New Control Strategy For Improvement Of Transient Behaviour In Multi Area Interconnected Power System With Emphasis On Robust Genetic Algorithm

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Abstract- *In this paper a new robust load frequencies controller (LFC) for two area interconnected power system is presented to quench the deviations in frequencies and tie line power due to different disturbances. The dynamic model of the interconnected power system is developed with state variables with the integral and area control error. The two area interconnected power system is subjected to a wide range of load disturbances. To validate the effectiveness of the proposed Genetic Algorithm controller over the PI controller, PID Controller, Fuzzy Logic Controller is compared. The results prove that the transient performance with the proposed Genetic Algorithm controller placed in both the areas is better than these obtained by the other controllers.*

Keywords: *Interconnected power system, Load Frequency Control (LFC), Fuzzy Logic Controller (FLC), Genetic Algorithm (GA).*

1. Introduction

Power engineers have the responsibility to deliver adequate and quality power to consumers. In order to achieve this, the power system must be maintained at the desired operating level by suitable modern control strategies. The modern power systems with industrial and commercial loads need to operate at constant frequency with reliable power. The load frequency control of an interconnected power system is being improved over the last few years. The goals of the LFC are to maintain zero steady state errors in a multi area interconnected power system [1-2]. Studies on two area interconnected power system networks were presented based on conventional and modern optimal control techniques. Recently many researchers have applied genetic algorithm controllers to improve the dynamic performance of the system. Genetic Algorithm, Fuzzy logic, PI, PID controllers were used to damp oscillations resulted from load perturbations [3-6]. Subsequently load frequency control of two area interconnected power systems using fuzzy control approach to quench the transients in frequency deviations and tie line power deviations is presented [3,8]. In all these works the basic dynamic model representation of a two area power system given in the reference [2] is considered and the responses of two area power systems are evaluated using proportional plus integral and derivative control with the help of fuzzy control methods. These results show that the frequency deviations are oscillatory.

In this work, we investigate the optimum adjustment of the classical AGC using genetic algorithms [3] and performance indices, namely the integral of time – multiplied absolute value of the error (ITAE) [4], which is given by,

$$S = \int_0^\infty t|e(t)|dt \quad ---(1.1)$$

A digital simulation is used in conjunction with the genetic algorithms optimization process to determine the optimum values of the AGC for the performance indices considered. Genetic algorithms are used as parameters search techniques which utilize the genetic operators to find near optimal solutions [5].

The work reported in this paper deals with the dynamic model of the power system with integral action and area control error. So Load Frequency Control Problem is restructured as a state transfer problem. The ultimate aim of this work is that, by using a suitable control strategy the system should be transferred from an initial state to the final state without any oscillations in frequency deviations and tie line power deviations so that the time required to reach the final steady state can be reduced greatly. The transient behaviour of the system for different load changes for different controllers are obtained and they are compared based on PI controller, PID Controller, Fuzzy Logic controller and proposed Genetic Algorithm (GA) controller for a two area interconnected system. The robustness of proposed genetic algorithm was applied and observed that the frequency transients are quenched at much faster rates without any oscillations, when compared with other control methods.

2. Modelling of two–area interconnected power system

A two area interconnected power system is shown in fig.1. Here k_1 and k_2 are integral control gains and u_1 and u_2 are stabilizing signals. The stabilizing signals are generated by the proposed genetic algorithm controller. Each power area has a number of generators which are closely coupled together so as to form a coherent group, i.e. all the generators respond in unison to changes in the load. Such a coherent area is called a control area. Each control area can be represented by an equivalent generator, governor and turbine system. The conventional LFC shown in fig.1 is based on tie-line bias control, where each control area tends to reduce the Area Control Error (ACE) to zero.

