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Decentralized control scheme for Load Frequency Control in a Power System

Shatabdi Ghoshal (Student)*, Mr. Yogesh (Assistant Professor)**
**(Electrical Engineering Department – Power System, GITM, MDU Rohtak, Haryana*
***(Electrical Engineering Department – Power System, GITM, MDU Rohtak, Haryana*
Corresponding Author: Shatabdi Ghoshal

ABSTRACT
This paper presents the decentralized control scheme in case of Load Frequency Control used in Power System. This scheme can be used in both single area and interconnected power system. But in an interconnected power system, random change in frequency may lead to change in both frequency and tie line power. To minimize this condition, we must control the frequency which lead to minimize the transient variations by ensuring that the steady state error is zero. Many control techniques are used and their aim is to deliver a control voltage and frequency in a permissible limit. If we change the real power, it will affect the frequency whereas reactive power is dependent on change in voltage. For robustness and reliable control techniques can be obtained with the help of MATLAB-Simulink.

***Keywords*:** Load Frequency Control (LFC), PID Controller, SIMULINK model, Tie-Line, Two Area System.

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I. INTRODUCTION

The purpose of a power system operation is provide continuous supply within an acceptable limit and to all the consumers. The equilibrium condition is reached by maintaining a balance between demand power and generated power. As AC power consist of both real and reactive components; so balancing both the real and reactive power can be

The basic role load frequency control in an power system is to maintain continuous power supply within a limit and provide

The main objective of power system operation and control is to maintain continuous supply of power with an acceptable quality, to all the consumers in the system. The system will be in equilibrium, when there is a balance between the power demand and the power generated. As the power in AC form has both real and reactive components: so balancing of real power and reactive power to be achieved.

Load frequency control

The main purpose of operating the load frequency control is to keep uniform the frequency changes during the load changes. During the power system operation rotor angle, frequency and active power are the main parameters to change.

In multi area system a change of power in one area is met by the increase in generation in all areas associated with a change in the tie-line power and a reduction in frequency. In the normal operating state the power system demands of areas are satisfied at the nominal frequency.

The basic role of Load Frequency Control is:

1. To maintain the desired megawatt output power of a generator matching with the changing load.
2. To assist in controlling the frequency of larger interconnection.
3. To keep the net interchange power between pool members, at the predetermined values.

II. MODELLING OF TWO AREA SYSTEM

As long as the system frequency is equal to its specified value (the assumption here), the difference between an area's actual interchange and its scheduled interchange is known as the "area control error" (ACE) (the area control error also includes a term dependent on the deviation in the system frequency from the specified value; this frequency-dependent term is not discussed here). The ACE is the single most important number associated with control operations; it is continuously monitored. Anytime the ACE is negative the area is "under generating" and needs to increase its total generation. Conversely, if the ACE is positive, the area is "over generating" and needs to decrease its generation. Over the last several decades, practically all control areas have switched to an automatic process known as "automatic generation control" (AGC). AGC automatically adjusts the generation in an area to keep the ACE close to zero, which in turn keeps the net area power interchange at its specified value. Since the ACE has a small amount of almost random "ripple" in its value due to the relentlessly changing system load, the usual goal of AGC is not to keep the ACE exactly at zero but rather to keep its magnitude close to zero, with an "average" value of zero. Modern power system network consists of a number of utilities interconnected together & power is exchanged between utilities over tie-lines by which they are connected. Automatic generation control (AGC) plays a very important role in power system as its main role is to maintain the system frequency and tie line flow at their scheduled values during normal period and also when the system is subjected to small step load perturbations. Many investigations in the field of automatic generation control of interconnected power system have been reported over the past few decades. Literature survey shows that most of the earlier work in the area of automatic generation control pertains to interconnected thermal system and relatively lesser attention has been devoted to automatic generation control (AGC) of interconnected hydro-thermal systems involving thermal and hydro subsystems of widely different characteristics. These investigations mostly pertain to two equal area thermal systems or two equal areas hydrothermal systems considering the system model either in continuous or continuous discrete mode with step loads perturbation occurring in an individual area.

