected power systems requires the matching of total generation with total load demand and associated system losses.

With time, the operating point of a power system changes and hence, these systems may experience deviations in nominal system frequency and scheduled power exchanges to other areas, which may yield undesirable effects. There are two variables of interest, namely, frequency and tie-line power exchanges. Their variations are weighted together by a linear combination to a single variable called the area control error (ACE).

II. AGC STUDIES

2.1 Two area Thermal-Thermal Power System

Perturbed model of a two-area Thermal-Thermal power system with conventional integral controller scheme is shown in Fig. 2.1.

Different variables have been defined as:

State variable:

$$X_1 = \Delta F_1 \;\; X_2 = \Delta P_{t1} \;\; X_3 = \Delta P_{g1} \;\; X_4 = \Delta F_2 \;\; X_5 = \Delta P_{t2} \;\; X_6 = \Delta P_{g2} \;\; X_7 = \Delta P_{tie1-2} \;\; X_8 = \int ACE_1 dt \;\; X_9 = \int ACE_2 dt$$

Control inputs: u_1 & u_2

Disturbance inputs : $d_1 = \Delta P_{D1}$ $d_2 = \Delta P_{D2}$

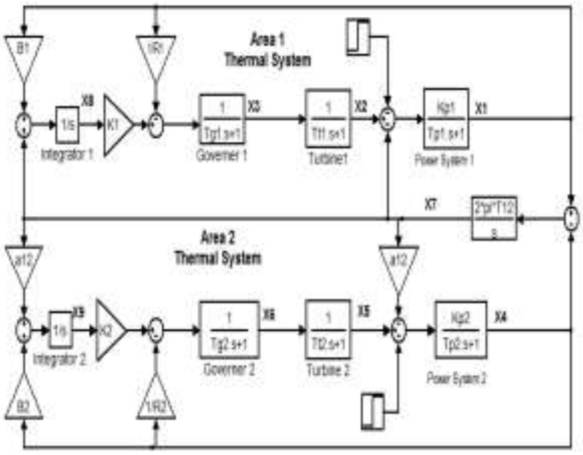

Fig. 2.1: Transfer function model of two-area Thermal-Thermal system

2.2 Two area Thermal-Hydro Power System

Two area Thermal-Hydro power system with conventional integral controller is shown in Fig. 2..2

With integral control, the equations for $\dot{x}_1$ to $\dot{x}_7$ and control input $\dot{u}_1$ & $\dot{u}_2$ are as given below:
Different variables have been defined as:

State variable:

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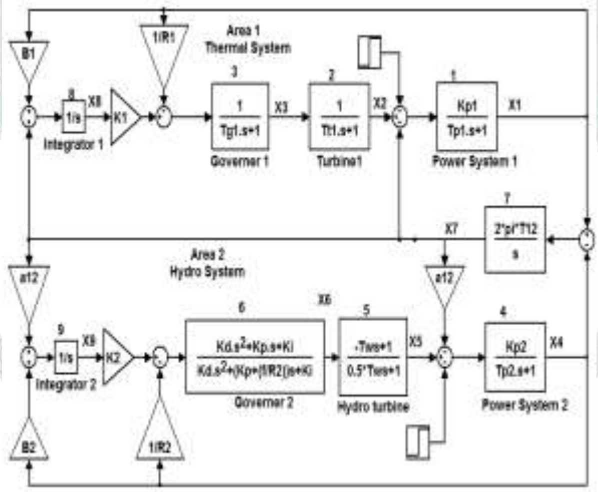


Fig. 2.2: Transfer function model of two-area Thermal-Hydro system

III. RESULTS

3.1 Two area Thermal-Thermal Power System

Simulations Model performed with no controller, with integral controller. BF based integral controller is applied to two-area electrical power system by applying 0.01 p.u. step load disturbance to area 1.

Fig. 3.1 to Fig. 3.3 show the dynamic responses of frequency deviations in two areas (i.e., Δf_1 and Δf_2) and the tie line power deviation (ΔP_{tie}) for the two area Thermal-Thermal power system for sample values of area load disturbances (d1 = 0.01p.u.). These figures show the performance of BF based integral controller trained with full state feedback in comparison with open loop and integral controllers on same scale.

