IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

LOAD FREQUENCY CONTROL FOR A TWO AREA INTERCONNECTED POWER SYSTEM USING GENETIC ALGORITHM CONTROLLER

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ABSTRACT

This editorial characterize the design, implementation and operational Performance of a Genetic Algorithm controller for the load frequency control Problem in power systems pertaining to of two area interconnected power System with AC tie line. The proposed Genetic Algorithm controller (GA) has designed which consists of two crisp Inputs namely deviation of frequency and derivative of frequency variation. This control scheme has been applied to a two area interconnected thermal Power system. The performance of the proposed GA controller is demonstrated and compared with Conventional PI controller. It is observed that from the simulation results of the proposed GA controller for two area interconnected non-reheat thermal power system provides very good Transient and steady state response.

KEYWORDS: Load frequency control (LFC), Genetic Algorithm Controller, Two-area interconnected power Systems.

INTRODUCTION

Currently, the Analysis of the load frequency control (LFC) is obligatory one because of the exponential growth in size and complexity of large interconnected power systems [1]. The basic role of the LFC is to maintain desired real power output of a generator unit and assist in controlling the frequency of interconnected power systems. Further LFC helps to keep the net inter change of power between interconnected areas at pre-specified values [1,2]. LFC will maintain its control only during normal (small and slow) changes in load and frequency of the system. When large real power imbalance occurs followed by more drastic emergency control must be applied to control.

The main objectives of the load frequency control is for a given load perturbation, the following classic requirements are to be met[1,3].

- Zero steady state error of Area Control Error (ACE) which ensures frequency deviation and tie-Line power deviation to zero.
- Ensure good transient response under disturbance
- To provide reliable operation and control of the system.
- Feedback controller should have simple structure.
- The control law should match with system non-linearity's
- Controller must be easy for implementation.

LFC is a very important role in power system operation and control for supplying sufficient and reliable electric power with good quality [3]. Many investigations in the area of LFC of isolated and interconnected power systems have been reported [4,5,6] and a number of control strategies have been proposed to achieve improved performance. The proportional plus integral (PI) control approach is successful in achieving zero steady state error in the frequency of the system, but it exhibits relatively poor dynamic performance as evidenced by large overshoot and transient frequency oscillation [6]. Moreover, the transient settling time is relatively large. In the application of optimal control technique, the controller design is normally based on a fixed parameter model of the system derived by a linearization process [8]. The non- linear nature of the load frequency control problem make it difficult to ensure stability for all operating points when an integral or a PI control is used [6,7].based on the Simulation results of various controllers, Hence to overcome this crisis, a new and modern intelligent controller been suggested to solve LFC problems. In recent years, modern 'intelligent' methods such as Artificial Neural Network (ANN), Fuzzy Logic (FL) and Genetic Algorithm (GA) have gained increasing interest for application in the LFC problem. These newer methods have promising results. Their notable features are mainly their applicability to a wider range of operating conditions and their model free nature [8-13].

A modern “Intelligent” controller method such as Genetic Algorithm controller for load frequency control for an interconnected power system has been proposed in this paper.

MODELING OF INTERCONNECTED POWER SYSTEMS

For the design of LFC, it is necessary to suitably model the power systems. This work describes the modeling aspects of a two-area thermal non-reheat transfer system with feedback signal. A procedure for obtaining state equations from the model has already proposed in many literatures. In general, the transfer function method and state variable method are mostly preferred for design of load frequently control[2,14].

1.1 Transfer function model as State variable Model

The state variable model for two-area thermal power system without reheat turbine (with feedback) is shown in figure 2.1. The model is valid for small perturbations around nominal operating point for the time duration of interest in LFC studies. The revise on the excitation system and the effects of voltage regulator are neglected to evolve a simple model. The feedback of integral of area control error (ACE) as speed changer command signals are scheduled frequency and tie line power.