Load Frequency Control in two- area system

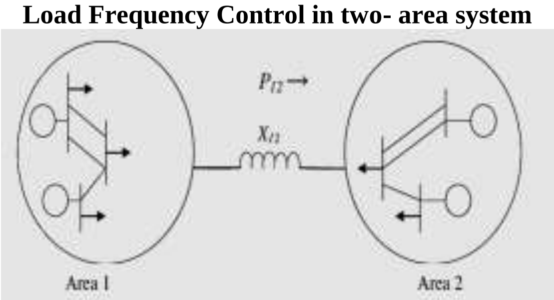

Fig.1 Load Frequency Control in Two area system

Consider these two areas represented by an equivalent generating units interconnected by a lossless tie line with reactance X_{tie}. Each area is represented by voltage source behind an equivalent reactance as shown in figure.

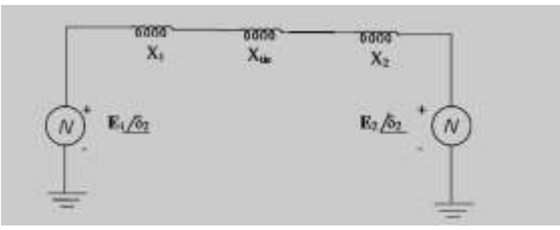

Fig.2 Equivalent diagram for two area system

During normal operation the real power transferred over the tie line is given by:

$$P_{12} = \frac{|E_1||E_2|}{X_{12}} \sin\delta_{12}$$

Where: $X_{12} = X_1 + X_{tie} + X_2$ and $\delta_{12} = \delta_1 - \delta_2$

Equation can be linearized for a small deviation in the flow ΔP_{12} from the nominal value, that is:

$$\Delta P_{12} = \frac{dP_{12}}{d\delta_{12}}\Big|_{\delta_{12_0}} \Delta\delta_{12} = P_s \ \Delta\delta_{12} \qquad \text{..... (1)}$$

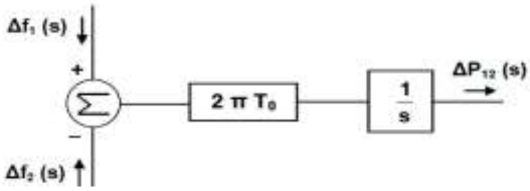

Fig.3 Linear representation of the tie line

P_S- the slope of the power angle curve at the initial operating angle

$\delta_{12\,0} = \delta_{1\,0} - \delta_{2\,0}$....... (2)

Thus,

$$P_s = \frac{dP_{12}}{d\delta_{12}}\Big|_{\delta_{12_0}} = \frac{|E_1||E_2|}{X_{12}} \cos\Delta\delta_{12_0}$$

Then

$$\Delta P_{12} = P_S\,(\Delta\delta_1 - \Delta\delta_2) \qquad \text{....... (4)}$$

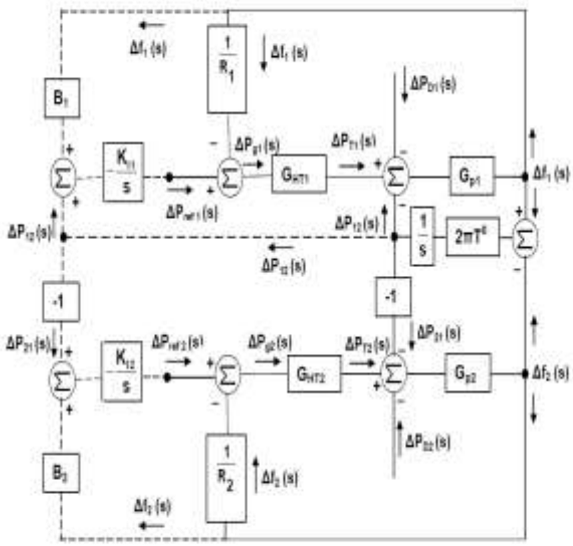

Fig.4 Block diagram representation of two area system with tie-line bias control

III. CONTROLLER

Now days the complexity of power system is generally increases. so different control action or controllers like optimal controller, variable structure control, robust control, conventional PI , PI controller, adaptive and self-tuning control were used for LFC of power system. Meanwhile, PI and PID controllers were studied for LFC the simplicity of their execution.

