

Load Frequency Control for Two Area Power System using Different Controllers

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Abstract— This paper explores the potential of using soft computing methodologies in controllers and their advantages over conventional methods. PID controller, being the most widely used controller in industrial applications, needs efficient methods to control the different parameters of the plant. As reported by several researchers, the conventional approach of PID controller is not very efficient due to the presence of non-linearity in the system of the plant. Also, the output of the conventional PID system has a quite high overshoot and settling time. The main focus of this work is on the controller to obtain good output frequency responses. The output response of proposed Fuzzy logic controller exhibits better performance and found reasonably good over these conventional controllers.

Key words: Conventional controller, Fuzzy logic controller (FLC, interconnected power system, load frequency control (LFC), PID tuning, tie-line

I. INTRODUCTION

Electrical Power systems are interconnected to provide secure and economical operation. [1]The main objective of automatic generation controller (AGC) is to maintain the balance between the generation and demand of a particular power system. The problem of controlling the real power output of generating units in response to changes in system frequency and tie-line power interchange within specified limits is known as load frequency control (LFC) [1]. The Objectives of LFC are to provide zero steady-state error of frequency and tie-line exchange variations, high damping of frequency oscillations and decreasing overshoot of the disturbance so that the system is not too far from the stability [2]. The interconnected power system is typically divided into control areas, with each consisting of one or more power utility companies. Sufficient supply for generation of each connected area to meet the load demand of its customers.

The above mentioned objectives are carried successfully in previous works by different authors using PI and PID controllers [4] & [5]. The interconnected power system is typically divided into control areas, with each consisting of one or more power utility companies. Sufficient supply for generation of each connected area to meet the load demand of its customers. In this paper Fuzzy Logic Controller (FLC) is used [10]. This type of controller adds a pole at origin resulting in system type so reducing the steady state error. System load is never steady using controller these can be controlled. When uncontrolled case more oscillation, negative overshoot be observed but while comparing to conventional type controller PID and propose work result gives better performances of dynamic responses.

II. CONTROLLER

There are many types of controller such like proportional, integral, derivative and combinational of these (PI, PID).

A. PID Controller

The block diagram of Proportional Integrative Derivative (PID) controller is shown in Fig.1.

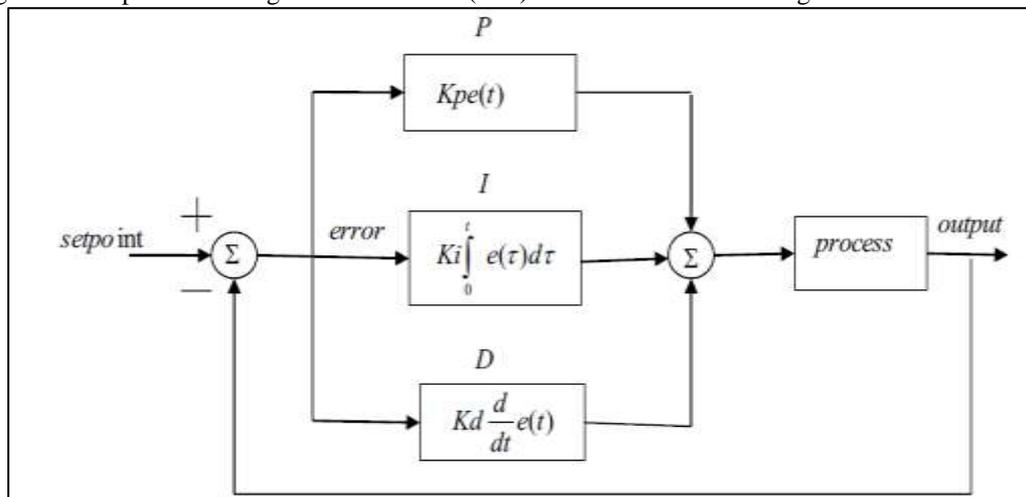


Fig. 1: Block diagram of a PID controller.