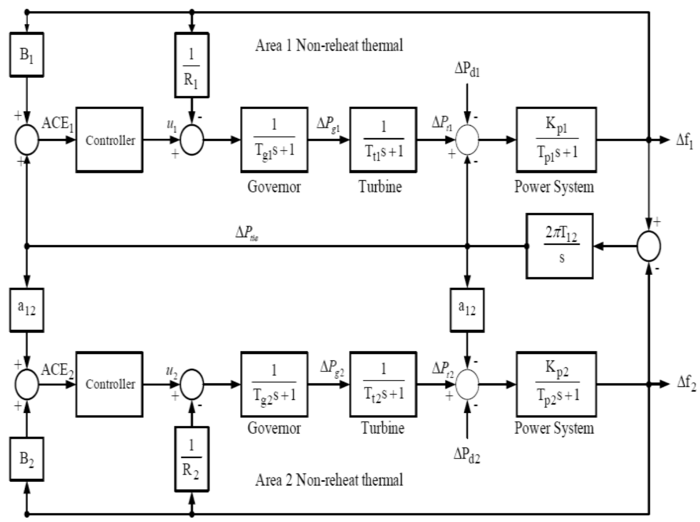

Fig.1: Two Area Interconnected Power System

3. New genetic algorithm controller for the interconnected power system

Genetic algorithms (GA) are global search techniques, based on the operations observed in natural selection and genetics [6]. They operate on a population of current approximations. The individuals initially drawn at random, from which improvement is sought. Individuals are encoded as strings (chromosomes) constructed over some particular alphabet, e.g., the binary alphabet {0, 1}, so that chromosomes values are uniquely mapped onto the decision variable domain. Once the decision variable domain representation of the current population is calculated, individual performance is assumed according to the objective function which characterizes the problem to be solved. It is also possible to use the variable parameters directly to represent the chromosomes in the GA solution.

At the reproduction stage, a fitness value is derived from the raw individual performance measure given by the objective function, and used to bias the selection process. Highly fit individuals will have increasing opportunities to pass on genetically important material to successive generations. In this way, the genetic algorithms search from many points in the search space at once and yet continually narrow the focus of the search to the areas of the observed best performance. The selection individuals are then modified through the application of genetic operators, in order to obtain the next generation. Genetic operators manipulate the characters (genes) that constitute the chromosomes directly, following the assumption that certain genes code, on average, for fitter individuals than other genes. Genetic operators can be divided into three main categories [5], reproduction, cross over and mutation.

1. Reproduction: Selects the fittest individuals in the current population to be used in generating the next population.
2. Cross over: Causes pairs, or larger groups of individuals to exchange genetic information with one another.
3. Mutation: Causes individual genetic representations to be changed according to some probabilistic rule.

Genetic algorithms are more likely to converge to global optimal than conventional optimization techniques, since they search from a population of points, and are based on probabilistic transition rules. Conventional optimization techniques are ordinarily based on deterministic hill – climbing methods, which, by definition, will only find local optima. Genetic algorithms can also tolerate discontinuities and noisy function evaluations.

In this study, the optimal values of the parameters frequency deviations and change in frequency deviations which minimize an array of different performance indices are easily and accurately computed using a genetic algorithm. In a typical run of the GA, an initial population is randomly generated. This initial population is referred to as the 0^{th} generation. Each individual in the initial population has an associated performance index value. Using the performance index information, the GA then produces a new population. The application of a genetic algorithm involves repetitively performing two steps.

1. The calculation of the performance index for each of the individuals in the current population. To do this, the system must be simulated to obtain the value of the performance index.
2. The genetic algorithm then produces the next generation of individuals using the reproduction, cross over and mutation operators.

These two steps are repeated from generation to generation until the population has converged, producing the optimum parameters. A flow chart of the genetic algorithm optimization procedure is given in fig.2.

