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To Study about Automatic Generation Control in Power System

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***Abstract*— In this paper, automatic generation control (AGC) of two area interconnected power system having diverse sources of power generation is studied. A two area power system comprises power generations from hydro, thermal and gas sources in area-1 and power generations from hydro and thermal sources in area-2. All the power generation units from different sources are equipped with speed governors. A continuous time transfer function model of the system for studying dynamic response for small load disturbances is presented. A proportional-integral-derivative (PID) automatic generation control scheme is applied only to power generations from thermal and gas sources and power generation from hydro source is allowed to operate at its scheduled level with only speed governor control. The two area power system is simulated for different nominal loading conditions. Genetic algorithm (GA) is used to obtain the optimal PID gains for various cases using integral squared error plus integral time absolute_error (ISE+ITAE) performance index for fitness evaluation. Some of the transient responses are shown for different nominal loading conditions due to step load disturbances in the system.**

Index Terms- **Component :Automatic gain control:Proportional integral derivative: Genatic algorithm.**

I. INTRODUCTION

Power systems consist of control areas representing a coherent group of generators i.e. generators which swing in unison characterized by equal frequency deviations. In addition to their own generations and to eliminate mismatch between generation and demand these control areas are interconnected through tie-lines for providing contractual exchange of power under normal operating conditions [1]. One of the control problems in power system operation is to maintain the frequency and power interchange between the areas at their rated values. Automatic generation control is to provide control signals to regulate the real power output of various electric generators within a prescribed area in response to changes in system frequency and tie-line loading so as to maintain the scheduled system frequency and established interchange with other areas (Elgerd, 1971). The performance of the automatic generation control depends upon how various power generating units respond to these signals. The speed of their response is limited by natural time lags of the various turbine dynamics and the power system itself. In other words the design of automatic generation controller depends upon various energy source dynamics involved in the AGC of the area. The primary purpose of AGC is to balance the total system generation against system load and losses so that the desired frequency and power interchange with neighboring systems are maintained [2].

1. **Load Frequency Control with Economic Dispatch Control**

Fig 1. Shows AGC model with economic dispatch

Load frequency control with integral controller achieve zero steady state error and fast dynamic response, but it exercise no control over the relative loading of various generating station (i.e. economic dispatch) of the control area. If a sudden increase in load(1%) occurs in control area, the load frequency control changes the speed changer settings of governor of all generating unit of the area so that ,together these unit match the load and the frequency returns to scheduled value [2].

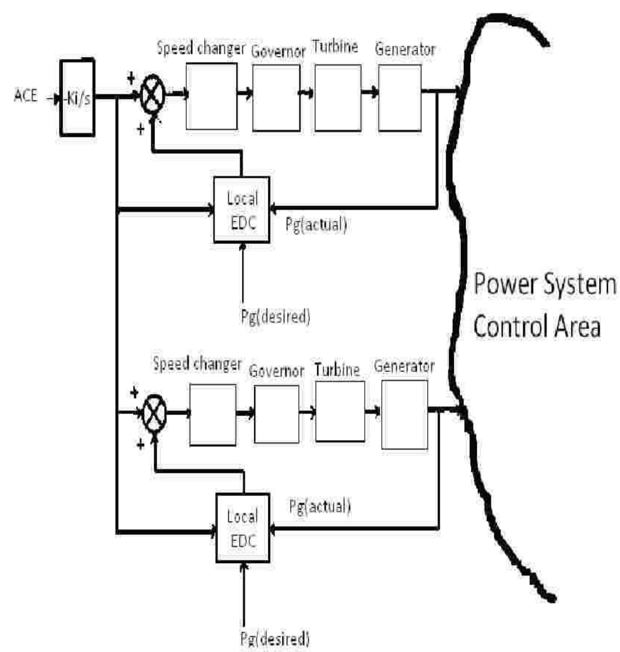


Fig 1.AGC Model with Economic Dispatch

However, in process of this change loading of various generating unit change in manner independent of economic loading consideration. In fact, some units may get overloaded. Some control over loading of individual unit can be exercise by adjusting the gain factor of integral. However this is not satisfactory. A satisfactory solution is achieved by using independent controls for load frequency and economic dispatch. While load frequency control is fast acting control and economic dispatch control is slow acting control, which adjust the speed changer setting in every minute in accordance with command signal generated by central economic dispatch centre [2]. Figure 1 shows schematic diagram.

II. AGC IN MULTI AREA SYSTEM

The AGC in multi area system can be realized by studying the AGC for a two-area system. Consider two areas represented by an equivalent generating unit interconnected by a lossless tie-line with reactance X_{tie} [4]. Each area is represented by a voltage source behind an equivalent reactance as shown in Fig.2.