The PID controller improves the transient response so as to reduce error amplitude with each oscillation and then output is eventually settled to a final desired value. Better margin of stability is ensured with PID controllers. The mathematical equation for the PID controller is given as [4] & [9].

$$y(t) = K_p e(t) + K_i \int_0^t e(\tau) d\tau + K_d \frac{de(t)}{dt} \quad (1)$$

Where $y(t)$ is the controller output and $u(t)$ is the error signal. K_p , K_i and K_d are proportional, integral and derivative gains of the controller. The limitation conventional PI and PID controllers are slow and lack of efficiency in handling system non-linearity. Generally these gains are tuned with help of different optimizing methods such as Ziegler Nicholas method, Genetic algorithm, etc., the optimum gain values once obtained is fixed for the controller. But in the case deregulated environment large uncertainties in load and change in system parameters is often occurred. The optimum controller gains calculated previously may not be suitable for new conditions, which results in improper working of controller. So to avoid such situations the gains must be tuned continuously.

B. Fuzzy Logic Controller

Since power system dynamic characteristics are complex and variable, conventional control methods cannot provide desired results. Intelligent controller can be replaced with conventional controller to get fast and good dynamic response in load frequency problems. Fuzzy Logic Controller (FLC) can be more useful in solving large scale of controlling problems with respect to conventional controller are slower.

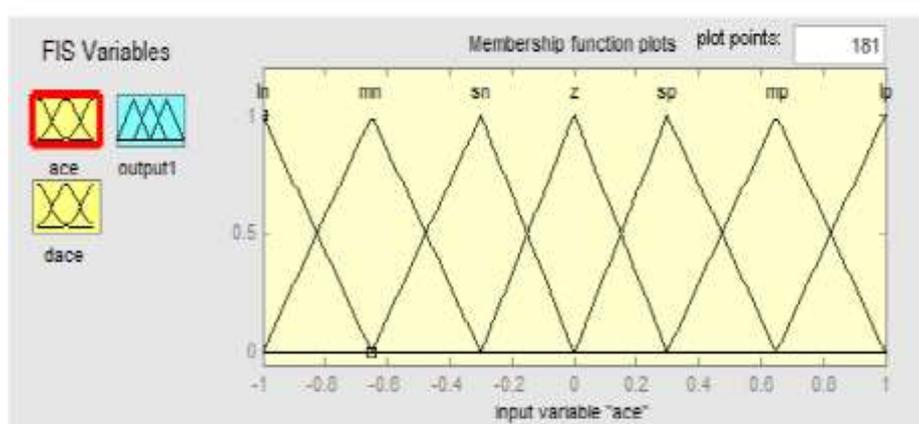


Fig. 2: Fuzzy Inference system for FLC

Fuzzy logic controller is designed to minimize fluctuation on system outputs. There are many studied on power system with fuzzy logic controller consist of three section namely fuzzifier, rule base and defuzzifier as shown in fig.2.[9] gives idea for the different steps of interference system[10].

The membership functions are decided according to input data or available data from these rules are to be designed.

The error e and change in error de are inputs of FLC. Two inputs signals are converted to fuzzy numbers first in fuzzifier using five membership functions. Positive Big (PB), Positive Small (PS), Zero (ZZ), Negative Small (NS), Negative Big (NB), Small (S), Medium (M), Big (B), very Big (VB), Very Very Big (VVB). Finally resultant fuzzy subsets representing the controller output are converted to the crisp values using the central of area (COA) defuzzifier scheme.

III. MODEL OF TWO AREA POWER SYSTEM

Each area is assumed to have only one equivalent generator and is equipped with governor- turbine system. They are the control signals from the controllers we choose.

The plant for a power system with a non-reheated turbine consists of three parts:

– Governor with dynamics: $G_g(s) = \frac{1}{T_G s + 1}$ (2)

– Turbine with dynamics: $G_t(s) = \frac{1}{T_T s + 1}$ (3)

– Load and machine with dynamics: $G_p(s) = \frac{1}{T_P s + 1}$ (4)

Now the open-loop transfer function without droop characteristic for load frequency control is

$$\tilde{P} = G_p G_t G_g = \frac{K_p}{(T_P s + 1)(T_T s + 1)(T_G s + 1)} \quad (5)$$

A two area model is adapted in the work is shown in Figure.3 [2] & [11]