PID CONTROLLER

The block diagram of Proportional Integrative Derivative (PID) controller is shown in fig. 5.

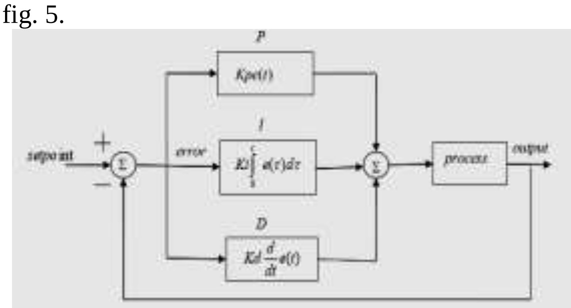

Fig.5 Block diagram of a PID Controller

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

$$y(t) = K_p e(t) + K_i \int_0^t e(\tau)\, d\tau + K_d \frac{d}{dt} e(t) \quad \ldots..(5)$$

Where y (t) is the controller output and e (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, the optimum gains 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.

IV. POWER SYSTEM MODEL USING DIFFFRENT CONTROLLER

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 diagram of two 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 6.

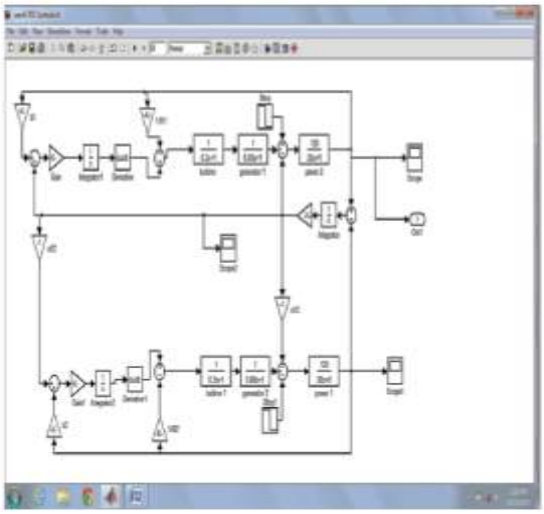

Fig.6 Simulink model of two area power system using PID controller.

The output response is shown in Fig.7, which having the comparison results between simple integral (I), proportional integral (PI), Proportional integral derivative (PID).

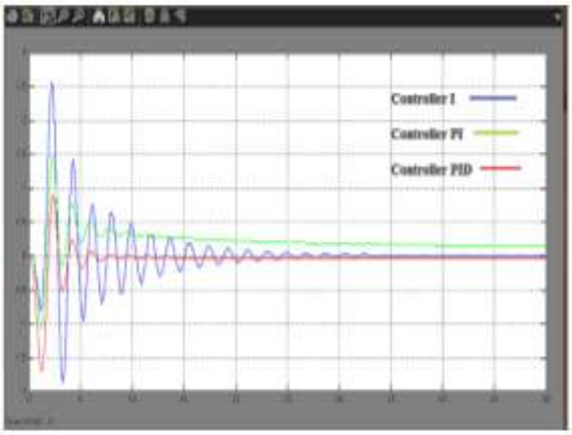

Fig. 7 Output frequency response using different Controller

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

	Kp		Ki		Kd		Settling time
Controller	Area1	Area2	Area1	Area 2	Area 1	Area 2	(sec.)
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 controller

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.

