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Controlling the Active Power and Frequency of Single and Multi Area Interconnected Power System Using PID Controller

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Abstract— The main objective of this paper is to control the active power and frequency known as Load Frequency Control of single area thermal and hydro plant as well as two area thermal and hydro power systems,. During the transportation, both the active power balance and the reactive power balance must be maintained between generating and utilizing the AC power. For this purpose proportional, conventional (integral) and derivative control configurations in various combinations are used and studied. The systems have been simulated on computer and analyzed. This paper presents the application of P controller, PI controller and PID controller to attain LFC in order to keep the frequency constant against the randomly varying power loads (active), which are also described as unknown external disturbance. LFC is also essential to regulate the tie-line power exchange error.

The single and multi-area interconnected systems responses have been obtained for uncontrolled and controlled cases and studied for comparison using the MATLAB/SIMULINK. The controller's response can be described in terms of the sensitivity of the controller to an error, the degree to which the controllers outreach the set point and the degree of system oscillation.

Keywords— Load Frequency Control, Active power and frequency control, P controller, PI controller, PID controller, tie-line power exchange error, responsiveness, MATLAB/SIMULINK.

INTRODUCTION

The main objective of any power systems is to convert natural energy into electric power. In order to make the performance of electrical equipment optimal, it is essential to ensure that the degree of quality of the electric power must be as high as possible. In the process of transportation, the two balances must be maintained named as the active power balance and the reactive power balance between generating and utilizing the AC power. It will be not be possible to maintain the balances of both the active and reactive powers without any proper control action. As a result of the imbalance, the frequency and voltage levels will vary with the change of the loads. Hence it is required to build a control in order to cancel the effects of the random load changes and to maintain the frequency and voltage at the desired values. In this paper various configurations of Proportional, Integral and Derivative controllers are used to modulate and adjust the active power and frequency of the single area as well as two area power plants. The values of Kp, Kd, Kr and Ki are calculated by manual tuning method. This paper deals with a design method for LFC in a multi area electric power system using a PID and controller whose parameters are tuned using MATLAB/SIMULINK

MECHANICAL-HYDRAULIC GOVERNOR

A schematic arrangement of the main features of a speed governing system of the kind used on speed turbine is shown in figure 1. To develop mathematical representation of the system, it is assumed that the system is operating under steady state condition.

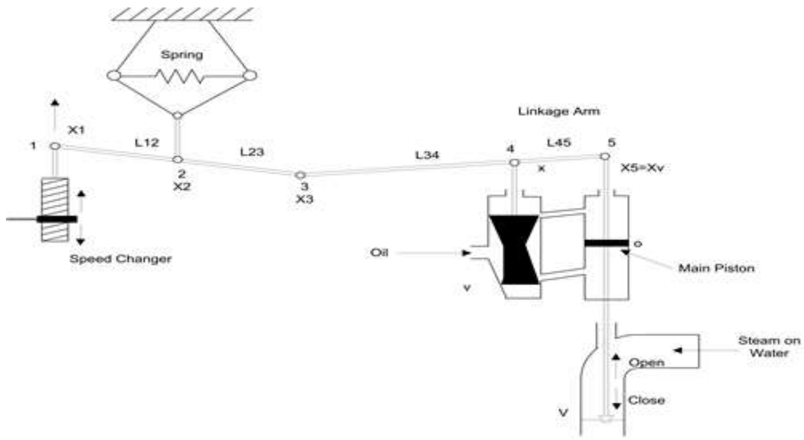

Figure 1: Mech. Hydraulic Governor

The mathematical equations are obtained as[1]:

$\Delta X_1 = K \Delta P_C$

$\Delta X_3 = - K_1 \Delta P_c$

$\Delta X_4 = K_3 \Delta X_3 + \Delta K_3 \Delta X_5$

$\Delta X_5(s) = -K_5 \frac{1}{s} X_4(s)$

$\Delta X_5(s) = \frac{K_1 K_3 \Delta P_C(s) - K_2 K_3 \Delta F(s)}{K_4 + \frac{s}{K_S}}$

$\Delta X_5(s) = [\Delta P_c(s) - \frac{1}{R} \Delta F(s)] * \frac{K_g}{1 + sT_g}$

Where

$R = \frac{K_1}{K_2}$ = speed regulation of the governor

$K_g = \frac{K_1 K_3}{K_4}$ = gain of speed governor

$T_g = \frac{1}{K_4 K_5}$ = time constant of speed governor

ELECTRO – HYDRAULIC SPEED GOVERNOR

An electro hydraulic speed control mechanism provides flexibility through the use of electronic circuits in place of mechanical components in the low power positions**.**

