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Different computational technique for solution of variation issue

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Abstract

Issue of large demand of electricity by customers in all countries becomes a big challenge to all. In this paper the issue of frequency and corresponding power in the generating station has been focused and three generating units taken as a source of electricity generation. Computational technique like; PI, PID, Fuzzy and GA Technique has been applied for the solution of such issues, when the generating unit is operating normal and also even in disturbing condition. The Simulink model has been simulated and comparative result of response has been tabulated for best effectiveness. Comparative results show that the GA techniques gives good results with respect to the other techniques by satisfying the all system parameters in all the conditions.

Keywords: PI; PID; Fuzzy; GA; Computational Technique; Thermal Generating Units

1. Introduction

In an interconnected power system, load frequency control (LFC) and automatic voltage regulator (AVR) equipment is installed for each generator. Figure 1, represents the schematic diagram of the load frequency control loop and the automatic voltage regulator loop. The controllers are set for a particular operating condition and take care of small changes in load demand to maintain the frequency and voltage magnitude within the specified limits. Small changes in real power are mainly dependent on changes in rotor angle δ and, thus, the frequency. The reactive power is mainly dependent on the voltage magnitude (i.e., on the generator excitation). The excitation system time constant is much smaller than the prime mover time constant and its transient decay much faster and does not affect the LFC dynamic. Thus, the cross-coupling between the LFC loop and the AVR loop is negligible, and the load frequency and excitation voltage control are analyzed independently. For controlling the frequency and power in the limit some computational technique like; PI, PID, Fuzzy and GA technique has been applied. Simulink transfer function model of three generating unit has been obtained, shown in Figure 1 [5], [8], [12].

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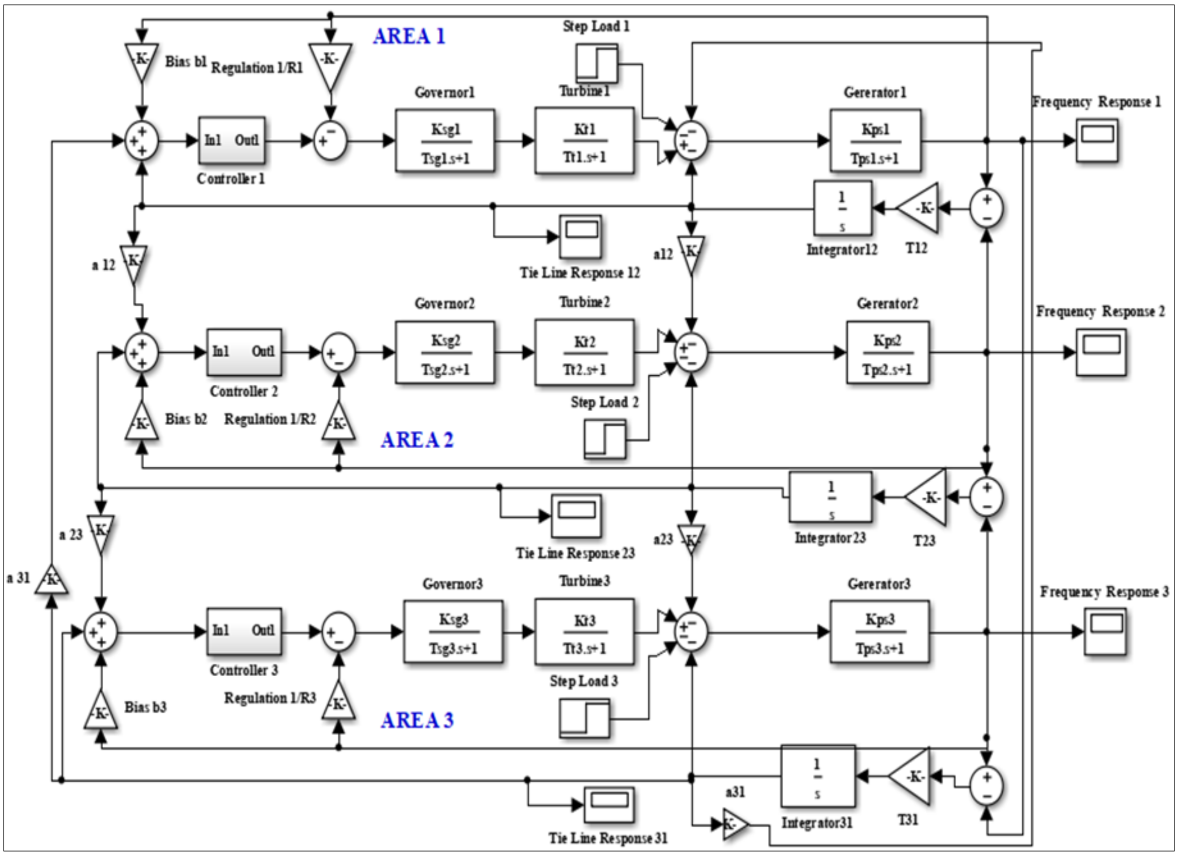

