Optimal Generation Control of a Two-Area Interconnected Power System with PI controller, PID controller and PID tuned Fuzzy Logic Controller

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Abstract- *The design of Automatic Generation Control (AGC) system plays a vital role in automation of Power System. This paper investigates the effects of integral controllers and fuzzy controller in an interconnected two area power system. The dynamic performance of system has been compared with Proportional Integral controller, PID controller and PID tuned Fuzzy Logic controller and observed that the performance is superior in terms of overshoot and settling time when PID controlled Fuzzy Controller is used.*

Keywords- Automatic Generation Control (AGC), Proportional Integral (PI) Controller, Proportional Integral Derivative (PID) Controller, MATLAB/SIMULINK, Fuzzy Logic Controller.

I. INTRODUCTION

The automatic generation control (AGC) is a technical requirement for the proper operation of an interconnected power system. Automatic generation control is very important in power system operation and control for supplying sufficient and reliable electric power with good quality, particularly for large scale electrical power systems that normally consist of interconnected control areas representing coherent groups of generators. In cases of area load changes and abnormal conditions, such as outages of generation and varying system parameters, mismatches in frequency and scheduled tie-line power flows between areas can be caused. These mismatches are corrected by controlling the frequency, which is defined as the regulation of the power output of generators within a prescribed area. Automatic generation control is the regulation of power output of controllable generators within a prescribed area in response to change in system frequency, tie-line loading, or a relation of these to each other, so as to maintain the schedule system frequency and establish the interchange with other areas within predetermined limits [1].

In practical cases, system parameters do not remain constant and continuously vary with changing operating conditions. To solve this problem various recent trend intelligent controllers are discussed in [5,6]. A number of control strategies have been employed in the design of load frequency controllers in order to achieve better dynamic performance. Among the various types of load frequency controllers, the most widely employed is the conventional proportional integral (PI) controller and PID Controller [7,8]. The conventional control method does not give required solutions due to complex and multivariable power systems. Therefore next step is taken to improve the reliability and robustness of the system using Fuzzy Controllers. Fuzzy Controllers are advantageous in solving wide range of control problems including AGC of interconnected power system. Fuzzy logic based controller can be implemented to analyze the load frequency control of two area interconnected power system with HVAC taking parameter uncertainties into account. The power system is modeled and simulated using MATLAB simulink environment. Then the frequency deviation has been studied and presented with PI controller, PID controller and Fuzzy Logic Controller.

II. PROBLEM FORMULATION

Investigations have been carried out on a two area power system. A step load perturbation of 1% of nominal loading has been considered in area-1. For the load frequency control, the conventional and intelligent controllers are implemented.

A. Two Area Power System

The two area power system model identified in the present study has the following configuration:

a) It is a two area interconnected power system consisting of identical single stage non-reheat thermal turbines.
b) The two areas are interconnected via HVAC tie line.

The step load perturbation of 1% of the nominal loading has been considered in either of the area for system analysis.

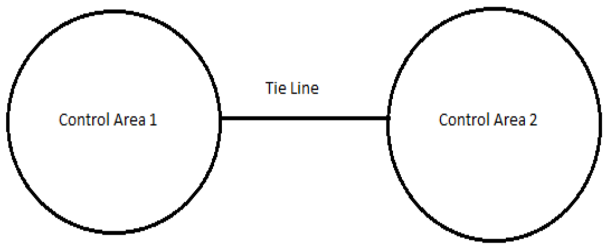

Figure 1: Two area interconnected control areas (single tie-line)

B. LFC of Two Area Interconnected Power System

A multi area LFC is based upon tie line bias control, where each area tends to reduce the area control error (ACE) to zero. ACE is determined by the net interchange minus the biased scheduled net interchange. The control error for each area consists of a linear combination of frequency and tie line error.

$$ACE_i = \sum_{j=1}^{n} \Delta P_{ij} + B_i \Delta\omega$$

C. PI CONTROLLER

PI is a controller in which two parameters caller P (Proportional) and I(Integral) are involved. In proportional control action, the output of controller is proportional to the error. When the error is zero, controller output is constant. In integral control action, the output of controller is change at the rate which is proportional to the actuating error signal. And in derivative control action the output of controller depends on time rate of change of actual errors. The characteristics of PI control action are

- Steady state accuracy improves
- Rise time increases
- Bandwidth decreases
- Response is oscillatory