V. RESULTS OF PID CONTROLLER FOR LFC OF TWO AREA POWER SYSTEM

Fig.8 to Fig.10 are showing the dynamic responses of deviation in frequency for both the areas (Δf_1,Δf_2) and the power deviation in tie line ($\Delta P_{tie(1,2)}$) for a power system heaving two control areas with thermal non-reheat turbines. The figures show the performances of a PID controller for LFC of power system, tuned via Internal Model Control (IMC). From figures we can clearly see that the responses are stable with very less overshoot and less settling time. So IMC-PID controller is a powerful controller which gives better stability for LFC of a two area power system.

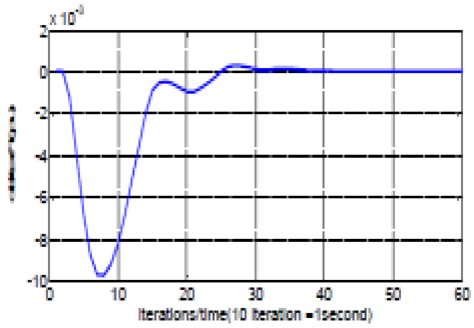

Fig.8 Change in frequency V/S time in area-1 for 0.01 step load change in area-1

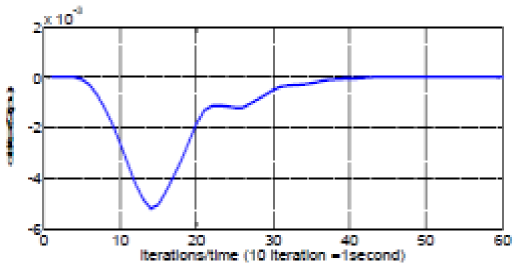

Fig.9 Change in frequency V/S time in area-2 for 0.01 step load change in area-1

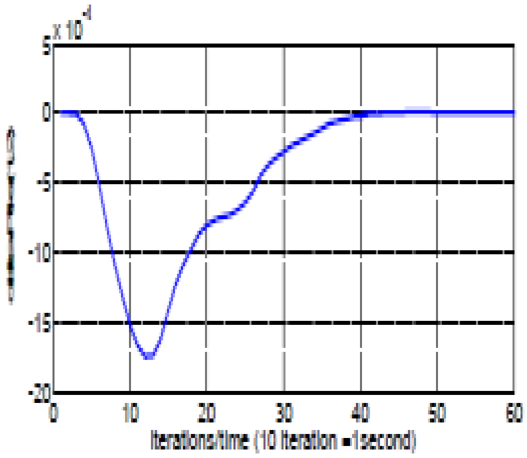

Fig.10 Change in tie line power V/S time for 0.01 step load change in area-1

VI. CONCLUSIONS AND SCOPE FOR FURTHER WORK

1. Load frequency control investigated in this project has recently come into question in operation of interconnected power networks. Frequency is a sensitive parameter which affects the system operation so it is controlled certainly. Therefore, power utilities consider the frequency and active power balance throughout their networks to sustain the interconnection. In interconnection between national/continental networks, providing the constant frequency between areas is a serious operational problem. Hence fast and no delay decision-making mechanism have to be installed in network control units namely the LFC.
2. The load frequency control is achieved within tree levels, considering many issues from maintaining constant frequency and the minimization of losses through tie lines to the optimal dispatch of generation between units or even areas.
3. The simulation techniques are very useful in studying and predicting the response of control systems, giving the opportunity to optimize the response and so the behavior of the system under study.
4. The great importance of the PID controllers is recognized, considering the facilities it offers by the different combinations of its terms.
5. As a further work, study could be extended to consider methods of optimal design of the gains of the PID controllers, like considering the artificial intelligence methods or the fussy logic giving the opportunity to obtain an optimal response of the control systems.
6. The economic dispatch of generation plays a vital rule in the AGC, and this issue could be studied as an extension of this project, adding an additional dimension to the task of our project.

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