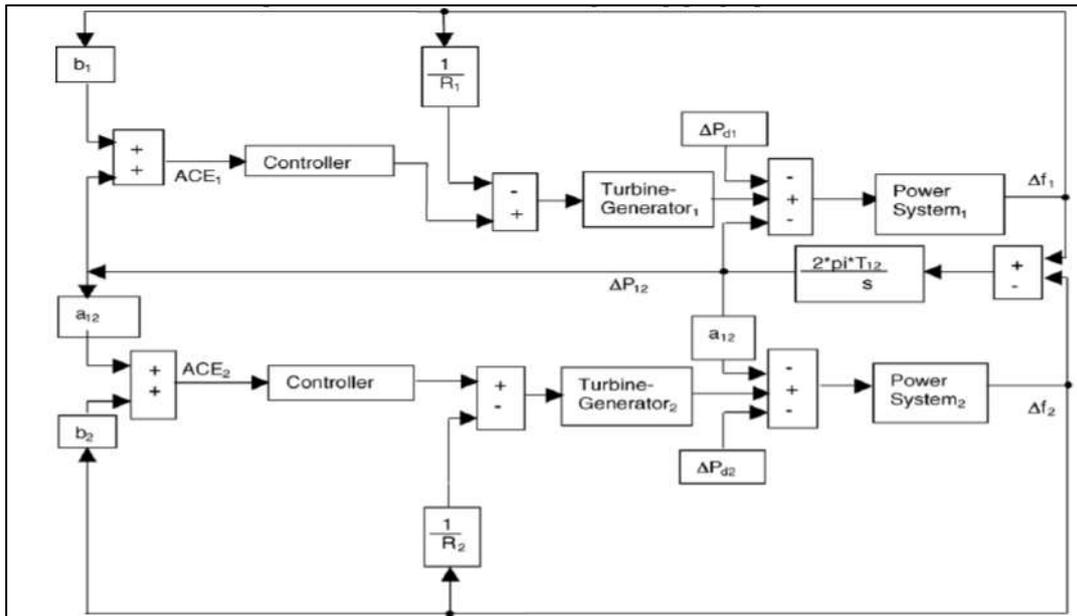


Fig. 3: Block diagram of two area power system.

The terms showed in the Figure 3 are termed given below:

f_i :Nominal system frequency of i th area. [HZ]

Δf_i :Incremental frequency deviation of i th area. [HZ pu]

T_{si} : Speed governor time constant of i th area [sec.]

K_{gi} : Gain of speed governor of i th area

R_i :Governor Speed regulation of the of i th area [Z H /pu.MW] T_{ti} : Governor Speed regulation of the of i th area [Z H

/pu.MW] K_{ti} : Gain of turbine of i th area

K_{pi} :Gain of power system (generator load) of i th area. [Z H /pu.MW] $K_{pi} = 1/D$

T_{pi} Gain of power system (generator load) of i th area. [Z H /pu.MW] $T_{pi} = 2H_i /D_{ifi}$

H_i : Inertia constant of i th area . [MW-sec/MVA]

ΔP_{Gi} :Incremental generator power output change of i th area .[pu MW] ΔP_{Ti} :Incremental turbine power output change of i th

area. [pu MW] K_i : Gain of controller of i th area.

IV. MATLAB SIMULINK MODEL

A. Power System Model using Different Controllers

In two area system, two single area systems are interconnected via tie-line. Interconnections established increases the overall system reliability. Even if some generating units in one area fail, the generating units in the other area can compensate to meet the load demand. The basic block diagram of five area interconnected power system is shown in Fig.2. A conventional integral controller is used on a power system model. The PID controller improves steady state error simultaneously allowing a transient response with little or no overshoot. As long as error remains, the integral output will increase causing the speed changer position, attains a constant value only when the frequency error has reduced to zero. The SIMULINK model of a two area interconnected power system using PID controller is shown in Figure 4 [6].