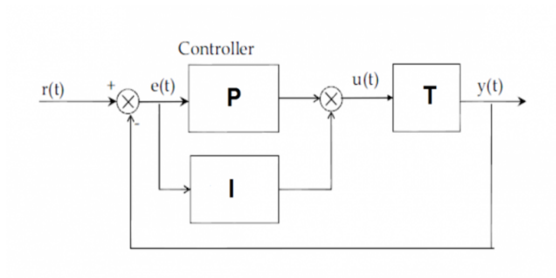

Figure 2: Block Diagram of PI Controller

D. PID CONTROLLER

PID controller is a generic control loop feedback mechanism (controller) widely used in industrial control system. A PID is the most commonly used feedback controller Calculates an error value as the difference between measured process variable and a desired response. The controller attempts to minimize the error by adjusting the process control input. The PID controller calculation (algorithm) involves three constant parameters called the proportional (P), integral (I) and derivative (D) values, these values can be interpreted in terms of time. P depends on the present error, I on the accumulation of past error, and D is a prediction of future error, based on current rate of change .The weighted sum of these three actions is used to adjust the process via a control element such as the position of a control valve, or power supplied to a heating element.

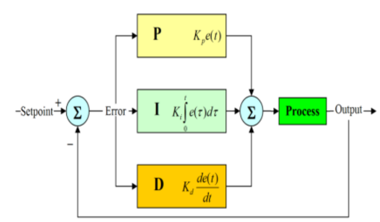

Figure.3: Block diagram of PID Controller

The characteristics of PID Controller are

- No oscillations
- Improves the transient response
- Improves steady state response

E. Fuzzy Logic Controller

The Fuzzy logic controller uses the fuzzy logics to make the decisions and to control the output of the controller. The main components in fuzzy logic based MPPT controller are fuzzification, rule-base, inference and defuzzification as shown in figure 3.

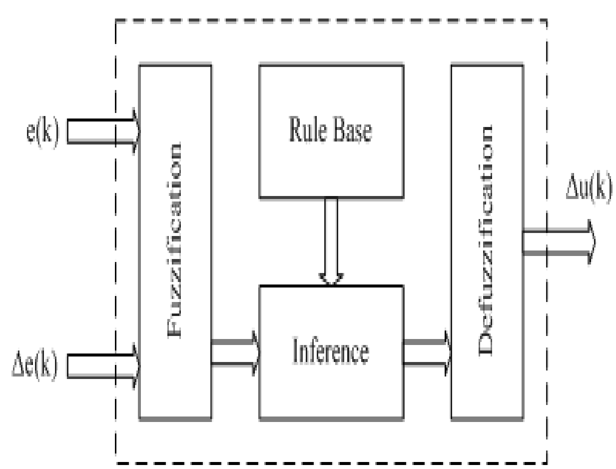

Figure 4: Fuzzy Logic basic block diagram

There are two inputs to the controller – error ACE and change in error ΔACE. The Fuzzification block converts the crisp inputs to fuzzy inputs. The rules are formed in rule base and are applied in inference block. The defuzzification converts the fuzzy output to the crisp output. The fuzzy inference is carried out by using Mamdani's method, and the defuzzification uses the centre of gravity to compute the output of this FLC which is the change in duty cycle.

III. METHODOLOGY

The fuzzy logic controller used in the system has two inputs. The error is the change in area control error (ACE) The equation for error and change in error is given by