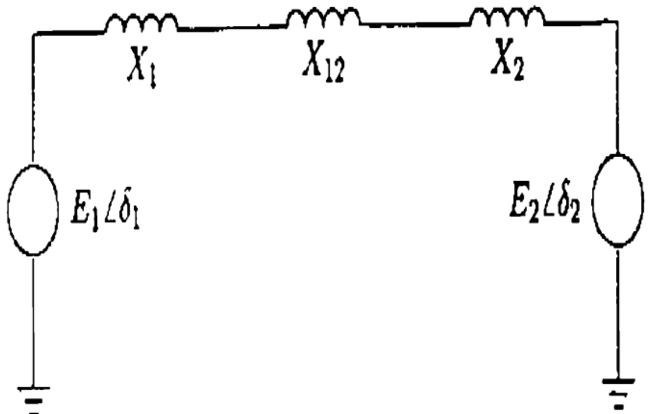


Fig.2 Equivalent network for a two area power System

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 $\delta_{12}= \delta 1- \delta_2$. The above equation can be linearized for a small deviation in the tie-line flow ΔP_{12} from the nominal value [4].

In normal operating state, the power system is operated so that the demands of areas are satisfied at nominal frequency [5]. A simple control strategy for normal mode is

- Keep frequency at nominal value
- Maintain tie-line flow at about schedule
- Each area should absorb its own load changes.

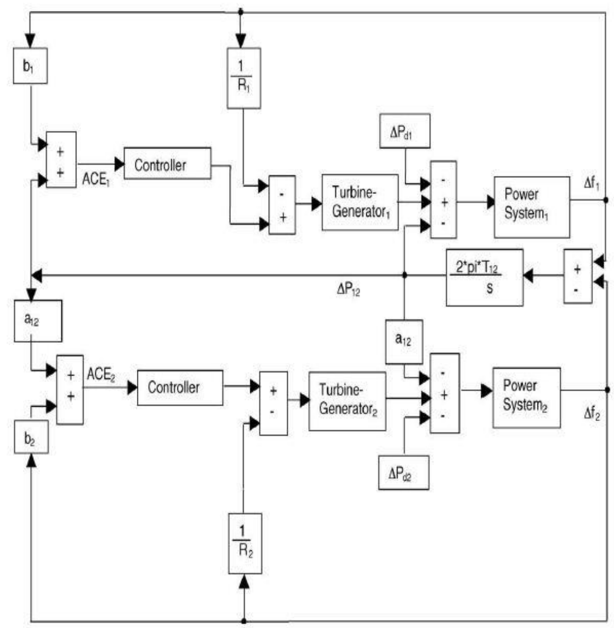


Fig. 3 Block diagram of two area power system.

The terms showed in the Figure 3 are termed given below:
fi :Nominal system frequency of ith area. [HZ]
Δf I :Incremental frequency deviation of ith area. [HZ pu]
Tsi : Speed governor time constant of i th area [sec.]
Kgi : Gain of speed governor of i th area
Ri :Governor Speed regulation of the of ith area [*Z H*/pu.MW]
Tti : Governor Speed regulation of the of ith area [*Z H*/pu.MW]
Kti : Gain of turbine of ith area
Kpi :Gain of power system (generator load) of i th area.[*Z H* /pu.MW]
Kpi = 1/D
Tpi Gain of power system (generator load) of i th area. [*ZH*/pu.MW]
Tpi = 2Hi /Difi
Hi : Inertia constant of i th area . [MW-sec/MVA]
*ΔPGi :*Incremental generator power output change of I th area .[pu MW]
*ΔPti :*Incremental turbine power output change of i th area. [pu MW]
Ki : Gain of controller of ith area.

III. CONTROL TECHNIQUE

A. PID Controller for AGC

There are many types of controller such like proportional, integral, derivative and combinational of these (PI, PID). The block diagram of Proportional Integrative Derivative (PID) controller is shown in Fig.3. 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 [14]. Better margin of stability is ensured with PID controllers. The mathematical equation for the PID controller is given as.

$$Y(t) = Kpe(t) + Ki\int e(\tau)dt + Kd\frac{d}{dt}e(t)$$

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 [14]. The tuning parameters are as follow

Proportional Gain (Kp)

Larger values typically mean faster response since the larger the error, the larger the Proportional term compensation. An excessively large proportional gain will
lead to process instability and oscillation.

Integral Gain (Ki)

Larger values imply steady state errors are eliminated more quickly. The trade-off is larger overshoot: any negative error integrated during transient response must be integrated away by positive error before we reach steady state.

Derivative Gain (Kd)

Larger values decrease overshoot, but slows down transient response and may lead to instability due to signal noise amplification in the differentiation of the error.