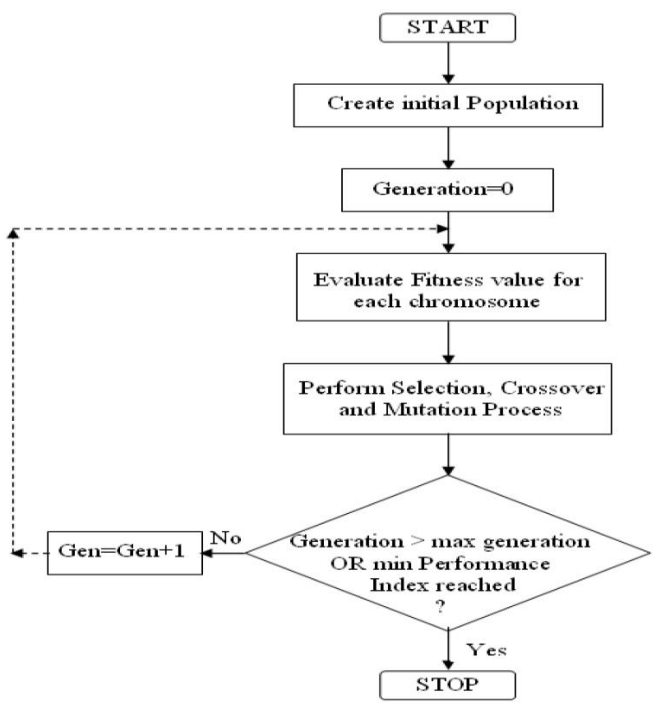

Fig.2: Genetic Algorithm Controller Flow Chart

4. Simulation study

In this paper the controllers have been applied to solve the load frequency control of a two area power system having the numerical data shown in Table1.

Table 1: Two area power system parameters

Parameters	Area1	Area2
T_p	20	22
T_g	0.2	0.3
T_t	0.4	0.5
R	2.5	3
K_p	120	100
T_{tie} (or) T_{12}	0.08	
a_{12}	– 1	

Load frequency control of a two area interconnected power system to quench the deviations in frequency and tie line power due to different load disturbances in any one area using different control strategies is attempted. The major objective of the work presented here is to obtain a suitable controller to improve the transient performance of the two-area power system without oscillations in less time of state transfer. The responses of the two area interconnected power system are evaluated with i) PI controller, ii) PID controller iii) Fuzzy PI controller and iv) Genetic algorithm controller. The two area inter connected power system is subjected to a wide range of load disturbances and the controllers are switched at t = 0 seconds, simulated results are obtained with different configurations by placing the controller in both the areas with load changes are assumed to be in both the areas.
The corresponding responses are shown in Figures 3 to 11.

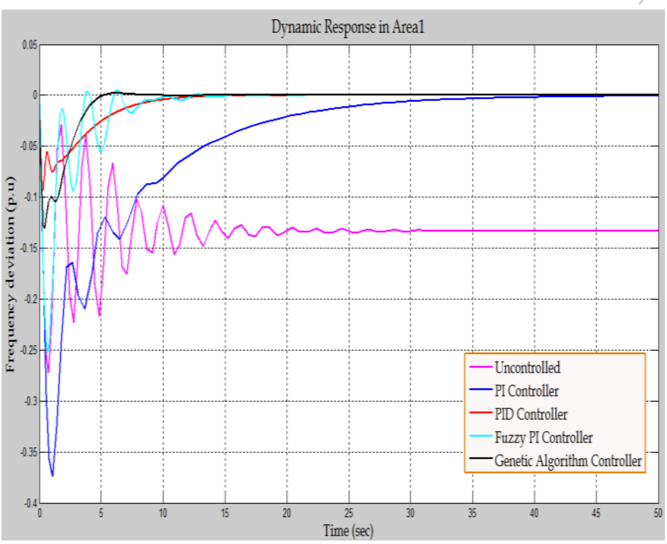

Figure 3: Change in frequency deviation of area1 for a load change of ΔP_{d1}= ΔP_{d2}= 0.1 with controllers in both areas