$$ACE = b\Delta f_1 + \Delta P_{tie}$$

A. Membership Functions

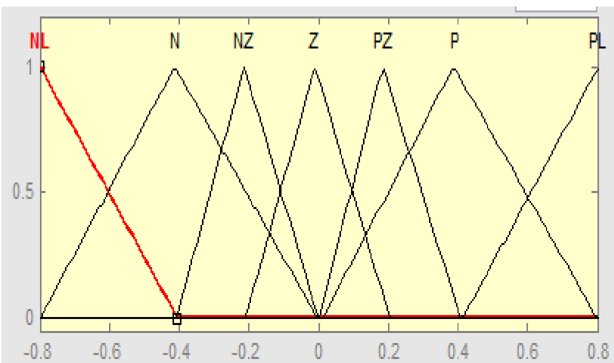

Figure 4: Membership function of ACE

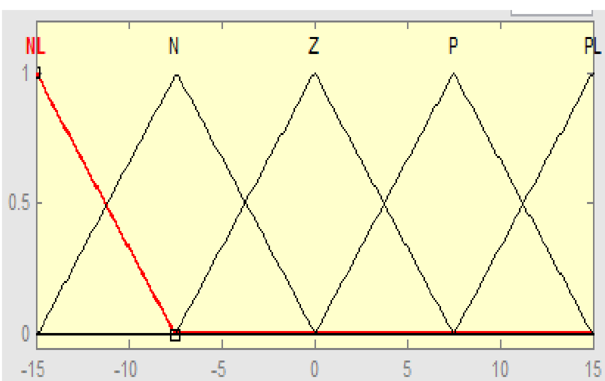

Figure 5: Membership function of ΔACE

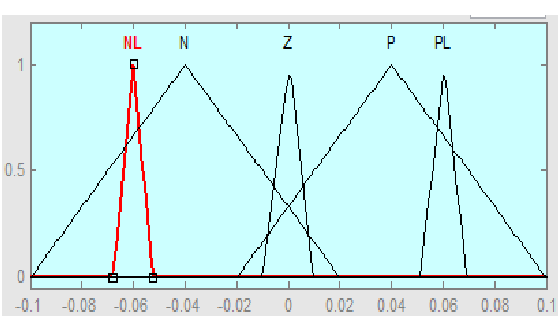

Figure 6 : Membership function of output

IV. SIMULATION RESULTS

In this paper, a simulink models has been designed to analyze the effect of PI controller, PID controller and PID tuned Fuzzy logic controller on the AGC of two area interconnected power system. The implementation worked with Matlab-Simulink software. The response plots for variables like frequency deviations in area 1 and area 2 and tie line power deviations for power system model, in the wake of load disturbance of 1% in area 1 are obtained to analyze the system dynamic performance.

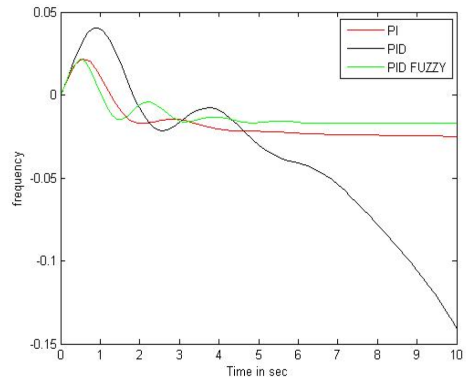

Figure 6.1: Change in frequency in area 1

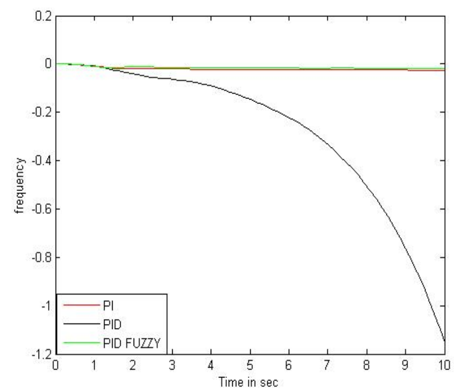

Figure 6.2: Change in frequency in area 2

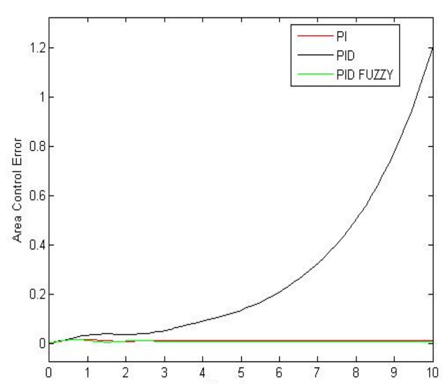

Figure 6.3: Change in area control error of area 1

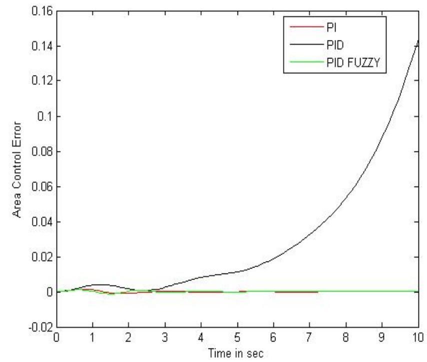

Figure 6.4: Change in area control error of area 2

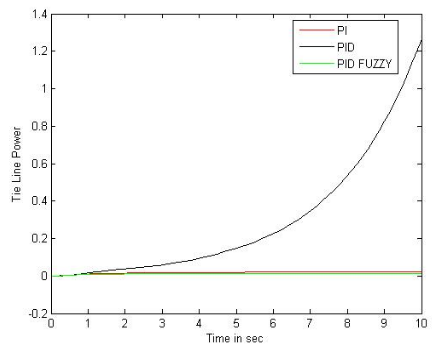

Figure 6.5: Change in tie-line power

V. CONCLUSION

In this paper, a power system model is proposed to improve the dynamic performance of two area interconnected power system. Firstly the system was controlled by PI controller and then with PID controller then a fuzzy logic control strategy is designed and its feasibility is studied by varying system parameters. It has been observed that responses of the system with fuzzy logic controller is better in terms of dynamic parameters such as peak overshoot and settling time when it is tuned with PID controller.

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