Figure 1 Transfer function model of three generating unit

2. Mathematically Approach

Let us assume that the steam is operating under steady state and is delivering power P_G from the generator at nominal speed or frequency f. Under this condition, the transfer functions equation of the governor, turbine, generator has been obtained and shown below;

Governor Transfer function = $\frac{Ksg}{Tsg\ s+1}$ (1)

Where K_{sg} is the gain of governor and T_{sg} is the time constant of governor.

Turbine Transfer function = $\frac{Kt}{Tt\ s+1}$ (2)

Where K_t is the gain of turbine and T_t is the time constant of turbine.

Generator Transfer Function = $\frac{Kps}{Tps\ s+1}$ (3)

Where K_{ps} is the gain of generator and T_{ps} is the time constant of generator, normally range of T_{ps} is 20s. $K_{ps} = \frac{1}{B}$, B is constant parameter in MW/Hz. $T_{ps} = \frac{2H}{Bf_0}$, H be the inertia constant of a generator (MW-s/MVA) and P_r the rating of the turbo-generator (MVA). f_o is frequency. [1], [2], [3], [4], [5], [10], [11].

2.1. Dynamic Equation of Frequency

Let us consider a simple case wherein the speed changer has a fixed setting, which means ΔP_C = 0 and the load demand alone changes.

For a sudden step change of load demand (ΔP_D),

$\Delta P_G(s) = \frac{\Delta P_D}{s}$ (4)

the change in frequency is given by

$\Delta F(s)|_{\Delta PC(s)=0} = -\frac{K_{ps} \times \Delta P_D}{T_{ps}} \times \frac{RT_{ps}}{K_{ps+R}} \left[\frac{1}{s} - \frac{1}{(s+\frac{K_{ps+R}}{RT_{ps}})}\right]$ (5)

$\Delta f(t) = L^{-1} \Delta F$ (s)

$\Delta f(t) = -\frac{RK_{ps}}{K_{ps+R}} \left[1 - e^{\left[-\frac{t}{T_{ps}}\frac{RT_{ps}}{K_{ps+R}}\right]}\right] \Delta P_D$ (6)

This is equation for dynamic state, help to determine the dynamic response of the system. [1], [10, [11], [12].

2.2. Corresponding Equation of Tie Line Power

Corresponding Power must be accounted for the incremental power balance equation of each area, since there is power flow in or out of the area through the tie line.

Power flow out of control area-1 can be expressed as

For Control area-1

$\Delta P_{TL1}(s) = 2\pi T_{12} \left[\frac{\Delta F_1(s)}{s} - \frac{\Delta F_2(s)}{s}\right]$ (7)

For Control area-2

$\Delta P_{TL2}(s) = 2\pi T_{21} \left[\frac{\Delta F_2(s)}{s} - \frac{\Delta F_1(s)}{s}\right]$ (8)

T_{12} is known as the synchronizing coefficient or the stiffness coefficient of the tie-line. [7], [11].

3. Different computational technique

Different types of computational techniques, PI, PID, Fuzzy and GA technique used to control the limit of frequency and power.

3.1. PI And PID Technique

Different types of technique are using from past year for controlling the frequency and power flow in interconnected power system. PI (Proportional Plus Integral) and PID (Proportional Plus Integral Plus Derivative) techniques are the traditional technique.