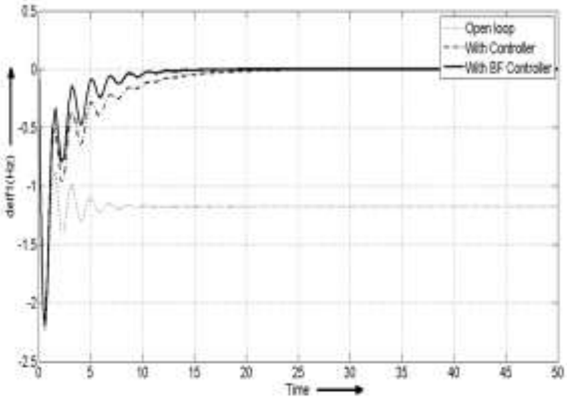


Fig. 3.1: Shows Δf_1 of two-area Thermal-Thermal Power System with Open loop, with conventional controller and With BF based integral controller

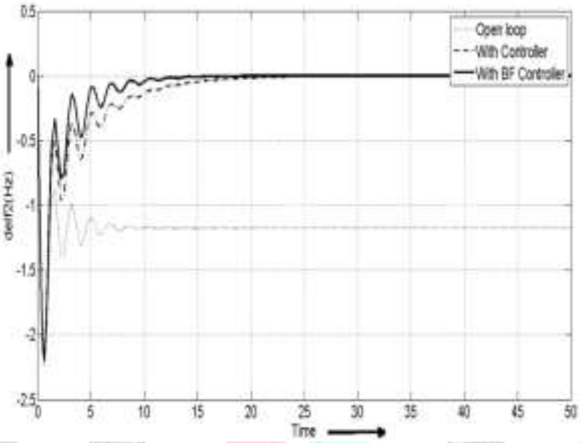


Fig. 3.2: Shows Δf_2 of two-area Thermal-Thermal Power System with Open loop, with conventional controller and With BF based integral controller

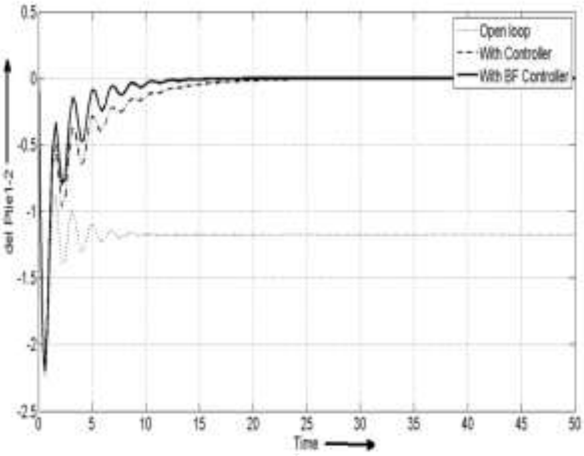


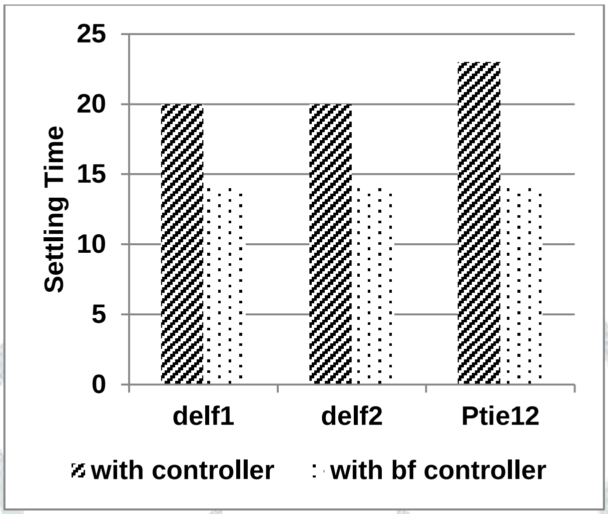
Fig. 3.3: Shows ΔP_{tie1-2} of two-area Thermal-Thermal Power System with Open loop, with conventional controller and With BF based integral controller

Fig. 3.1 to Fig. 3.34 shows the dynamic responses of two-area Thermal-Thermal system. Three graphs are showing in one graph, without controller, with controller and with BF based integral controller. These graph concluded that BF based integral controller give less settling time and low peak overshoot.