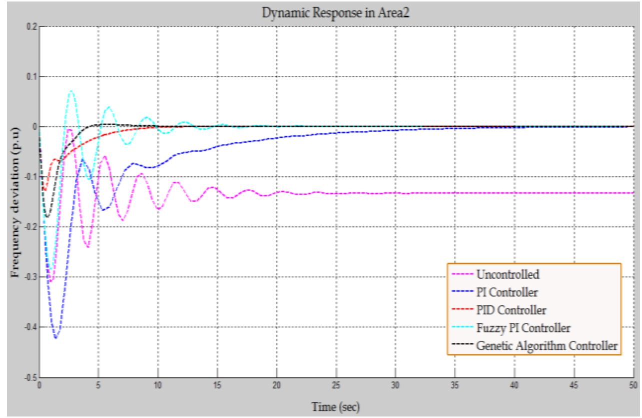

Figure 4: Change in frequency deviation of area2 for a load change of ΔP_{d1}= ΔP_{d2}= 0.1 with controllers in both areas

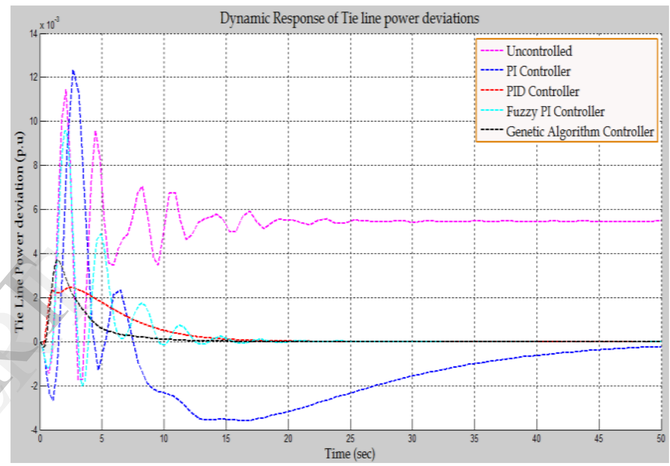

Figure 5: Change in tie line power deviation for a load Change of ΔP_{d1}= ΔP_{d2}= 0.1 with controllers in both areas

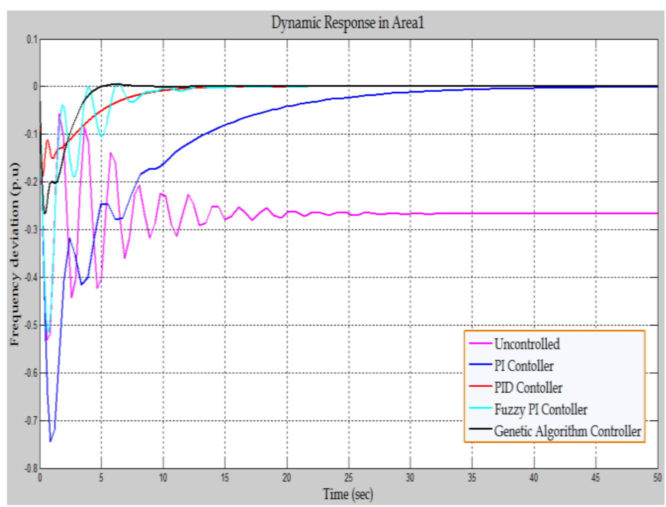

Figure 6: Change in frequency deviation of area1 for a load change of ΔP_{d1}= ΔP_{d2}= 0.2 with controllers in both areas