The transfer function of the PI controller is

$G(s) = Kp + \frac{Ki}{s}$ (9)

Where K_p is proportional gain and Ki is an integral gain.

The transfer function of the PID controller is

$G(s) = Kp + \frac{ki}{s} + sKd$ (10)

Where K_p is proportional gain, Ki is an integral gain and K_d is derivative gain.

3.2. Fuzzy Technique

Fuzzy logic technique was first proposed by Lotfi Zadeh in 1965. The use of fuzzy logic can help to circumvent the need for rigorous mathematical modeling. Fuzzy logic controller is shown below in figure 2.

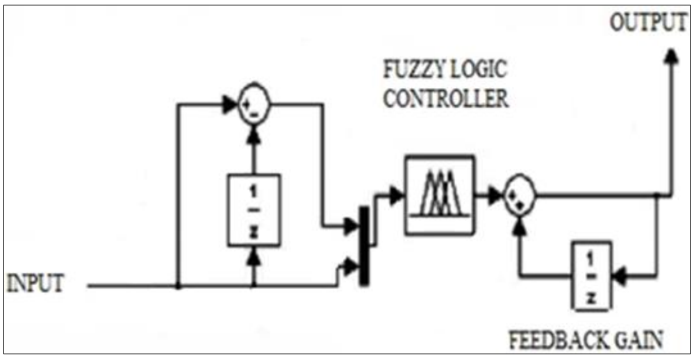

Figure 2 Fuzzy logic control scheme model

In this fuzzy system having 9 membership functions, which makes 81(9x9) rule.

3.3. GA Technique

GA technique is a decision-making technique which relate to the set of priorities constraints or criteria for maximizing reliability, efficiency, strength and many more. Genetic Algorithm (GA) is the collective name for a range of problem-solving techniques based on principles of biological evolution, which are being increasingly applied to a variety of problems, ranging from practical applications in industry and commerce to leading-edge scientific research. It uses iterative progress, such as growth or development in a population. This population is then selected in a guided random search using parallel processing to achieve the desired end. Such processes are often inspired by biological mechanisms of evolution. Main parts of GA are chromosomes, selection, recombination (crossover), mutation.

GA apply for optimizing gain coefficients of conventional PID controller. The parameter used in GA controller for solving the problem of frequency and power in thermal generating unit is shown in Table 1. All the parameters value has been chosen default.

Table 1 GA Parameters for System

Parameters	Two Generating System	Three Generating System
Fitness Function	@dha_ash	@dha_ash
Variables	6	9
Population Size	25	25
Selection	Stochastic Uniform	Stochastic Uniform
Mutation	Constraint Dependent	Constraint Dependent
Cross Over	Scattered	Scattered
Bound Limit	Upper [0] and Lower [-5]	Upper [0] and Lower [-5]

4. Results

Three generating unit model has been obtained and simulated by the MATLAB Simulink software to minimize the problem of frequency and power of thermal generating units. In this simulation, different computational techniques PI, PID, Fuzzy, GA Technique has been used for obtaining the comparative dynamic response and results has been tabulated in Table 2.

