Computational Techniques for the issue of Variation Problem

ASHISH DHAMANDA
Electrical Engineering Department
Gurukula Kangri Deemed to be University Haridwar, UK
INDIA

Abstract:- In this paper the problems of frequency and power in the generating units has been focused and two thermal generating units has been taken as a source of power generation. Computational techniques GA PI, Fuzzy and PID has been applied for the solution of such issues, when the system is operating normal and also even in disturbing condition. The Simulink model has been simulated through MATLAB software and combined responses have been tabulated for effective results. Comparative result shows that the GA technique gives good and efficient results with respect to the other computational techniques by even when the number of generating units increased.

Keywords: Power Generation, Computational Technique, GA, Fuzzy, PI, PID, Generating Units.

1 Introduction

The continuous increase of power system complexity and installation of more and more new equipment in power systems has demanded better methods for power system analysis, planning, and control. At present, analysis of modern power systems is generally based on digital computers. Hence, establishment of a mathematical model, describing the physical processes of a power system, is the foundation for the analysis and investigation of various power system problems. Correct and accurate computation for power system analysis requires a correct and accurate mathematical model of the power system. Transient processes of the power system are very fast. This is why power system operation heavily relies on the applications of automatic control. With the installation of many different automatic control devices, the operation of which largely depends on the application of electronic and computing technology, modern power system operation has reached a very high level of automation. The continuous increase of power system complexity and installation of more and more new equipment in power systems has demanded better methods for power system analysis, planning, and control. At present, analysis of modern power systems is generally based on digital computers. Hence, establishment of a mathematical model, describing the physical processes of a power system, is the foundation for the analysis and investigation of various power system problems. Correct and accurate computation for power system analysis requires a correct and accurate mathematical model of the power system. Transient processes of the power system are very fast. This is why power system operation heavily relies on the applications of automatic control. With the installation of many different automatic control devices, the operation of which largely depends on the application of electronic and computing technology, modern power system operation has reached a very high level of automation.

For controlling the frequency and power in the limit some computational techniques GA PI, Fuzzy and PID has been applied. Simulink transfer function model of two and three generating unit has been obtained, shown in Figure 1.[1], [5], [6], [7], [8], [9], [10].