Table 2.1 Set of equations representing Transfer function model for two area interconnected system with feedback signal

Transfer function model representations	
$\triangle F_1(s) = \frac{K_{ps1}}{1+ST_{Ps1}}[\triangle P_{g1}(s) - \triangle P_{d1}(s) - \triangle P_{tie1}(s)]$	After taking Laplace transform, $\dot{\triangle F_1} = \frac{1}{T_{Ps1}}[K_{ps1}\triangle P_{g1} - \triangle F_1 - K_{ps1}\triangle P_{d1} - K_{ps1}\triangle P_{tie1}]$
$\triangle P_{g1}(s) = \frac{1}{1+ST_{t1}}[\triangle X_{e1}(s)]$	$\dot{\triangle P_{g1}} = \frac{1}{T_{t1}}[\triangle X_{e1} - \triangle P_{g1}]$
$\triangle X_{e1}(s) = \frac{1}{1+ST_{sg1}}[\triangle Pc1(s) - \frac{1}{R_1}\triangle F_1(s)]$	$\triangle X_{e1} = \frac{1}{T_{sg1}}[\triangle P_{c1} - \triangle X_{e1} - \frac{1}{R_1 T_{sg1}}\triangle F_1]$
$\int ACE_2 = \int[\beta_1\triangle F_1(s) + \triangle P_{tie1}(s)]$	$ACE_1 = \beta_1\triangle F_1(s) + \triangle P_{tie1}(s)$
$\triangle P_{tie1}(s) = \frac{2\pi T_{12}}{S}[\triangle F_1(s) - \triangle F_2(s)]$	$\dot{\triangle P_{tie1}} = 2\pi T_{12}\triangle F_1 - 2\pi T_{12}\triangle F_2$
$\triangle F_2(s) = \frac{K_{ps2}}{1+ST_{Ps2}}[\triangle P_{g2}(s) - \triangle P_{d2}(s) - \triangle P_{tie2}(s)]$	$\dot{\triangle F_2} = \frac{1}{T_{Ps2}}[K_{ps2}\triangle P_{g2} - \triangle F_2 - K_{ps1}\triangle P_{d2} - a_{12}K_{ps2}\triangle P_{tie2}]$
$\triangle P_{g2}(s) = \frac{1}{1+ST_{t2}}[\triangle X_{e2}(s)]$	$\dot{\triangle P_{g2}} = \frac{1}{T_{t2}}[\triangle X_{e2} - \triangle P_{g2}]$
$\triangle X_{e2}(s) = \frac{1}{1+ST_{sg2}}[\triangle P_{c2}(s) - \frac{1}{R_2}\triangle F_2(s)]$	$\dot{\triangle X_{e2}} = \frac{1}{T_{sg2}}[\triangle P_{c2} - \triangle X_{e2} - \frac{1}{R_2 T_{sg2}}\triangle F_2]$
$\int ACE_2 = \int[\beta_1\triangle F_2(s) + a_{12}\triangle P_{tie1}(s)]$	$ACE_2 = \beta_1\triangle F_2(s) + a_{12}\triangle P_{tie1}(s)$

The above equations in the Table 2.1 are put in the form , $X = Ax + Bu + \gamma d$ (2.1)

and Output equation $Y = CX$ (2.2)

where the system state vector [X], System control input is [u], System disturbance input vector is [d],and system matrix [A].By using the above set of equations in the table 2.1, the state variable model for the proposed system has been achieved[2].

The state variable model for two-area thermal power system without reheat turbine (with feedback) is shown in figure 2.1. The model is valid for small perturbations around nominal operating point for the time duration of interest in LFC studies. The studies on the excitation system and the effects of voltage regulator are neglected to evolve a simple model. The feedback of integral of ACE as speed changer command signals are scheduled frequency and tie line power.

DESIGN OF CONVENTIONAL CONTROLLERS

For efficient operation of power system, some important conventional controllers have been considered in this work for control of two area interconnected power systems which helps to compare and discuss its flaws and merits [14].

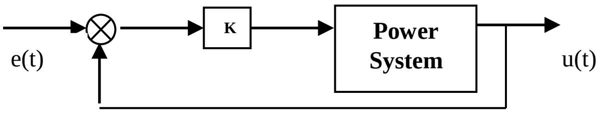


Figure 3.1 Block diagram of Controller with Power system

3.1 Proportional Controller

It produces an output signal u(t), which is proportional to the input signal e(t) as shown in fig 3.1.

i.e., $u(t) = Kp\, e(t)$ (2.3)

Where Kp = proportional gain or constant.

3.2 Integral Controller

It produces an output signal u(t) which is proportional to the integral of the input signal e(t) as shown in fig 3.1.

i.e., $u(t) \;\alpha \int e(t)$; $u(t) \;\alpha\; \frac{K_i}{s}\; e(t)$ (2.4)

Where Ki = integral gain (or) constant.

3.3 Proportional Plus Integral Controller

It produces an output signal, u(t) consisting of two terms, one proportional to input signal e(t) and other proportional to integral of the input signal e(t) as shown in fig 3.1.