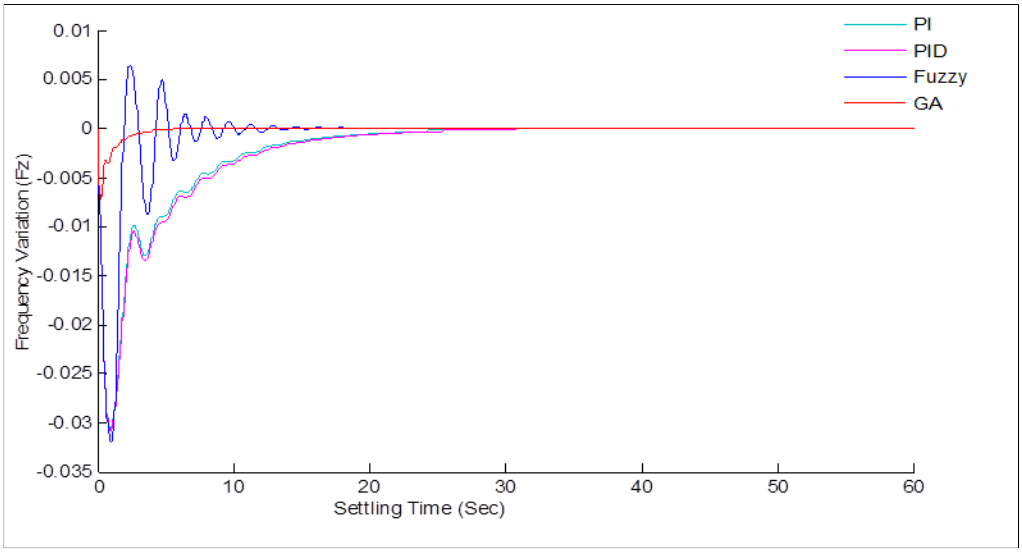

Figure 3 Frequency Variation Response of Three Generating Unit (Area 1)

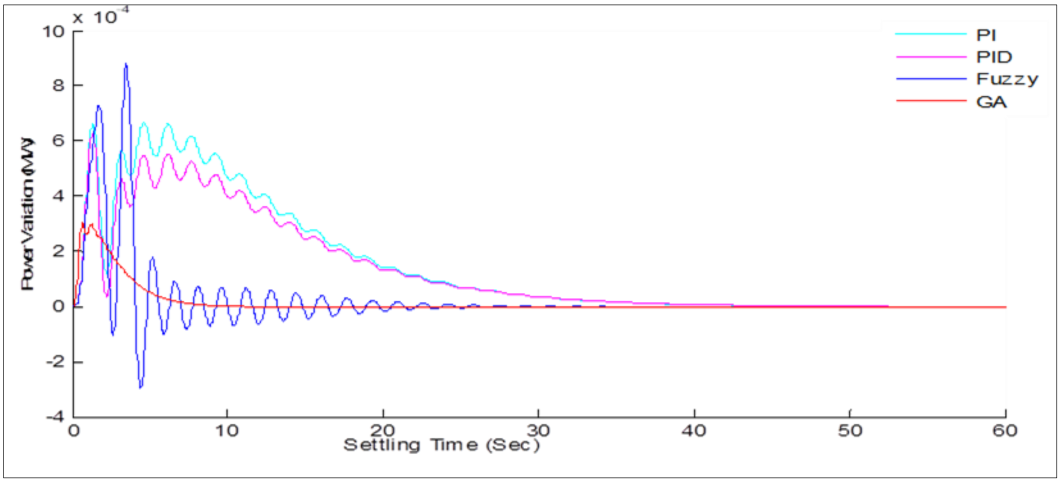

Figure 4 Power Variation Response of Three Generating Unit (Area 1)

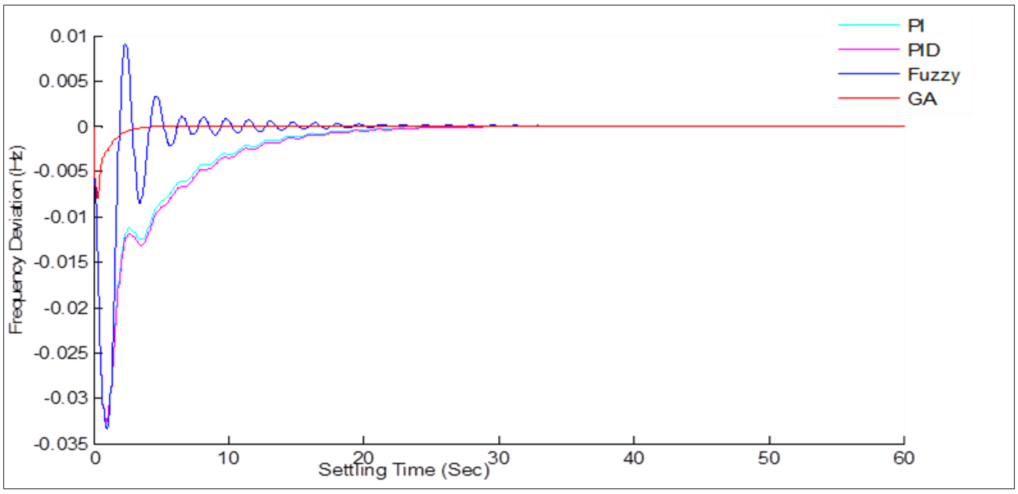

Figure 5 Frequency Variation Response of Three Generating Unit (Area 2)