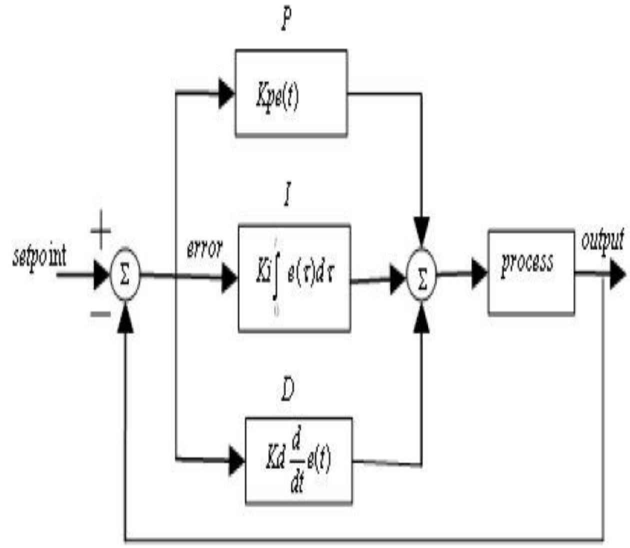
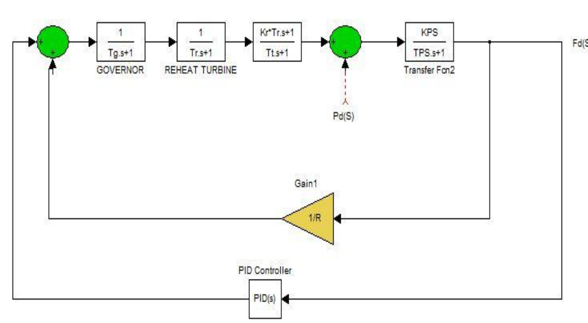


Fig.4 Block diagram of a PID controller.

They can perform poorly in some applications. PID controllers, when used alone, can give poor performance when the PID loop gains must be reduced so that the control system does not overshoot, oscillate or hunt about the control set point value. A problem with the Derivative term is that small amounts of measurement or process noise can cause large amounts of change in the output [14].

IV. MATLAB SIMULINK MODEL

1. Simulink Model Of Two Are Power System Using "PID" Controller::



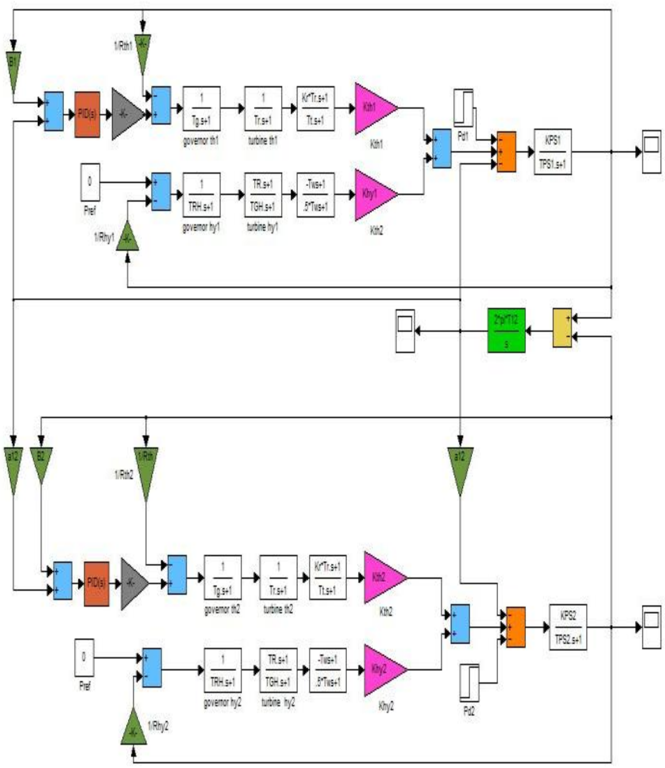
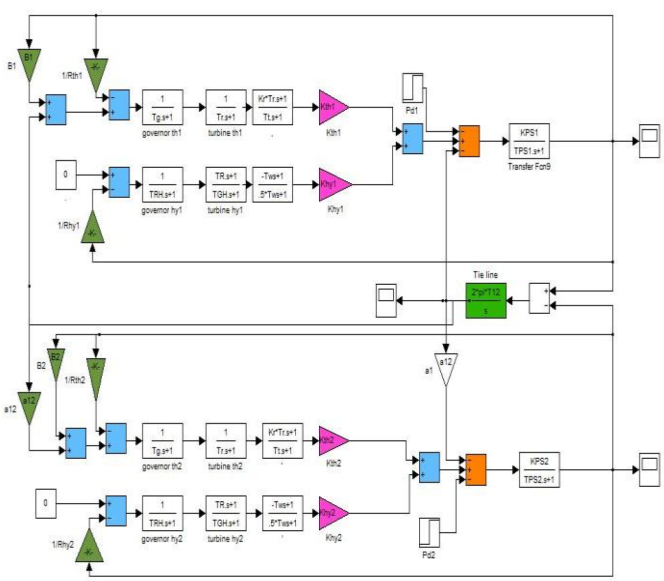


