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Optimisation of Two Area Power System Using Differential Evaluation Algorithm

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Abstract: Load Frequency Control (LFC) is used to adjust the real power generation based on the load changes. When the real power demand is increased than the supply then the output frequency of the generator will reduce from the rated value. The difference in frequency between actual and rated reference value is called change in frequency. This change in frequency is used to adjust the steam supply and thereby the real power generation. Proportional (P) and Integral (I) controllers are used to control this LFC. To find the best value of this PI gain constants needs an intelligent approach is required. In this project intelligent algorithm Differential Evolution (DE) is used to find gain constant of PI controller. The advantage of the proposed controller is that it can handle system non-linearity and at the same time proposed controller is faster than the conventional controllers. The proposed controller is modeled for an interconnected two area power system as a simulation model in MATLAB/SIMULINK. The performance of intelligent algorithms based controllers are compared with the conventional Proportional Integral (PI) controller. The effectiveness of the proposed controller in increasing the damping of local and inter area modes of oscillation is demonstrated in a two area interconnected power system. The result shows that this controller has good dynamic response and at the same time faster than the conventional controller.

Keywords: Area Control Error, Differential Evolution (DE), Load Frequency Control (LFC), conventional Proportional Integral.

I. INTRODUCTION

In a power station, the generating electric power unit must satisfy the load demand to all consumers in the system with desired qualities. The electric energy system can be operated at the desired operating level by maintaining nominal frequency, voltage profile and level of reliability. The nominal frequency and the voltage profile are maintained automatically by Power System Operation and Control.

Power system operation and control have the responsibility to ensure that adequate power is delivered to the load reliably and economically. The main objective of power system control is to maintain the continuous balance between electrical generation and varying load demand while system frequency and voltage levels are maintained constant.

The load variations in the power system affect the quality of power. If the power demand is more than the generated power, system frequency will decrease and if the power demand is lesser than the generated power, system frequency will increase affecting the real power of the system. Hence the balance of the power system gets disturbed.

To supply the load demand without giving much constrain to a single system and to improve the reliability, power systems are interconnected and power is exchanged between the systems over the tie-lines by which they are connected. Even in interconnected power system the load change in any one of the systems affects the performance of other systems. Hence, Load Frequency Control (LFC) is a very important issue in power system operation and control for supplying sufficient and both good quality and reliable power [1-3].

Many researchers have discussed that about LFC systems with PI controllers. These controllers are not suitable under non-linear load. [4] Discusses about the artificial intelligence GA for the load frequency control and [5] Tabu search method in LFC.

The paper is organized as follows, section II deals with two-area power system. Controllers were discussed in section III and in section IV, simulation results were explained. Finally concluded with conclusion in section V.

II. TWO –AREA POWER SYSTEM

For simplicity, the final derived transfer function is represented for each block of the system and shown in figure 1. The transfer function of the speed governor, the non-reheat turbine and the generator are derived using standard mathematical procedure available in the literature

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and the final values are represented here in equations (1), (2) and (3).

Equation (1) gives the transfer function of speed governor. Where, KG is the gain of the governor and TG is the time constant of the governor.

$$G_p(s) = \frac{K_G}{1+sT_G} \quad (1)$$

Equation (2) shows the non-reheat turbine model. Where, K_T is the gain of the non-reheat turbine and T_T is the time constant of the non-reheat turbine.

$$G_G(s) = \frac{K_T}{1+sT_T} \quad (2)$$

Equation (3) gives model of the power system in which, K_P and T_P denote gain and time constant of the power system which is expressed in equation (4) and (5). H is per unit inertia constant, f is system frequency, and D is percent change in load by percent change in frequency.

$$G_p(s) = \frac{K_p}{1+sT_p} \quad (3)$$

$$K_p = \frac{1}{D} \quad (4)$$

$$T_p = \frac{2H}{fD} \quad (5)$$

The steady state and dynamic response of change in frequency can be derived as shown in equation (6) and tie line power is expressed in equation (7).

$$\Delta f(s) = G_P(s)\left[\Delta P_T(s) - \Delta P_D(s)\right] \quad (6)$$

Where, Δf(s) is the change in frequency error, $\Delta P_T(s)$ is the change in turbine power output; $\Delta P_D(s)$ is the change in load.

$$\Delta P_{tie12actual} = \frac{2\Pi T_{12}}{s}\left[\Delta f_1 - \Delta f_2\right] \quad (7)$$