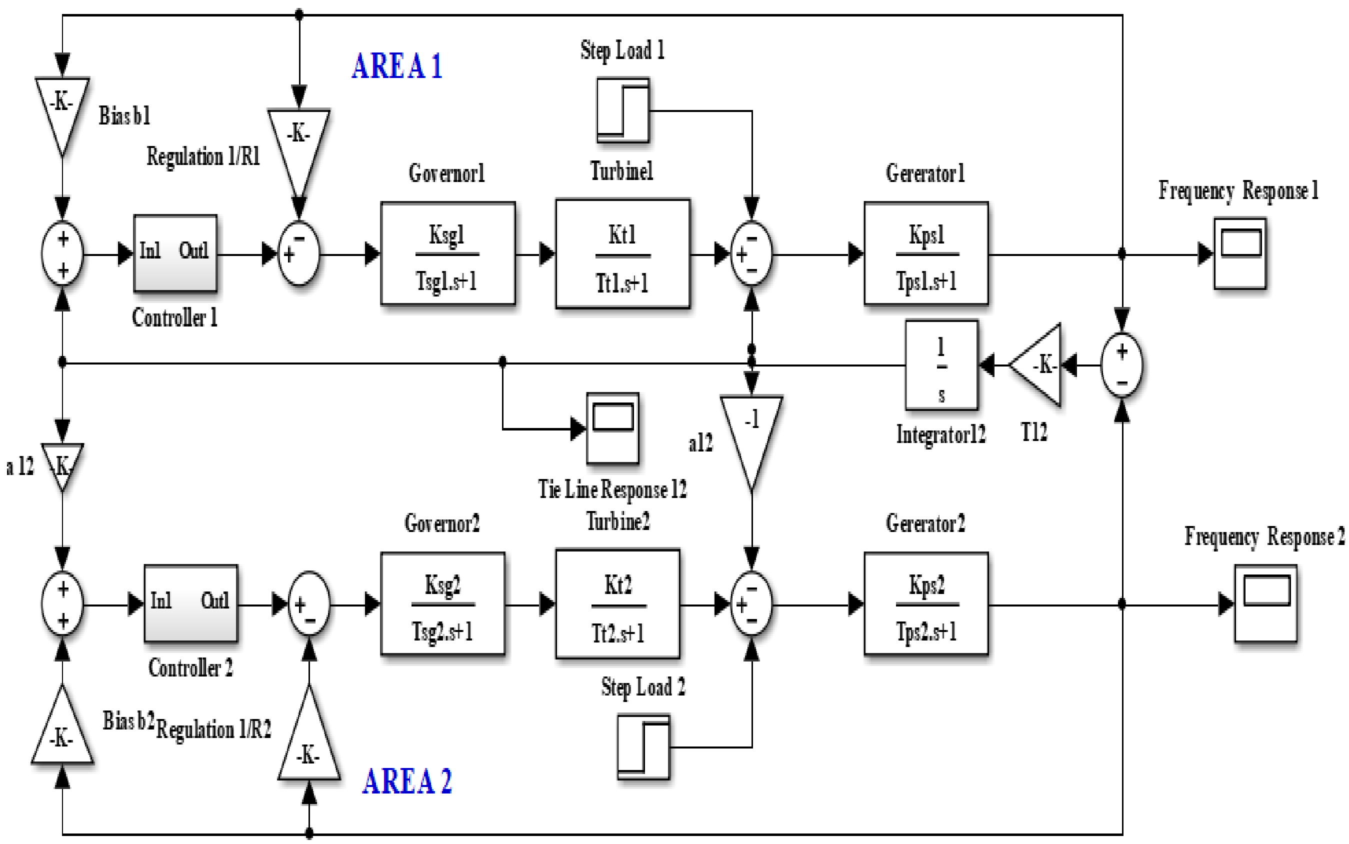

Figure 1: Transfer function model of two generating unit

2 Equation Mathematically

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. [2], [3], [4], [10]

2.1 Frequency From Dynamic Equation

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

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

the change in frequency is given by

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

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

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

This is equation for dynamic state, help to determine the dynamic response of the system.

2.2 Tie Line Power Equation

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

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

For Control area-2

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

T_{12} is known as the synchronizing coefficient or the stiffness coefficient of the tie-line. [2], [3], [4], [5], [8], [10].

3 Computational Techniques

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

3.1 PI And PID Techniques

PI (Proportional Plus Integral) and PID (Proportional Plus Integral Plus Derivative) techniques are the traditional technique.

The transfer function of the PI controller is

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

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

The transfer function of the PID controller is

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

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

3.2 Fuzzy Technique

Fuzzy technique is an innovative technology that enhances conventional system design with engineering expertise. The use of fuzzy logic can help to circumvent the need for rigorous mathematical modeling. Fuzzy logic controller is shown below in figure 2.

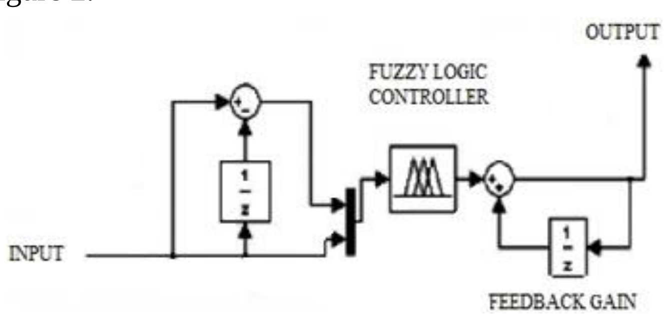

Figure 2: Fuzzy logic control scheme model

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

3.3 GA Technique

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.