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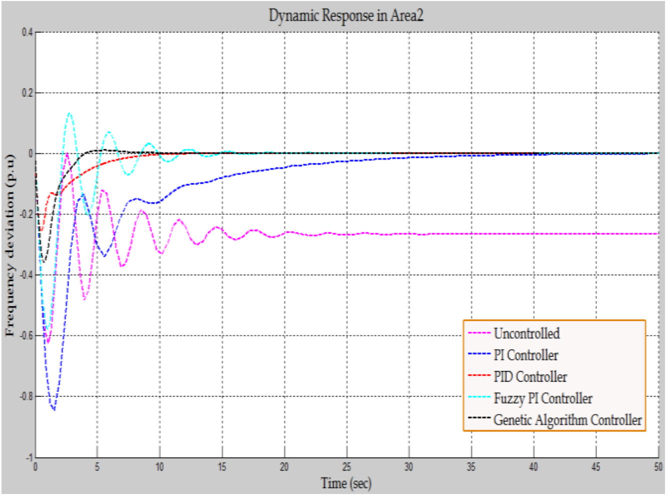

Figure 7: Change in frequency deviation of area2 for a load change of $\Delta P_{d1}= \Delta P_{d2}= 0.2$ with controllers in both areas

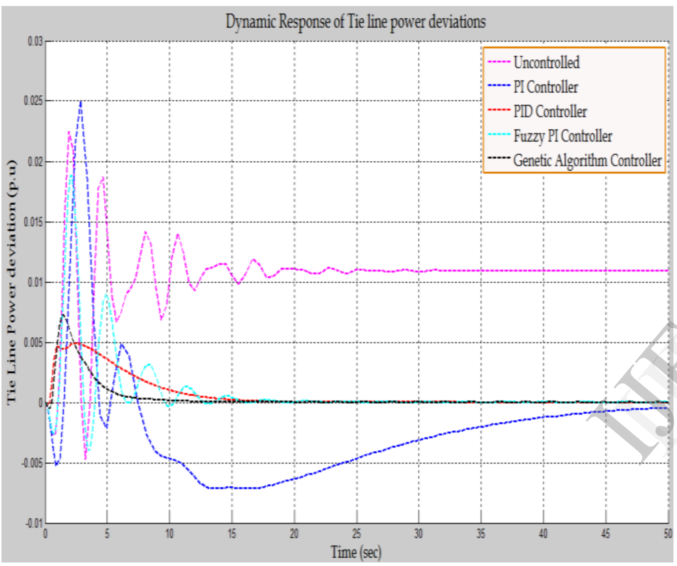

Figure 8: Change in tie line power deviation for a load change of $\Delta P_{d1}= \Delta P_{d2}= 0.2$ with controllers in both areas

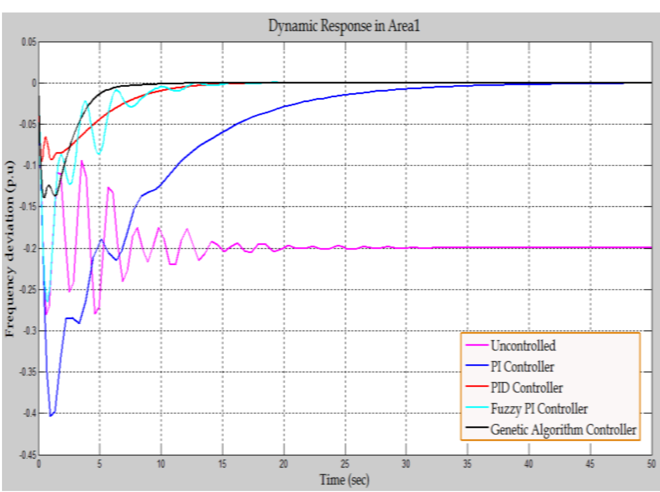

Figure 9: Change in frequency deviation of area1 for a load change of $\Delta P_{d1}= 0.1$ & $\Delta P_{d2}= 0.2$ with controllers in both areas