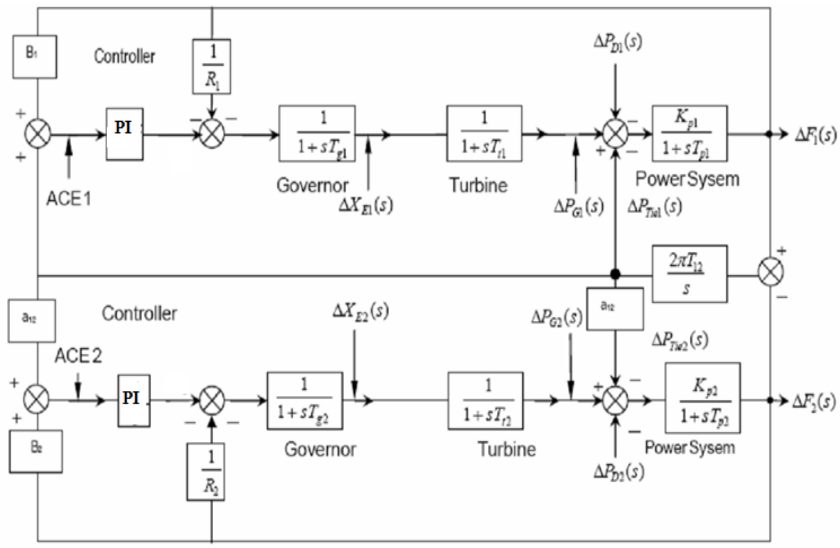

Fig.1.Transfer function model of two-area power system

III.CONTROLLER

Conventional controllers are linear controller, as they work on the fixed parameter values. Proportional controller reduces the rise time, but never eliminates the steady state error. An Integral controller will eliminate the steady state error. A PI controller is a feedback controller which drives the plant to be controlled by a weighted sum of the error (difference between the output and the desired set-point) and the integral of that error.

A. Disadvantages of PI controller

- ✓ Slow response time.
- ✓ Limited range of control.
- ✓ Not suitable for nonlinear systems.
- ✓ Take more time to settle i.e. settling time is more.
- ✓ Overshoot is high for nonlinear system.
- ✓ Uncertainty in measurements.

To overcome the disadvantages of the conventional controllers, different types of intelligent controllers are proposed.

Non-conventional or Artificial intelligence controllers are one which operates with the decision taken by humans. These controllers are adaptive in nature to the changes occurring unpredictably in the systems.

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There are several types of intelligent controllers are designed in last decade. Some of them are

- Fuzzy Logic controllers
- Neural Network controllers
- Genetic Algorithm.
- Differential Evolution

In this project Differential Evolution (DE) algorithm is used.DE works based on vector operation in mathematics. The set of control variables are considered as a vector and this vectors form the population. The population is used to find best values of control variables.

B. Advantages of Proposed Controller

DE has good convergence characteristic and use real value control variables hence no need of encoding and decoding. Set of control variables which decide problem solution forms a vector. Set of vector forms population, evolves iteration by iteration to converge into optimal solution. Random variation in vectors used for the evolution. The basic operations in DE are encoding real world problem into DE optimization problem, mutation, recombination and selection. DE select a vector called target vector and it undergone mutation and recombination process results trail vector. Selection procedure selects either target or trail vector based on their fitness [6].

- Very fast response to the changes in the system.
- Settling time of the system is small.
- High speed operation and control.
- Damping of the system gets increased.
- Handle the non-linearity with ease.

IV. DE BASED LFC

To optimize LFC problem the control variables, gain constant of PI controllers are considered. The limits on these control variables form prime constraints. Actual values of these control variables are used in vectors. Vectors form population and initialized randomly from the solution space and then evolution is carried out using mutation and recombination and selection process.

C. Algorithm

The procedure for DE to solve LFC is as follows,

Step 1: Control variables of LFC (P_1, I_1, P_2 and I_2) are selected as particles of a vector.
Step 2: Initialize vectors in the population within solution space.
Step 3: LFC error value is taken as fitness function of DE.
Step 4: Target vector is selected and mutated to get mutated vector.
Step 5: Crossover is done on mutated vector to get trail vector.
Step6: Selection process decides existence or replacement of target vector with trail vector.
Step 7: Next iteration population is generated using selection process.
Step 8: Repeat step 4 to step 7 till stopping criterion is satisfied.
Step 9: Print the optimal result after stopping criterion is satisfied.