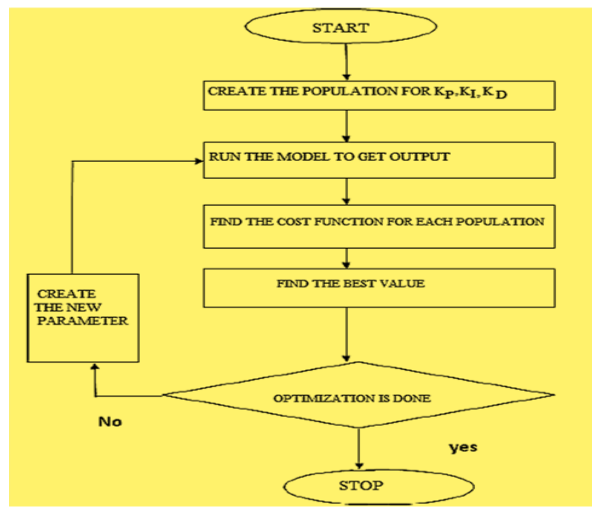

Figure 3 Flow chart of GA

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: Parameters of GA for Multi Area System

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

4 Result

Two thermal generating unit model have been simulated by the Simulink software to minimize the problem of power and frequency. Different computational techniques GA, PI, PID, Fuzzy techniques has been appiled for obtaining the combined response and results has been tabulated in Table 2;

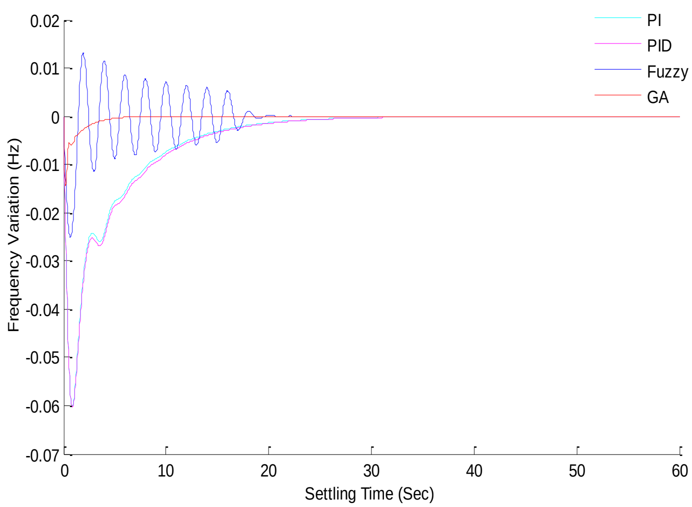

Figure 4: Frequency Variation Response of Two Generating Unit

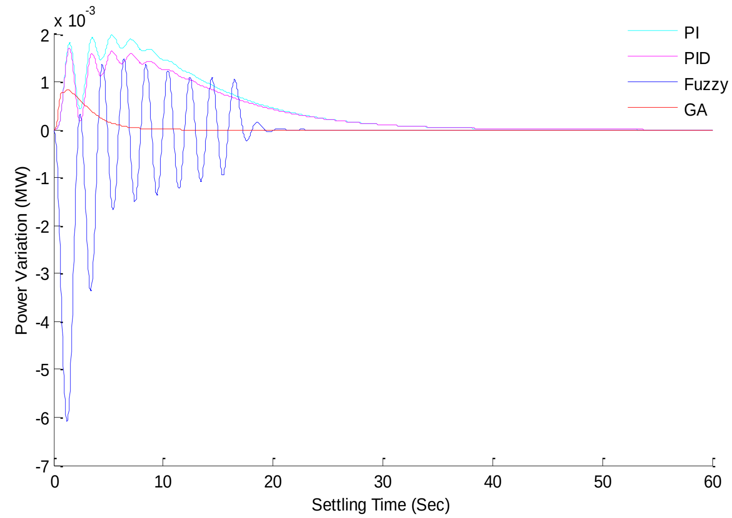

Figure 5: Power Variation Response of Two Generating Unit

The comparative result of settling time of load frequency and tie-line power deviation are tabulated in Table 2;

Table 2: Comparative Result of Two Generating Unit

Techniques	**Settling Time (Sec)**	
	Frequency Variation (Hertz)	**Power Variation (MW)**
GA	**8**	11
Fuzzy	**20**	21
PID	**27**	43
PI	**28**	44

Table 2 shows that GA technique provides good and efficient results with respect to other techniques for two thermal generating units.