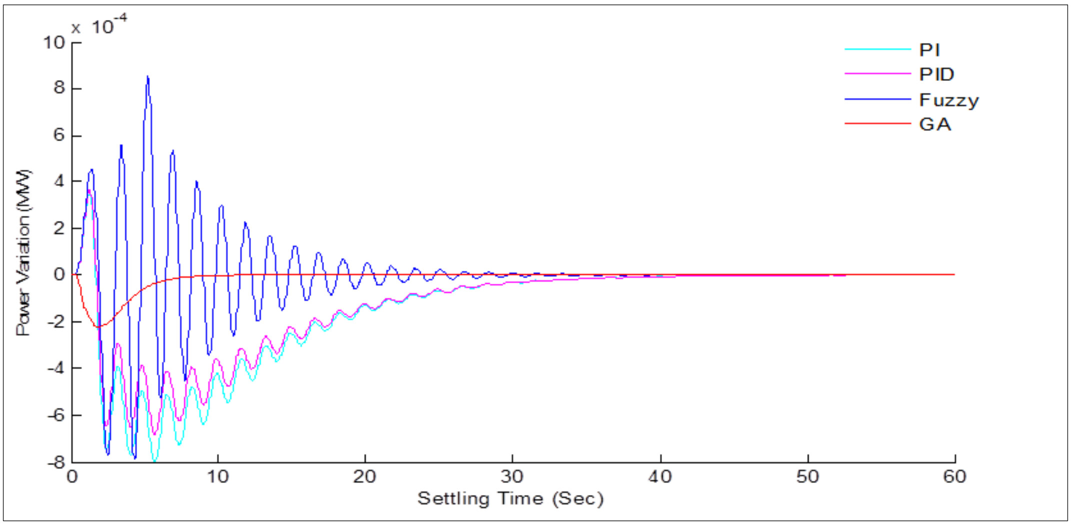

Figure 6 Frequency Variation Response of Three Generating Unit (Area 2)

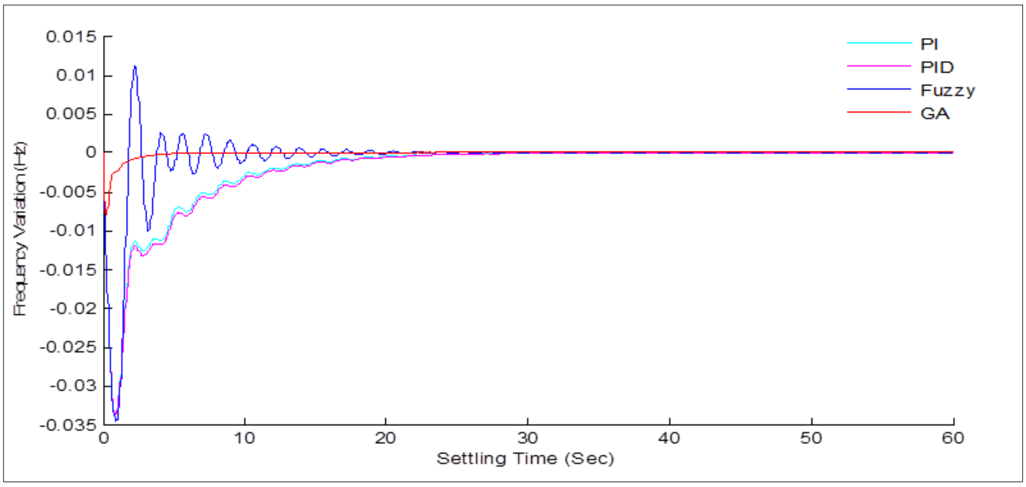

Figure 7 Frequency Variation Response of Three Generating Unit (Area 3)