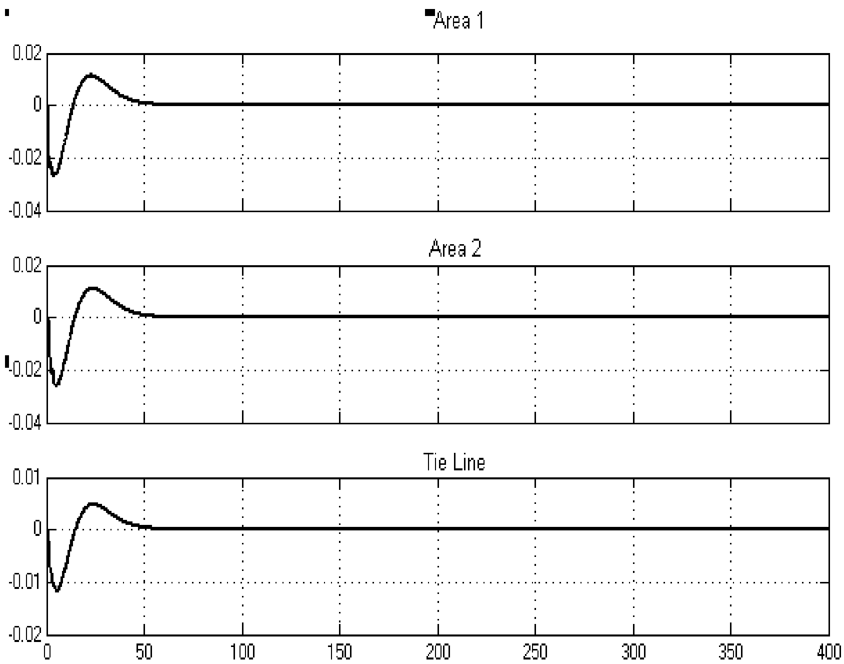

Fig. 2. Frequency deviations for PI controller

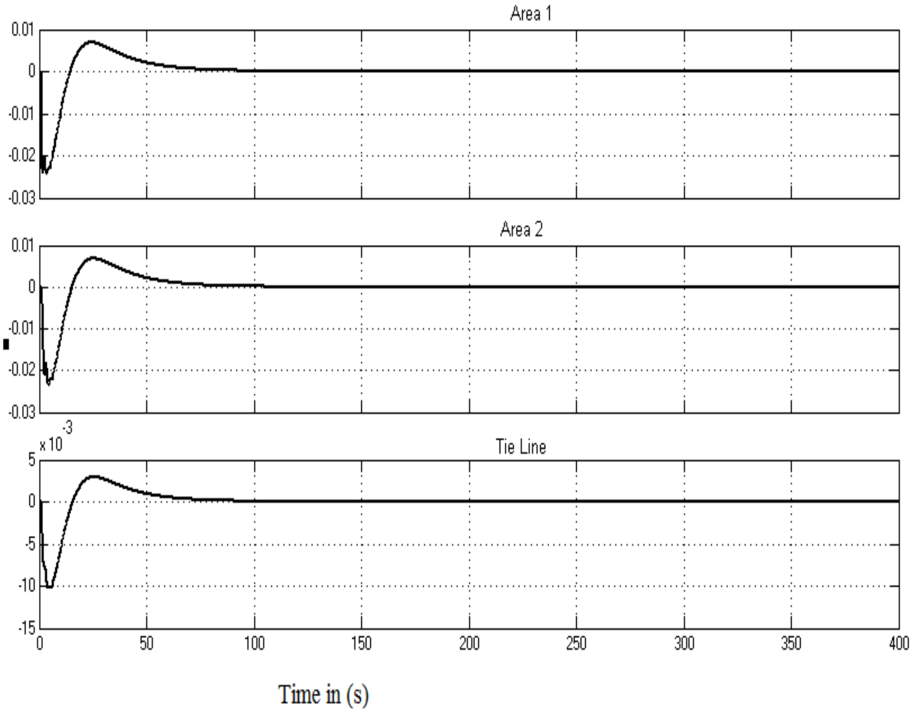

Fig.3. Frequency deviations DE based controller

Fig. 2 and Fig. 3 show the dynamic response of PI and DE_PI controller. Table 1 shows the comparison of PI and DE based PI controller responses in terms of settling time and overshoots.

TABLE 1 COMPARISON OF ALGORITHMS PERFORMANCE

Parameters	PI Controller	DE Algorithm
P_1	0.000980	0.0009741
I_1	1.774780	1.6000000
P_2	-0.016800	-0.0286300
I_2	-0.001305	-0.0010160
Tie line Overshoot (p.u)	0.0051	0.0048
Settling Time (s)	55	43

V. CONCLUSION

The intelligent controllers DE is designed and implemented in a two area interconnected power system. The effectiveness of the proposed controller in increasing damping of the local and inter area mode oscillations is demonstrated with the help of an interconnected power system. These controllers are easy to design than some of the other intelligence controllers. The simulation results are compared with the PI controller. The result shows that the intelligence a controller is much more effective than the PI controller and has good response time. The proposed controller also has better dynamic response than the conventional controllers. It is proved that this controller is much more suitable for non-linear systems (power systems) than the conventional PI controller.

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