5 Conclusion

Two thermal units have been applied to solve frequency and power problem. Transfer function model of two and three thermal generating units has been obtained and simulated through MATLAB Simulink software. Load change has been assumed to 0.02 variation. Comparative dynamic response of system has been shown in figure 6 to figure 13 and results are tabulated in Table 2, which shows that the GA gives good, efficient and favorable results with respect to the PI, PID and Fuzzy techniques. So, it can be concluded that GA technique performs better when the system is being complex

APPENDIX

Two thermal generating system's parameters are as under:

$T_{gov1} = T_{gov2} = T_{gov3} = T_{gov4} = 0.0\,8$ 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; $T_{12} = T_{23} = T_{34} = T_{41} = 0.0\,867$ MW/ Radian; $P_{tie\ max} = 200$ MW; $R_1 = R_2 = R_3 = R_4 = 2.4$ Hz/p.u MW; Frequency f = 50Hz.

References:

[1] S. Ghosh, A. Gupta, H. Dashora and S. Ranjan, "Mathematical Approach to Generate Efficiency, Maps for Induction Motor and Optimization for EV", 2020 IEEE First International Conference on Smart Technologies for Power, Energy and Control (STPEC), Nagpur, India, 2020, pp. 1-6, DOI: 10.1109/STPEC49749.2020.9297758

[2] Arora, K., Kumar, A., Kamboj, V. K., Prashar, D., Jha, S., Shrestha, B., & Joshi, G. P. (2020). Optimization Methodologies and Testing on Standard Benchmark Functions of Load Frequency Control for Interconnected Multi Area Power System in Smart Grids. Mathematics, 8(6), 980. DOI:10.3390/math8060980.

[3] Montoya, F. G., Baños, R., Alcayde, A., & Manzano-Agugliaro, F. (2019). Optimization Methods Applied to Power Systems. Energies, 12(12), 2302. DOI:10.3390/en12122302.

[4] Chaturvedi Ratnesh and Dwivedi Bharti. (2014). Fuzzy and PI Controller Based Load Frequency Control of Thermal-Hydro Power System, International Journal of Innovative Science, Engineering & Technology, Vol. 1 Issue 3 http://www.ijiset.com/v1s3/IJISET_V1_I3_44.pdf.

[5] Hassen S. Z. Sayed and Jahmeerbacus M. I. (2013). Optimal Frequency Regulation of a Two-area Power System, 2013 IEEE International Conference on Industrial Technology (ICIT) pp. 140-145. DOI: 10.1109/ICIT.2013.6505662.

[6] Surya Prakash, S K Sinha. (2012). Four Area Load Frequency Control of Interconnected Hydro-Thermal Power System by Intelligent PID Control technique, Students Conference on Engineering and Systems pp. 1-6. DOI: 10.1109/SCES.2012.6199090.

[7] Anupam Trivedi, N. M. Pindoriya, Dipti Srinivasan and Deepak Sharma (2011). Improved Multi-objective Evolutionary Algorithm for Day Ahead Thermal Generation Scheduling. IEEE Congress of Evolutionary Computation (CEC) pp. 2170-2177. DOI: 10.1109/CEC.2011.5949883.

[8] S. Sivanagaraju, G. Sreenivasan. (2011). Power System Operation and Control, PEARSON, https://www.pearsoned.co.in/prc/book/s-sivanagaraju-power-system-operation-control-1e-1/9788131726624.

[9] Gabano J.D., Poinot T. and Kanoun H. (2011). Identification of a Thermal System Using Continuous Linear Parameter Varying Fractional Modelling, IET Control Theory Application, Vol. 5, issue 7, p. 889-899, DOI: 10.1049/iet-cta.2010.0222.

[10] Park Min-Su and Chun Yeong-Han. (2009). Tuning of Generating Unit Controller for the Generators with Governor, 2009 Transmission & Distribution Conference & Exposition: Asia and Pacific, pp.1-4, DOI: 10.1109/TD-ASIA.2009.5356854