Fig 5. Simulink model of two area power system using PID controller

I “OUTPUT” Frequency Response Using different Controller:



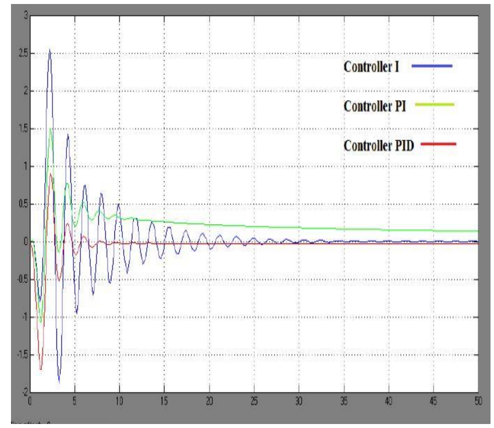


Fig 6. Frequency response using different controller

2.Two –Area Interconnected Model:

Fig 7. : two-area thermal model without PID

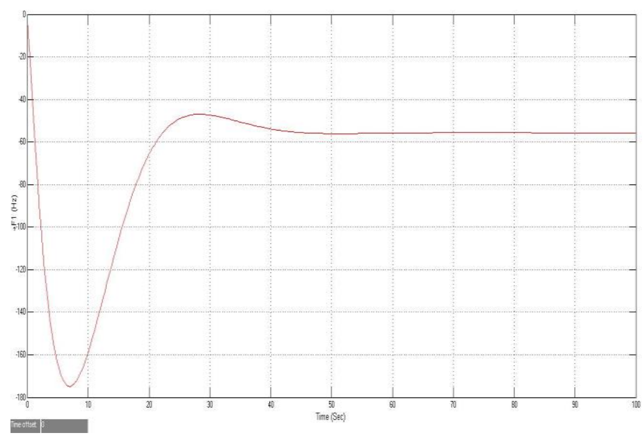
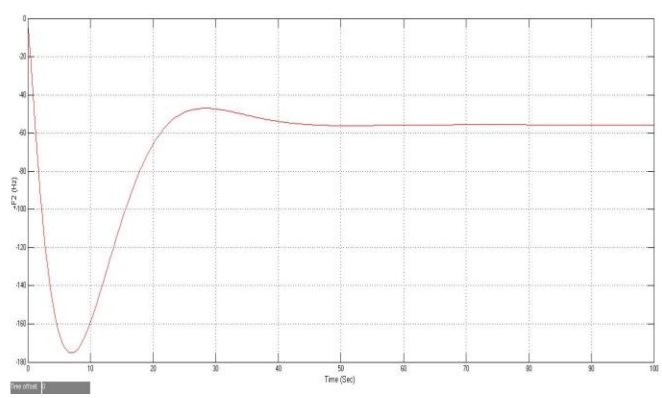


Fig 8. Frequency response of area- 1 with-out PID controller



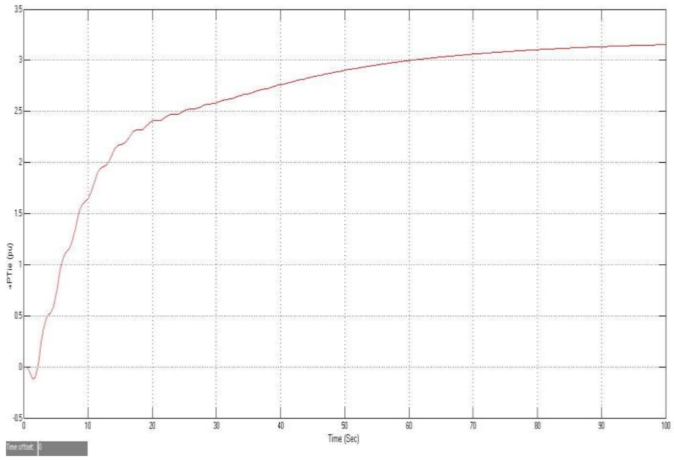


Fig 5. TIE line power response of both area with-out PID controller

V. CONCLUSION

Thus, from the series of above simulations made and from their respective results obtained, we can conclude that the frequency deviation response is the best for two-area thermal model. We can also model the AGC of two area power system having power generation from hydro, thermal in area-1 and from hydro and thermal in area-2. The typical two area system also has been simulated for different scheduled generations under different normal loading conditions with step load disturbance in either area. It has been found that the optimal gains of the AGC are different for different loading conditions. The gains have been found to be different for each PID in an area to achieve better dynamic performance. AGC gains must be selected on typical nominal loading of the power system,

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