



TUNING OF PID CONTROLLER BY IMPROVED GA TECHNIQUE FOR AN ISOLATED NUCLEAR POWER SYSTEM

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July 18, 2018

Abstract

This paper offers a distinctive solution to the LFC problem for a single-area nuclear power system based on without controller, PID, PSO-PID, CUCKOO-PID, and GA-PID controllers. The active model of power system and controller design are particularized. Results are carried out to validate the performance of different type of PID controllers under various dynamic conditions. GA-PID tuned controller gives better dynamic response of the power system for different step perturbations in terms of robustness.

Keywords: Genetic Algorithm (GA), Load Frequency Control (LFC) Performance Index (PI)

1 INTRODUCTION

Utility of power system is necessary to keep the continuous supply of electric power to the consumer without any disturbances[10]. For symmetry, the power system is to maintain a balance between load demand of the consumer and power generated of the power plant [1-3]. Increasing the complexity in the world, the power demand is also increases. The demand of the consumer increases due to a frequency is changed from its formal value. Same way, it is necessary to maintain the frequency is to be constant. LFC is one of the basic strategies to get balancing between the real power and reactive power. The conventional method of PID controllers such as Ziegler Nichols method, Tyreus-Luyben method, Cohen-Coon method, Fertik method and Integral Model Control method are used for controlling the load frequency of power system [5-7]. GA controller is one of the most intelligent controllers for controlling the load frequency of power system as well as improves the dynamic performance of system [7]. Kumar [4] has proposed the automatic generation control (AGC) by using an intelligent controller for multi area system and the parameters of PID controller optimized by using an Algorithm. Authors [5] have studied on LFC of two area interconnected nuclear power plant using PSO controller and the responses are compared with conventional controllers. J. Kennedy et al. [8] designed an PSO algorithm for improving the dynamic performance of the system were demonstrated. Authors [9] reported on the optimal controller for LFC of multi area power system and compared the results of PI for different values.

The work discussed here to focus more on modeling of nuclear power system with new weights of state variables. The deviations in system frequency is observed when step disturbance is applied by proper tuning of GA-PID controller gain. The improved GA-PID controller gives better performance in time domain aspects in comparison with above mentioned controllers.

2 MODELLING OF SYSTEM

As per the requirement of nuclear power system for LFC, speed governor, turbine and generator should be modelled and shown in fig. 1 [5]. Here the mathematical model used for nuclear unit

tandem compound turbines, one two LP sections with HP re-heater and one HP section. The HP section dissipates MSR before entering the LP turbine unit. Decrement of erosion and moisture amounts is observed by using MSR unit which reduces the moisture content of the steam entering the LP turbine and HP steam is used to reheat the HP exhaust. A step load disturbance in power demand (pu) given to the power system.

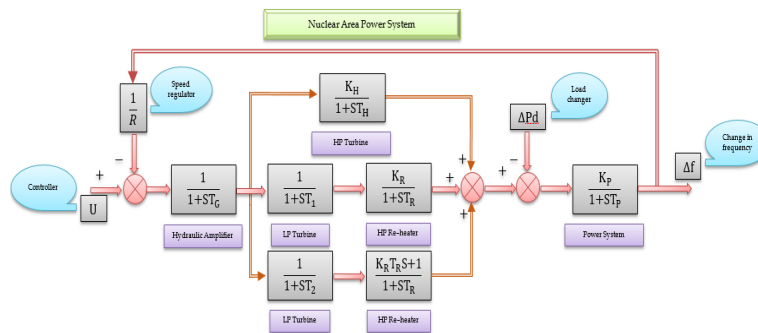


Figure 1: single area power generation model

Generally the performance of LFC has been done on linearized aspects. It is not possible to consider all dynamics in frequency control because of difficulty arise in synthesis and analysis. To achieve exact observation of the LFC issues, it is compulsory to deliberate the key requirements and constraints imposed by dynamics of a physical system and in turn model them for judging performance. Single area nuclear generating system represents by block diagram of closed loop-controlled system components are non-linear. In order to get a linear model, perform linearization around an operating point and which is to be used designing process of a controller. Therefore, classical algorithms used to design a Load Frequency Control with PID controller in terms of state space variables for a given power system.