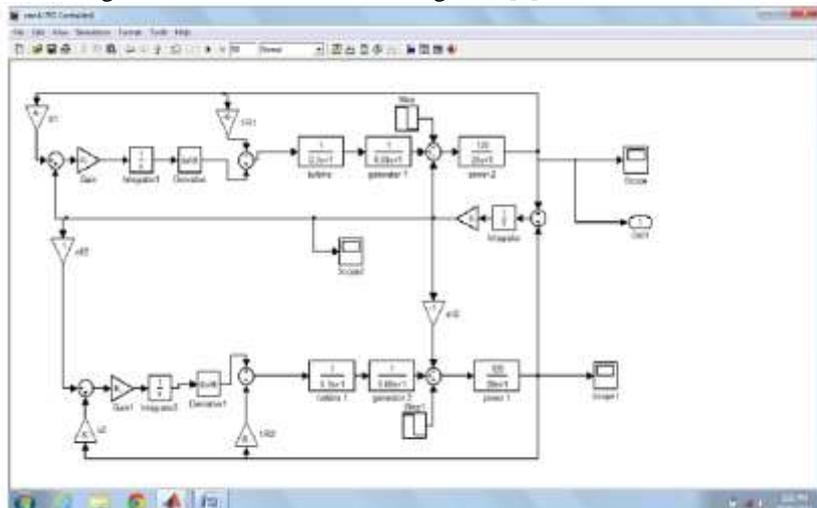


Fig. 4: Simulink model of two area power system using PID controller.

The output response is shown in Fig.5, which having the comparison results between simple integral (I), proportional integral (PI), Proportional integral derivative (PID).

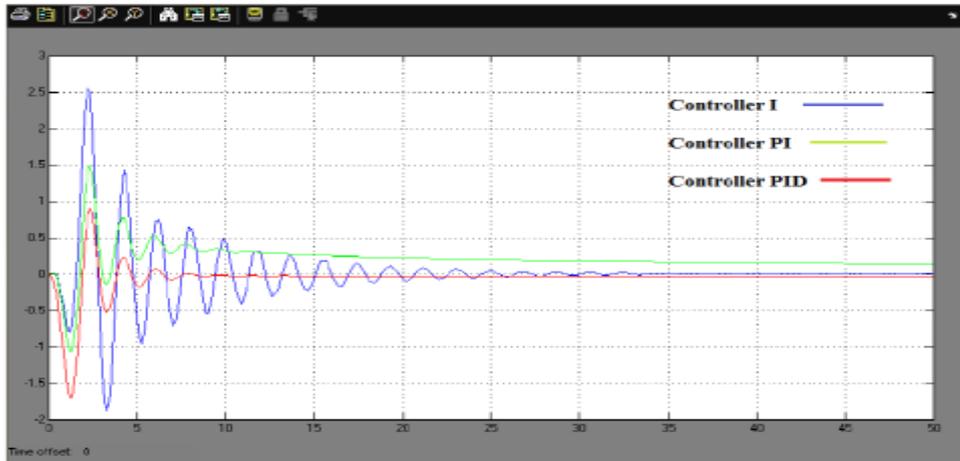


Fig. 5: Output frequency response using different controller.

The gain value of different types of controller using in two area power system is given in Table 1.

Controller	Kp		Ki		Kd		Settling time (sec.)
	Area1	Area2	Area1	Area 2	Area 1	Area 2	
I	-	-	0.2742	0.4680	-	-	35
PI	0.1109	0.0121	0.2742	0.2019	-	-	25
PID	0.1109	0.0121	0.2742	0.2019	0.1110	0.003	10

Table 1: Different values of gain for different controllers

It shows that for different controllers getting different settling time value. The settling time of PID controller is less than I, PI controller. We can control oscillations, rise time and settling time using different control method.

B. Power system Model using fuzzy Logic controller

In this type of controller gain value of controller is automatically fixed. The MATLAB Simulink diagram is shown in Figure 6.