$U(t) \;\alpha\; [e(t) + \int e(t)\, dt]$; $U(t) = Kp\, e(t) + Ki \int e(t)\, dt$

Where Kp = proportional gain and Ki = integral gain

The output of PI controller in the load frequency control is given by the expression

$Kp\, ACEi + Ki \int ACEi\, dt$ (2.5)

DESIGN OF GENETIC ALGORITHM CONTROLLERS

Genetic Algorithm is search procedures whose mechanics are based on those of natural genetics. Genetic Algorithms (GAs) are simple, derivative free, effective and quite robust in solving the optimization problems inspired by the laws of natural selection and genetics. GAs can provide near global solution and can also handle the control variable effectively. In this work, it has been considered instead of conventional P, D and PI controllers.

4.1 Genetic Operators

Genetic algorithm consists of a population of bits (reproduction) transformed by three genetic operators such as selection, crossover and mutation. Each chromosome represents a possible solution for the problem being optimized and each bit represents a value for some variable of the problem.

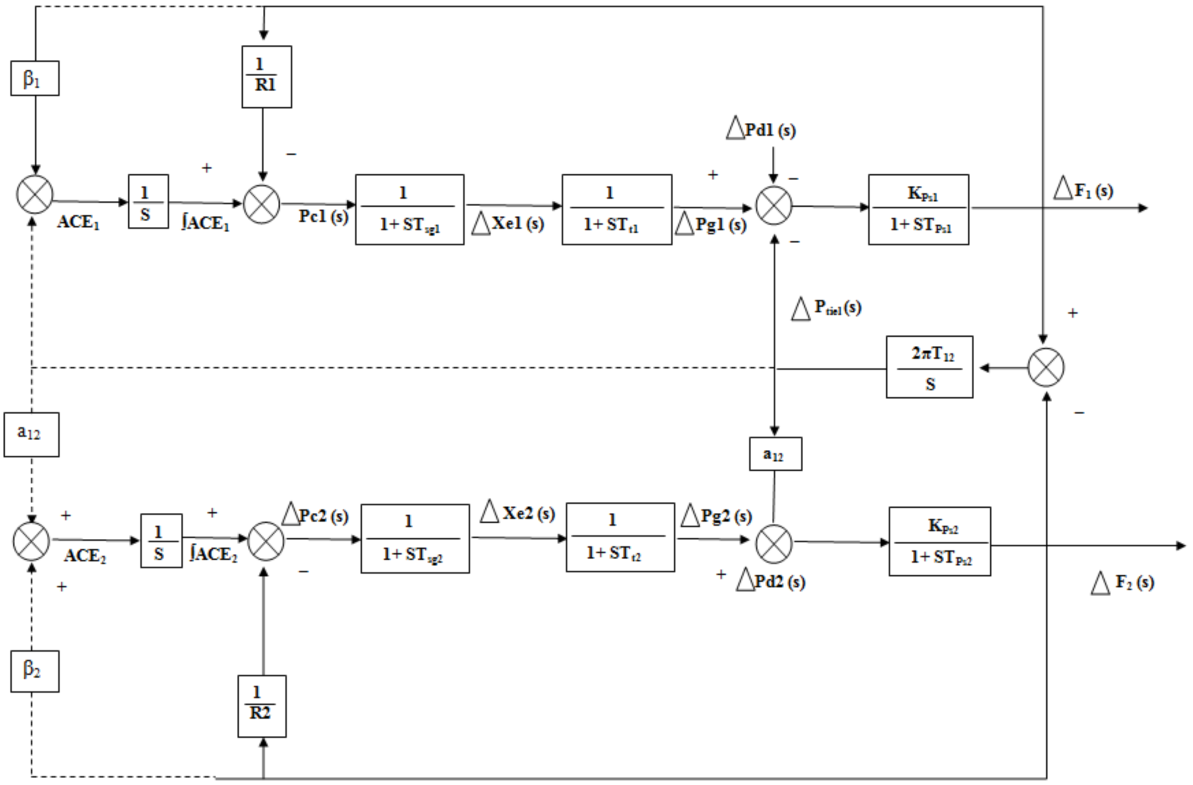


Fig 2.1: Modeling of two area non-reheat thermal power system (with feedback control)

The first population is generated at random and each new generation is created by the selection of reproduction operator and altered by cross over and mutation for better solution.