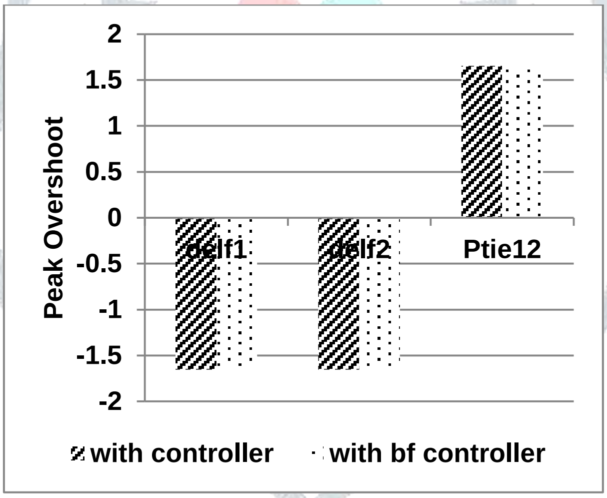
The overall results without controller, with integral controller and with BF based integral controllers applied to two-area Thermal-Thermal power system are summarized in Table-3.1. It shows that the settling time (T_s) in case of BF based integral controller is better than the conventional integral controller. Graph 3.1(a) and Graph 3.1(b) shows the bar graph of settling time (T_s) and maximum peak overshoot (M_p).

	delf1	delf2	Ptie12
With Controller	20 sec	20 sec	23 sec
with BF controller	14 sec	14 sec	14 sec

Table-3.1: Settling Time of two-area Thermal-Thermal system



Graph-3.1(a): Bar graph for settling time



Graph.3.1(b): Bar graph for Maximum Peak Overshoot

3.2 Two area Thermal-Hydro Power System

Simulations Model performed with no controller, with integral controller. BF based integral controller is applied to two-area electrical power system by applying 0.01 p.u. step load disturbance to area 1.

Fig. 3.4 to Fig. 3.6 show the dynamic responses of frequency deviations in two areas (i.e., Δf_1 and Δf_2) and the tie line power deviation (ΔP_{tie}) for the two area Thermal-Hydro power system for sample values of area load disturbances (d1 = 0.01p.u.). These figures show the performance of BF based integral controller trained with full state feedback in comparison with open loop and integral controllers on same scale.

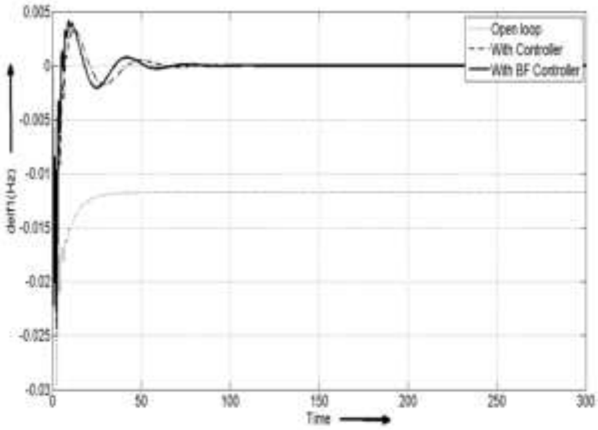


Fig. 3.4: Shows Δf_1 of two-area Thermal-Hydro Power System with Open loop, with conventional controller and With BF based integral controller

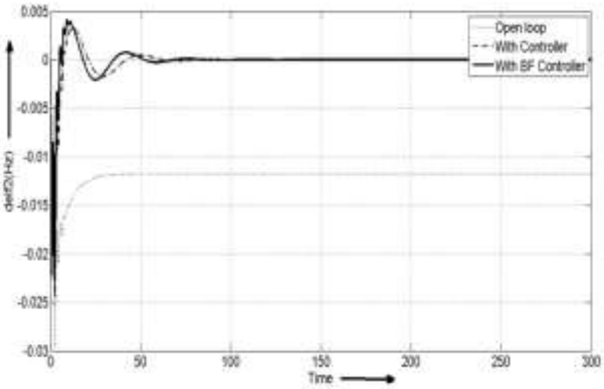


Fig. 3.5: Shows Δf_2 of two-area Thermal-Hydro Power System with Open loop, with conventional controller and With BF based integral controller

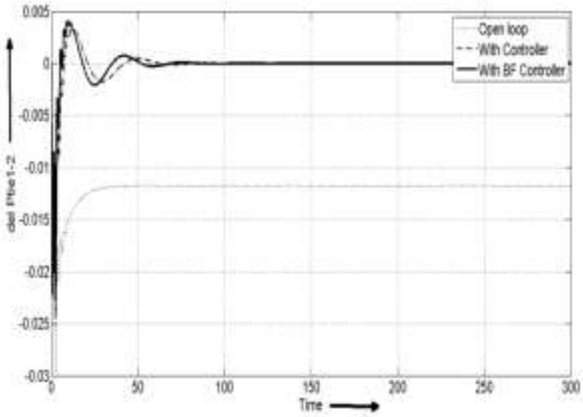


Fig. 3.6: Shows ΔP_{tie1-2} of two-area Thermal-Hydro Power System with Open loop, with conventional controller and With BF based integral controller