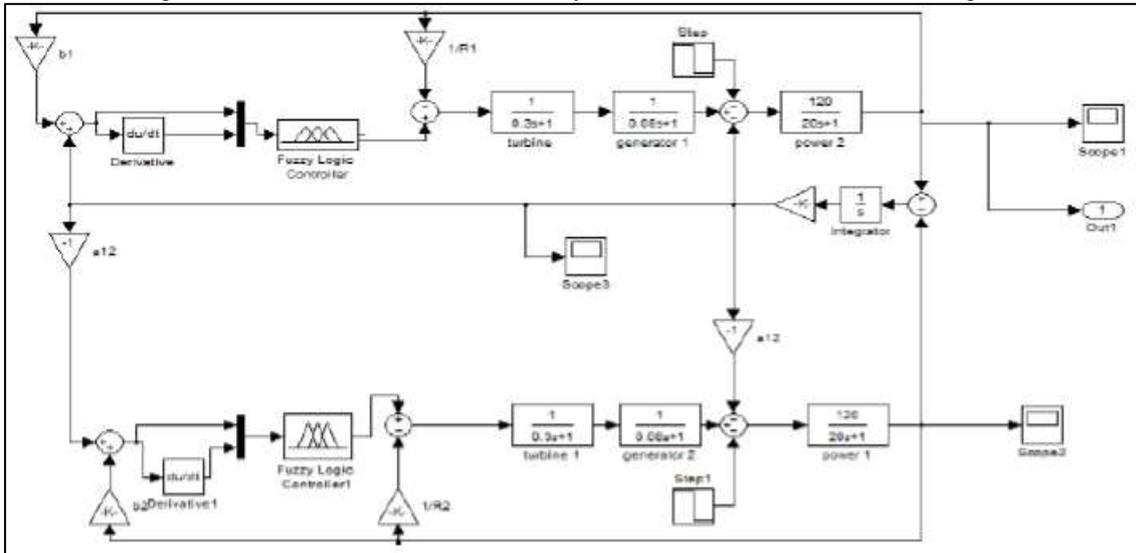


Fig. 6: Simulink model of two area power system using PID tuning controller.

The output response of PID tuning method for area1, area 2 and Tie-line is shown in Fig.7, Fig. 8, and Fig.9 respectively.

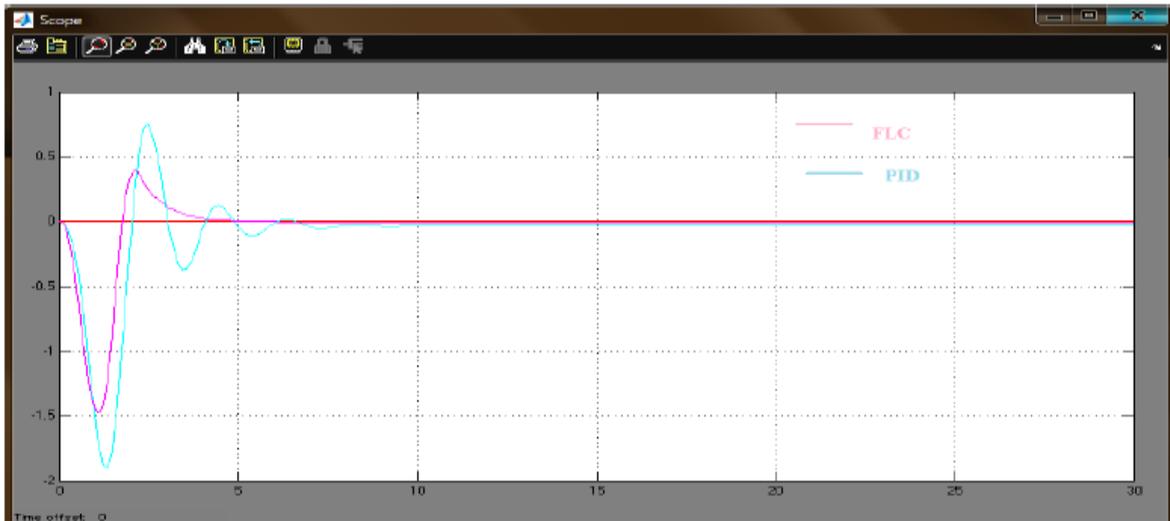


Fig. 7: Output response of area 1.