4.2 Selection (or) Reproduction

The selection operator creates a new population or generation by selecting individual from the old population based towards the best. This means that there will be more copies of the best individuals, although there may be some copies of the worst. This operator can be implemented in a variety of way but the simplest one is Roulette wheel selection.

In this connection, individual variables are copied according to their objective functions (fitness function). Copying variables according to their fitness value means that variable with a higher value has a higher probability of contributing one or more off spring in the next generation.

4.3 Cross- Over

After selection, cross-over may proceed in two steps. First, members of newly reproduced variables in the mating pool are mated at random. Second, each pair of variables undergoes crossing over as follows.

An integer position K along the variable is selected uniformly at random between I and variable length (p) less one i.e., 1, p-1. Two new variables are created by swapping all characters between position k+1 and p inclusively.

4.4 Mutation

Mutation plays a decided secondary role in the operation of GA. Mutation is needed because, even though reproduction and crossover effectively search and recombine extent notions, occasionally they may lose some potentially useful genetic materials. In the simple GA, Mutation is the occasional (with small probability) random alteration of the values of a variable position. The frequency of mutation to obtain good results in empirical genetic algorithm studies is of the order of one mutation per thousand bit transfer.

RESULTS AND DISCUSSION

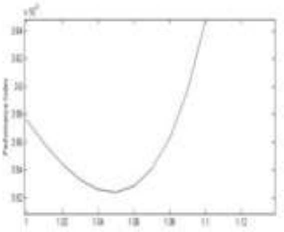
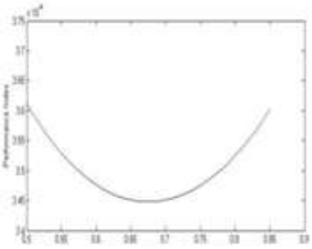
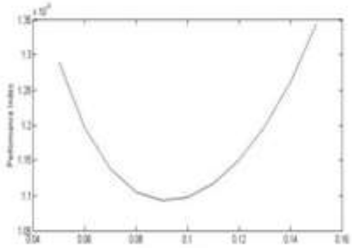
5.1 Determination and tuning of optimal value of gain (K_i) with P,I and Proportional Plus Integral Controller

The proportional controller improves steady state tracking accuracy, disturbance signal rejection and relative stability. The proportional controller is not alone used because it produces constant steady state error. Here we assume that Kp1 = Kp2 = Kp. Since the two areas are identical and the cost curve is shown in Table 5.1. The lowest point on U-curve is considered as optimum value.

As like a P controller, Here again Ki1 = Ki2 = Ki has been assumed for integral controller; from the cost curve drawn between Ki and performance index j, optimum controller gain can be obtained for integral controller. The lowest point on the U-shaped curve is taken as optimum value of gain Ki as shown in cost curve in Table 5.1.

The introduction of PI controller increases the order and type number of the system by 1. The optimum value of Kp is kept constant and performance index j can be obtained for various values of controller gain Ki. the optimum value of Ki can be determined as shown in cost curve given in table 5.1.

Table 5.1 Simulation results represents the Cost Curve for P,I and Proportional Plus Integral Controller

P Controller	I Controller	PI Controller
		

The proposed GA controller and conventional PI controller are implemented for an interconnected power systems and system; responses are obtained for a step load change of 0.01 p.u MW in the system.

The data for the two area interconnected thermal power system are T_{g1} = $T_{g2=}$ 0.08sec;T_{t1} = $T_{t2=}$ 0.3sec; T_{p1} = 20sec;R_1 = $R_{2=}$ 2.4Hz/p.u. M.W;$2\pi T_{12}$ = 0.545sec ;Kp_1 = $Kp2_{=}$ 120Hz/p.u. MW;A_{12} = -1

For comparative analysis, the system frequency deviation responses of two controllers are implemented and their responses are plotted as a function of time't' which is shown in figure 5.1, 5.2 and 5.3respectively.