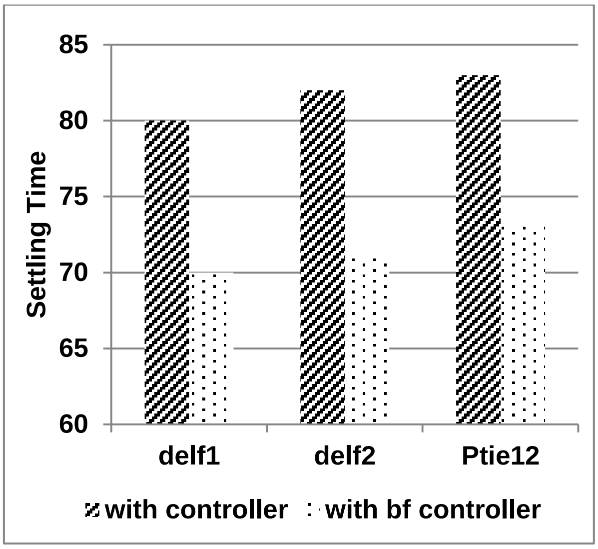
Fig. 3.4 to Fig. 3.6 show the dynamic responses of frequency deviations in two areas (i.e., Δf_1 and Δf_2) and the tie line power deviation (ΔP_{tie}) for the two area Thermal-Hydro power system

Fig. 3.4 to Fig. 3.6 shows the dynamic responses of two-area Thermal-Hydro system. Three graphs are showing in one graph, dotted line shows without controller, dash dot line shows with controller and solid line shows with BF based integral controller. These graph concluded that BF based integral controller give less settling time and low peak overshoot.

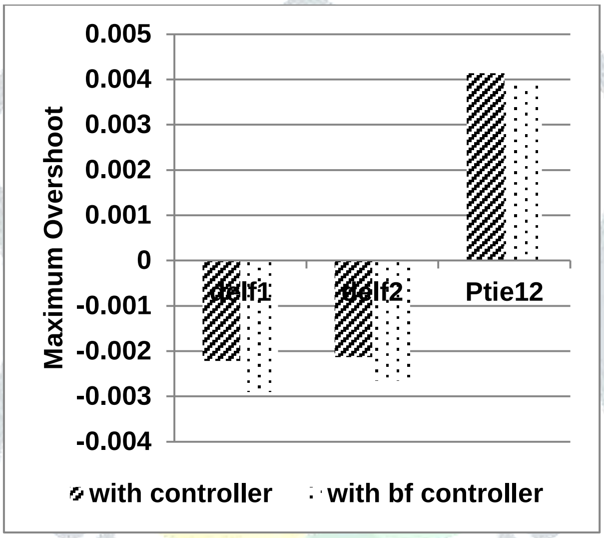
The overall results without controller, with integral and with BF based integral controllers applied to two-area Thermal-Hydro power system are summarized in Table3.2 shows that the settling time (T_s) in case of BF based integral controller is better than the conventional integral controller. Graph 3.2(a) and Graph 3.2(b) shows the bar graph of settling time (T_s) and maximum peak overshoot (M_p).

	delf1	delf2	Ptie12
with controller	80 sec	82 sec	83 sec
with BF controller	70 sec	71 sec	73 sec

Table 3.2: Settling Time of two-area Thermal-Hydro system



Graph-3.2(a): Bar graph for settling time



Graph-3.2(b): Bar graph for Maximum Peak Overshoot

IV. CONCLUSION

Simulation model of two-area Thermal-Thermal and two area Thermal-Hydro interconnected power systems has been developed. See the dynamic response of these models by without applying the controller. Then conventional controller is applied to see the dynamic response. Without controller steady state error is present in the power system. To remove this steady state error, controller is applied to the simulation model. Integral controller is optimized by the BF technology. Apply the BF based integral controller to the simulation model. It has been demonstrated that, the BF controllers can be successfully developed, which can give performance much superior than the integral controllers under simultaneous load disturbances of any random magnitudes within any chosen range in various interconnected areas.

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The BF controllers developed in present work offer the benefits over conventional integral controllers like;

1. Fast transient recovery
2. Less time to settle the excursions of system state variables within acceptable limits
3. Ability to give satisfactory performance even with incomplete state feedback
4. Ability to give satisfactory performance under simultaneous load perturbations in all the interconnected areas and unregulated area.

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