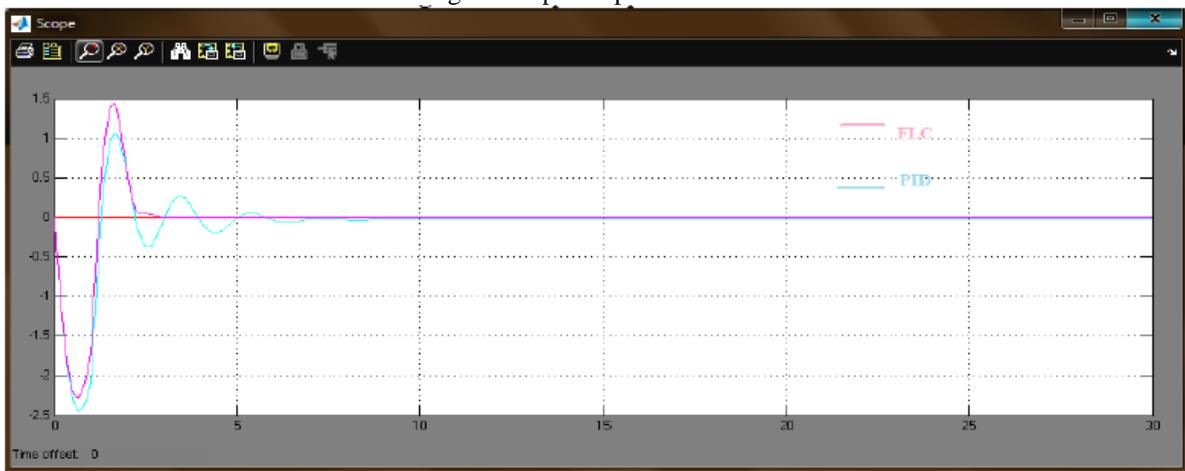


Fig. 8: Output response of area 2.

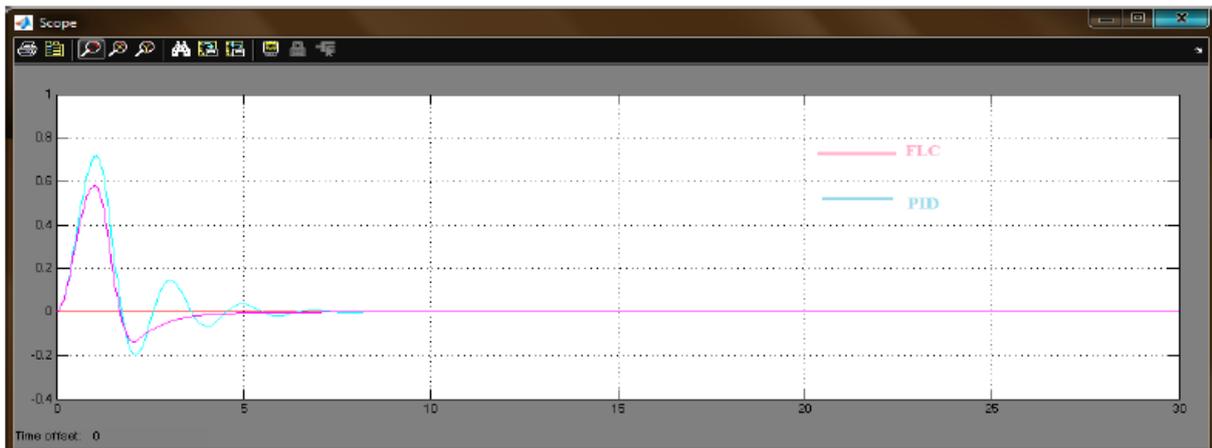


Fig. 9: Output response of tie-line of power system.

For better dynamic responses using fuzzy logic controller method, we reduce settling time, oscillation. The response of power system also varies according to rated power capacity of any system.

V. SIMULATION RESULT

The simulation results of two area system area are shown below. In this three cases are considered based on the values used for LFC parameters.

Case 1: In this case we consider the parameters of deviation of area 1 shown in fig.7

Case 2: In this case we consider the parameters of deviation of area 2 shown in fig.8

Case 3: In this case we consider the parameters of deviation of area for tie-line shown in fig.9

In this case way easily compare the output responses without controller, P, PI, PID and proposed Fuzzy logic controller (FLC). The system having FLC controller gives better dynamic responses comparing to conventional.

VI. CONCLUSIONS

A PID controller used for load frequency controller of two area interconnected power system has been presented. It can be implemented in four area power system and controlled by using advanced controller systems. The system performance was observed on the basis of dynamic parameters i.e. settling time, overshoot and undershoot. The system performance characteristics reveals that the performance of fuzzy logic controller method better than other controllers. As a further study, the proposed method can be applied to multi area power system load frequency control (ALFC) and also optimum values can be obtained by Genetic Algorithm and Neural networks.

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