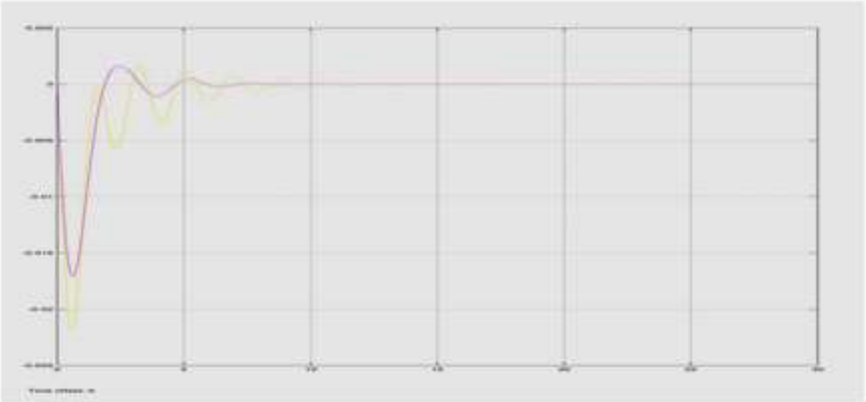


Fig. 5.1 Frequency deviation in area 1 of a two area Thermal Power system for a step load disturbance

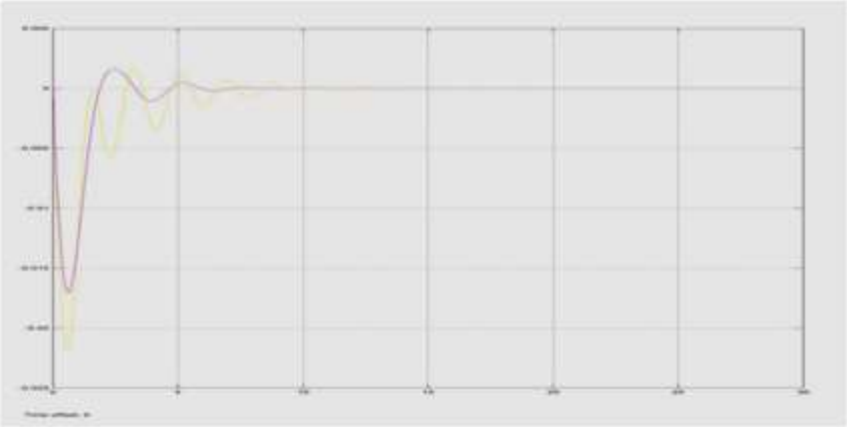


Fig. 5.2 Frequency deviation in area 2 of a two area Thermal Power system for a step load disturbance

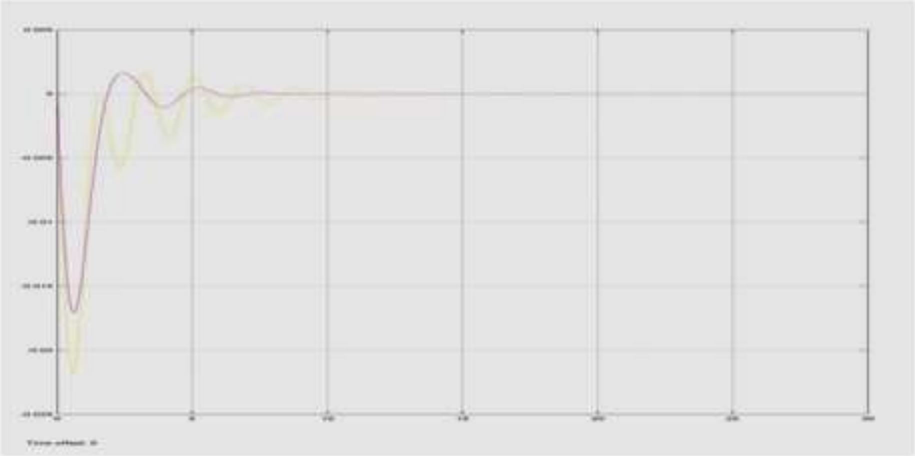


Fig. 5.3 Frequency deviation in tie line of a two area Thermal Power system for a step load disturbance

From the above response, it's evident that the proposed controller performance at transient state and at steady state is better than the conventional PI Controller. The GA controller has better dynamic response, quick in operation, reduced error magnitude and minimized frequency transients.

CONCLUSION

A Genetic Algorithm controller has been designed and implemented for two area thermal power system with non-reheat. The comparison has been made between the response of the GA controller and conventional Integral controller. From the simulation results, steady state frequency error is zero and Stability of the system has achieved with high quality transient response as well as distinguished by good steady state and dynamic state characteristics. The proposed design is simple and effective but also easy to implement for operation and control in power systems.

ACKNOWLEDGEMENTS

The author wish to thank the authorities of Annamalai University, Annamalai nagar, Tamilnadu, India For the facilities provided to prepare this paper

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