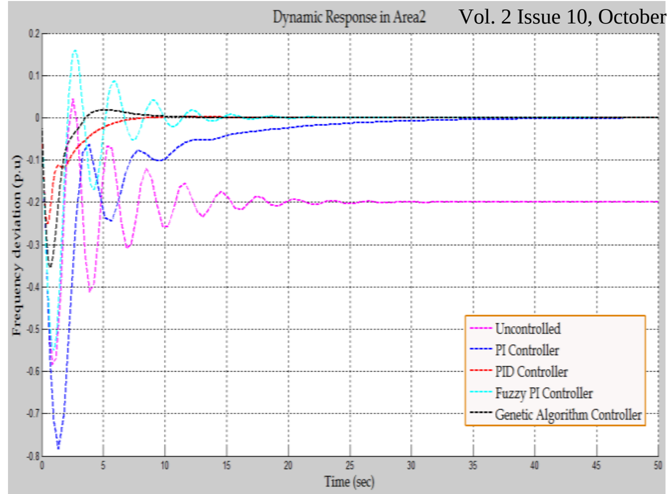

Figure 10: Change in frequency deviation of area2 for a load change of $\Delta P_{d1}= 0.1$ & $\Delta P_{d2}= 0.2$ with controllers in both areas

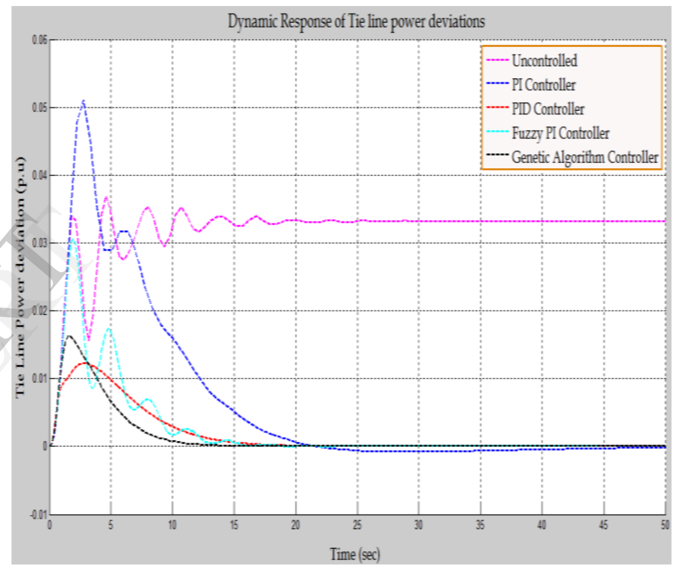

Figure 11: Change in tie line power deviation for a load change of $\Delta P_{d1}= 0.1$ & $\Delta P_{d2}= 0.2$ with controllers in both areas

5. Conclusion

The load frequency control problem of two tie line interconnected power system is studied with various controllers for different configurations of the power system using dynamic model. The uncontrolled system responses reveal that the static errors are increasing with increase of load changes and regulation constants. The control system responses indicate that the deviations of frequency in each area and tie line power deviations are increasing with increase in load. All the deviations are oscillatory for all the controllers placed in area1 with load changes in area1 and area2. However it is observed that the responses are non-oscillatory only in the case of new genetic algorithm controllers placed in both the areas with load changes in area1 and area2. The deviations of frequency in each area and tie line powers are found to be the lowest with less times of state transfer for this case. Similar trend in the behaviour of the system with increase in load changes is noticed except that the settling times and negative over shoots is more. Even with the wide variations of the load and switching times the system is reaching steady state without any static error with least deviations the scheme of genetic algorithm controllers placed in both the areas is considered to be more robust in nature.

Nomenclature

ΔP_g : Generated power derivation
ΔP_d : Change in power demand
ΔP_c : Change in speed changer position
Δ_{Ptie} : Incremental tie line power
K_p : Static gain power system inertia dynamic block
T_p : Time constant of power system inertia dynamic block
T_g : Governor time constant
T_t : Turbine (non reheat type) time constant
R : Speed regulation parameter
B : Frequency-biasing factor

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