3 SYSTEM MODELLING

In this section a nuclear power system with PID controller is taken, a new state variable formation is shown below:

$$\dot{X} = A x + B u + F d \quad (1)$$

Where

A=

$$\begin{bmatrix} -0.05 & 6 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -0.05 & 0 & 6 & 0 & 0 & 0 & 0 & 0 & 0 \\ 2.292 & 0 & 0 & 0.56 & 2.66 & -1.25 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 2.26 & 0 & 5.72 & -0.23 & -19.92 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ -0.00013 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 0 & 0.04 & -0.006 & 0 & 0 & 0.07 & 0.72 & 1.08 & 0.40 & -0.17 & -1.58 & -5.46 & -4.354 \end{bmatrix}$$

$$B = \begin{bmatrix} 2.2916 \\ 0.5625 \\ 2.6563 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} \quad F = \begin{bmatrix} -6 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

Here, data for isolated power system is,

$$\begin{aligned} T_G &= 0.08 \text{ sec}; T_H = 0.5 \text{ sec}; T_{R_1} = 0.5 \text{ sec}; T_{R_2} = 10 \text{ sec}; T_P = 20 \text{ sec}; K_G = 1; \\ K_H &= 0.2; K_{R_1} = 0.3; K_{R_2} = 0.5; T_1 = 7 \text{ sec}; T_2 = 9 \text{ sec}; K_p = 120 \text{ Hz/p.u.MW}; \\ R &= 2.4 \text{ Hz/p.u.MW}; u = 1.7465 + \frac{3.3685}{S} + 4.0915 S \end{aligned}$$

Tuning is done to get the gain value or controller parameters such that the preferred frequency is sustained within precise value. Algorithms such as GA, PSO and Cuckoo heuristic search methods are applied for tuning of PID gains. The tuning of controller based on proposed improved GA-PID controller is justified as compared with other controllers gives better performance in time domain aspects. The basic algorithm [7] by which GAs operate is reasonably well established. GA is an extensively used to solve complex optimization searching problems. Flow chart of improved GA search optimization method is shown in fig.2. The process of GA contains reproduction, crossover and mutation for minimization of performance index (PI) which is integral time absolute error (ITAE) i.e., $ITAE = \int te(t)dt$ and frequency deviation is an error function.

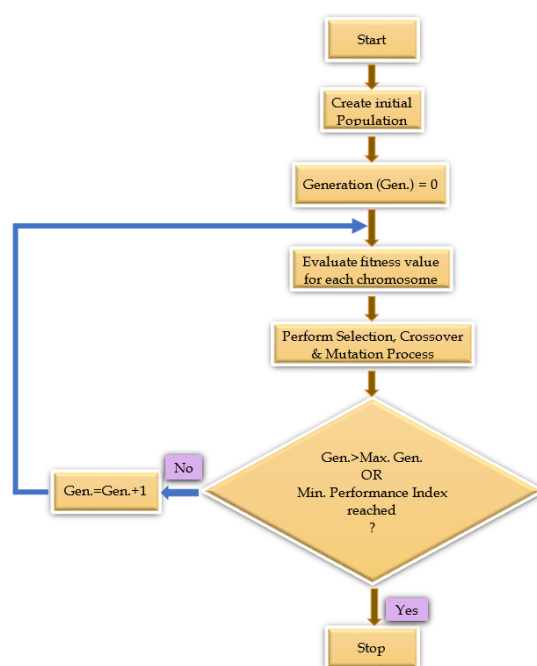


Figure 2: Genetic Algorithm flow chart

4 SIMULATION AND DISCUSSION

In this section, the results show that the performance of various optimization methods are compared with and without controllers are shown in fig. 3 to 7 and tabulated in table 1 by applying a step change in load disturbance ($\Delta P_d = 0.01, 0.02, 0.03, 0.04, 0.05$). From table 1, the time domain specifications for with and without controllers are mentioned and observed that GA-PID controller performs better transient behavior. In this regard the dead beat response of a GA-PID controller obtained within minimum time, which indicates that used controller is more robustness.

Table 1 Comparison of different controllers

Disturbance with $\Delta P_d=0.01$			
Type of Controller	Undershoot	Static Error	Settling Time
Uncontrolled	-0.1000	-0.0164	41.36
PID controlled	-0.0966	0	69.21
CUCKOO-PID controlled	-0.0358	0	20.31
PSO-PID controlled	-0.0244	0	13.53
GA-PID controlled	-0.0295	0	10.02
Disturbance with $\Delta P_d=0.02$			
Type of Controller	Undershoot	Static Error	Settling Time
Uncontrolled	-0.1939	-0.0329	41.99
PID controlled	-0.1939	0	70.52
CUCKOO-PID controlled	-0.0974	0	21.75
PSO-PID controlled	-0.0470	0	14.40
GA-PID controlled	-0.0596	0	10.31
Disturbance with $\Delta P_d=0.03$			
Type of Controller	Undershoot	Static Error	Settling Time
Uncontrolled	-0.3005	-0.0492	42.65
PID controlled	-0.2913	0	71.04
CUCKOO-PID controlled	-0.1491	0	22.06
PSO-PID controlled	-0.0764	0	15.14
GA-PID controlled	-0.0877	0	10.97
Disturbance with $\Delta P_d=0.04$			
Type of Controller	Undershoot	Static Error	Settling Time
Uncontrolled	-0.3903	-0.0650	43.40
PID controlled	-0.3903	0	71.83
CUCKOO-PID controlled	-0.1507	0	23.02
PSO-PID controlled	-0.0914	0	16.15
GA-PID controlled	-0.1176	0	11.65
Disturbance with $\Delta P_d=0.05$			
Type of Controller	Undershoot	Static Error	Settling Time
Uncontrolled	-0.4865	-0.0799	44.28
PID controlled	-0.4811	0	72.72
CUCKOO-PID controlled	-0.1607	0	24.18
PSO-PID controlled	-0.1181	0	16.46
GA-PID controlled	-0.1478	0	12.72