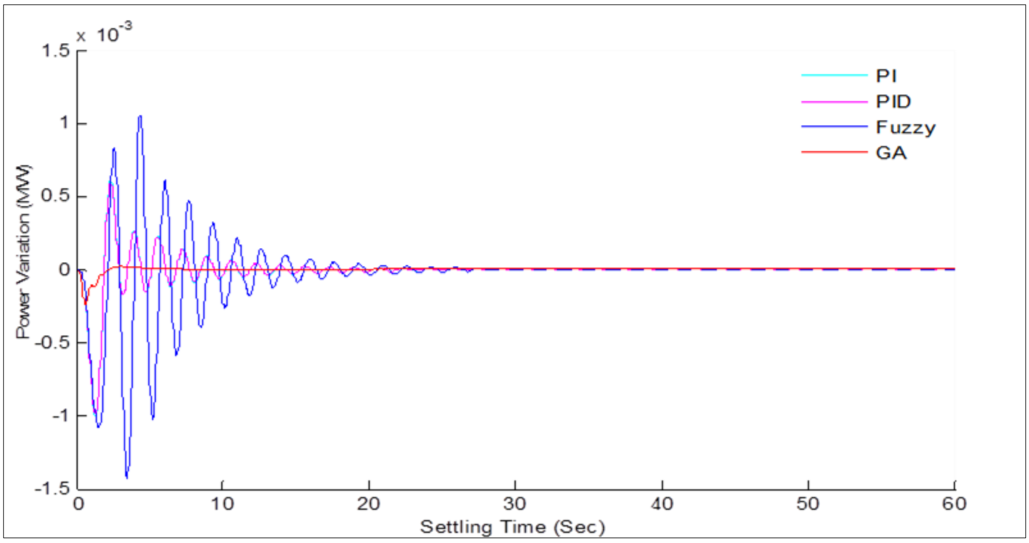

Figure 8 Power Variation Response of Three Generating Unit (Area 3)

Comparative results of all obtained dynamic responses of three generating units have been tabulated in Table 2.

Table 2 Comparative Result of Three Generating Unit

Techniques	Settling Time (Sec)					
	Frequency Variation (Hertz)			Power Variation (MW)		
	Area 1	Area 2	Area 3	Area1	Area2	Area3
PI	27	26	26	44	39	26
PID	26	25	25	43	38	25
Fuzzy	24	23	22	29	28	24
GA	6	5	6	10	8	6

Table 2 shows that GA technique gives efficient fine and good result compare to PI, PID and Fuzzy technique for three thermal generating unit.

5. Conclusion

GA, Fuzzy, PI and PID techniques has been applied to solve the frequency and power variation problem. Transfer function model of three thermal generating units has been obtained and simulated through simulink software. Load change has been assumed to 0.02 variation. Comparative dynamic response of system has been shown in figure 3 to figure 8 and results are tabulated in Table 3, which shows that the GA techniques gives very good efficient, favorable, finest results with respect to the Fuzzy, PI, PID techniques. So, it can be concluded that GA Technique perform better when the system is being complex with increasing number of generating units.

Appendix

Two and three thermal generating system's parameters are as under:

$R_1 = R_2 = R_3 = R_4 = 2.4$ Hz/p.u MW;
$T_{gov1} = T_{gov2} = T_{gov3} = T_{gov4} = 0.08$ Sec;
$T_{gen1} = T_{gen2} = T_{gen3} = T_{gen4} = 20$ Sec;
$Ttur_1 = Ttur_2 = Ttur_3 = Ttur_4 = 0.3$ Sec;
$a_{12} = a_{23} = a_{34} = a_{41} = 1$;
$H_1 = H_2 = H_3 = H_4 = 5$ MW-S/MVA;
$P_{r1} = P_{r2} = P_{r3} = P_{r4} = 2000$ MW;
$K_{gen1} = K_{gen2} = K_{gen3} = K_{gen4} = 120$ Hz/pu MW;
$K_{gov1} = K_{gov2} = K_{gov3} = K_{gov4} = 1$;
$K_{tur1} = K_{tur2} = K_{tur3} = K_{tur4} = 1$;
$D_{1234} = 8.33*10^{-3}$ p.u MW/Hz.;
$b_{1234} = 0.425$ p.u.MW/hz; $\Delta P_{D1234} = 0.01$ p.u;
$T_{12} = T_{23} = T_{34} = T_{41} = 0.0867$ MW/ Radian;
$P_{tie\,max} = 200$ MW, Frequency f = 50Hz;

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