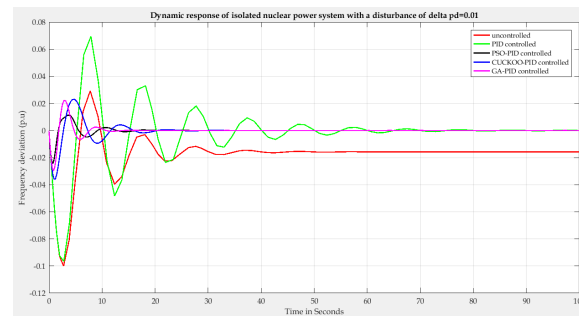


Figure 3: Dynamic response of controlled and uncontrolled system with $P_d = 0.01$

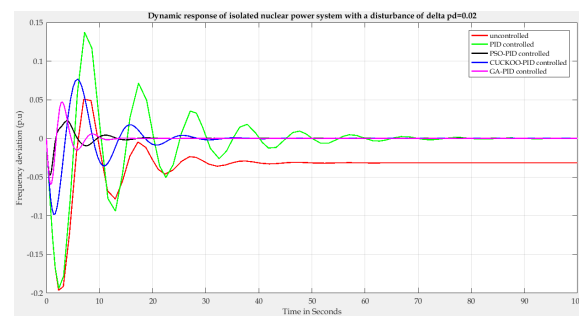


Figure 4: Dynamic response of controlled and uncontrolled system with $P_d = 0.02$

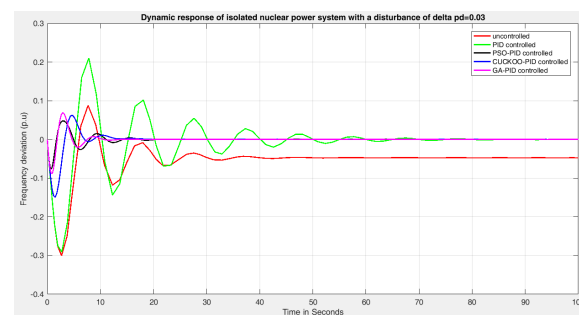


Figure 5: Dynamic response of controlled and uncontrolled system with $P_d = 0.03$

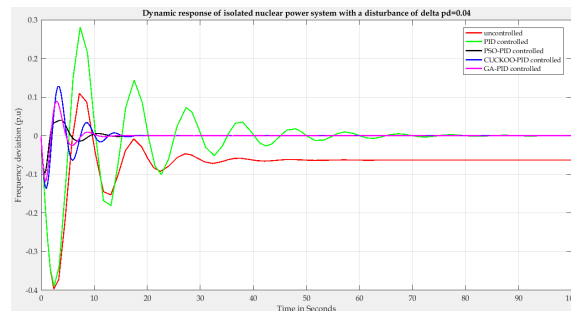


Figure 6: Dynamic response of controlled and uncontrolled system with $P_d = 0.04$

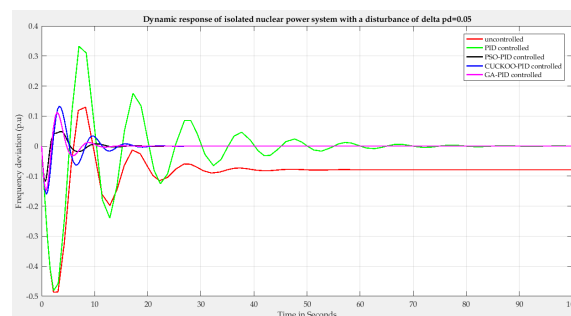


Figure 7: Dynamic response of controlled and uncontrolled system with $P_d = 0.05$

5 CONCLUSION

In this paper, different optimization methods are used for tuning of a PID controller to quench the frequency deviations of an isolated nuclear power system. Different step perturbations are applied to a power system and responses are compared in terms of settling time, peak undershoot and steady state error. LFC problem using improved GA given better performance when compared with other controllers. The settling time of GA-PID controller is less as compared to the other PID controllers.

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