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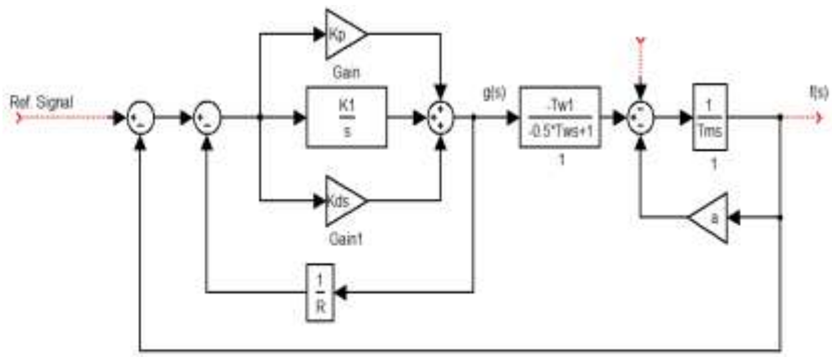

Fig 2. Electro-Hydraulic Governor

The surplus power is given as[2]

ΔP_G-ΔP_D = $\frac{2H}{f^o}\frac{d\Delta f}{dt}$ + $B\Delta f$ per MW

Taking the Laplace transform,

$\Delta P_G(s)$-$\Delta P_D(s)$ = $\frac{2H}{f_o}$ $s\Delta f(s)$ + $B\Delta f(s)$

Or we can write $\Delta f(s) = G_P(s)\ [\Delta P_G(s)-\Delta P_D(s)]$

$G_P(s) \approx \frac{K_P}{1+sT}$

$\frac{1}{K_P} = \frac{2H}{f^o B}$ sec

$T_P = \frac{1}{B}$ Hz/P.U. MW

Murthy and Harihara have shown the temporary droop governor as:

$K_P = \frac{1}{\delta}$, $K_i = \frac{1}{\delta T_\gamma}$ and $K_d = \frac{T_n}{\delta}$[1]

LOAD FREQUENCY CONTROL OF A SINGLE AREA POWER SYSTEM

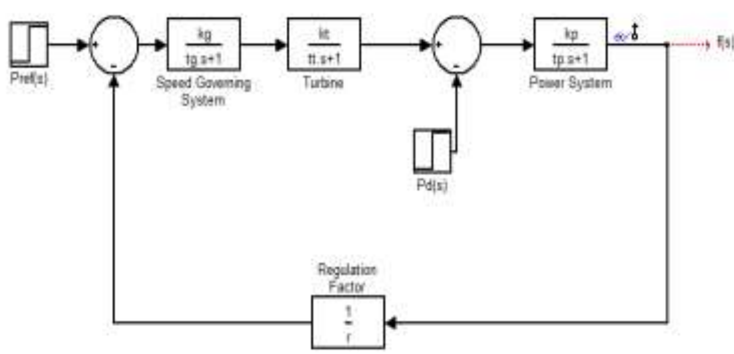

Fig 3. Block Diagram of Single Area Power Plant

CONTROLLED CASE: INTEGRAL CONTROL

Simulated frequency response of single area non–reheat thermal plant is given in fig. (3.4).

Integral gain value has been taken as

$P_D = 0.01$ $K_i = 0.6$

$T_G = 0.08$ sec $K_P = 120$ (generator gain)

F(S) = $\Delta f(s) = -\frac{K_p}{(1+sT_p)+(\frac{1}{R}+\frac{K_i}{s})\times\frac{Kp}{(1+sT_g)(1+sT_t)}} \times \frac{M}{s}$ [2]

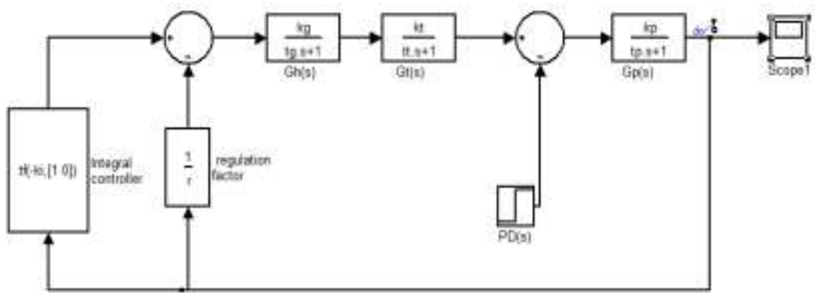

Fig 4. Block Diagram of Single Area Power Plant (controlled)

Simulation Result:

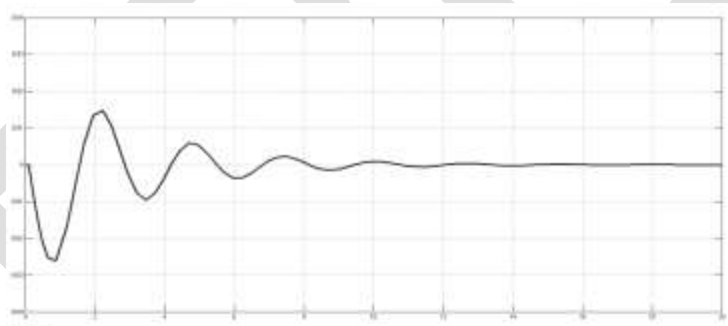

Figure 4.1: Response of Single Area Power Plant

TWO AREA INTERCONNECTED POWER SYSTEMS

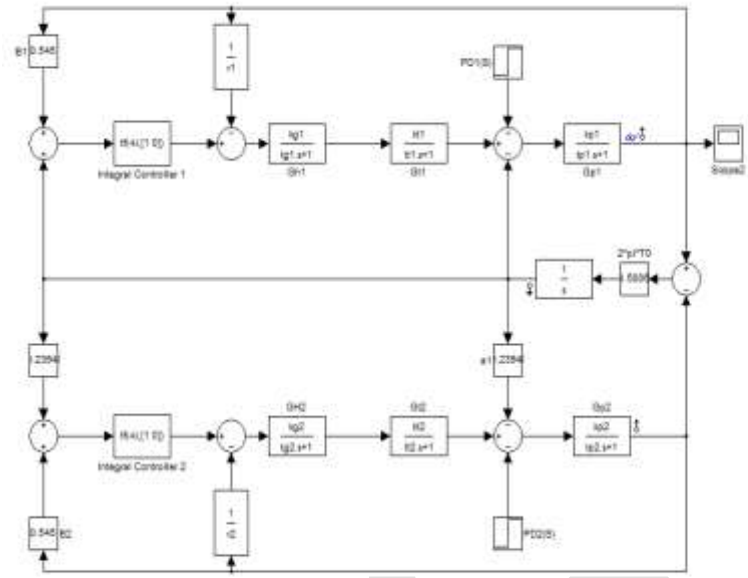

Fig 5. Block Diagram of Two Area Interconnected Power System (controlled)

Simulation Result:

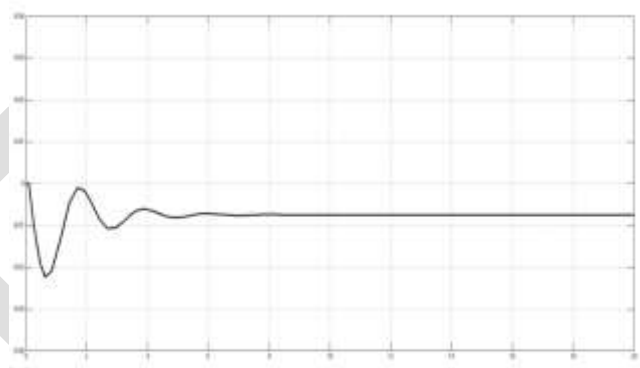

Fig 5.1. Response of Two Area Interconnected Power System (controlled)

PROPORTIONAL, INTEGRAL (CONVENTIONAL) AND DERIVATIVE CONTROL ON POWER SYSTEMS

Two controllers together, normally proportional plus derivative, proportional plus integral and integral plus derivative are used in forward path as well as feedback path to arrive at appropriate control configurations which yields best response.

Parameter	Value
K_P	120 H_Z/P.U.MW
K_r	0.5
R	2.4 H_Z/P.U.MW
ΔP_t	0.01

Table 1: Value of different Parameters

PROPORTIONAL PLUS DERIVATIVE CONTROLLER

Here the two controllers together, i.e. proportional plus derivative are used in forward path and feedback path respectively to arrive at appropriate control configurations which yields best response. The block diagram of the configuration is shown below:

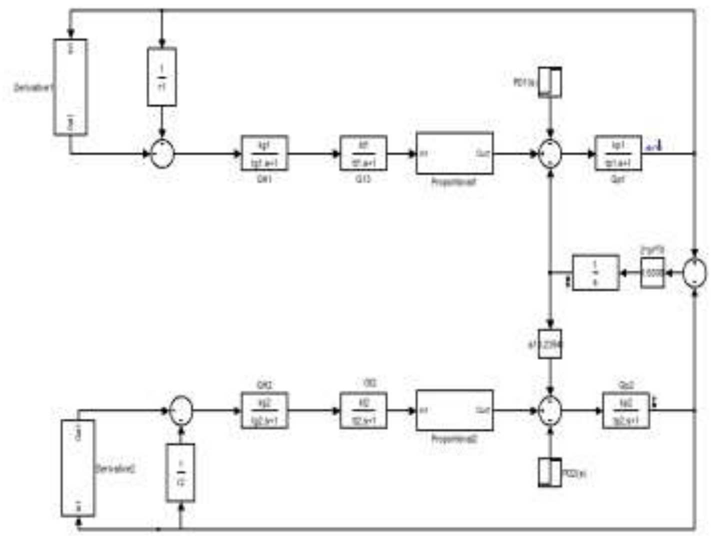

Fig 6. Block Diagram of Power System using proportional plus derivative controller

Simulation Result:

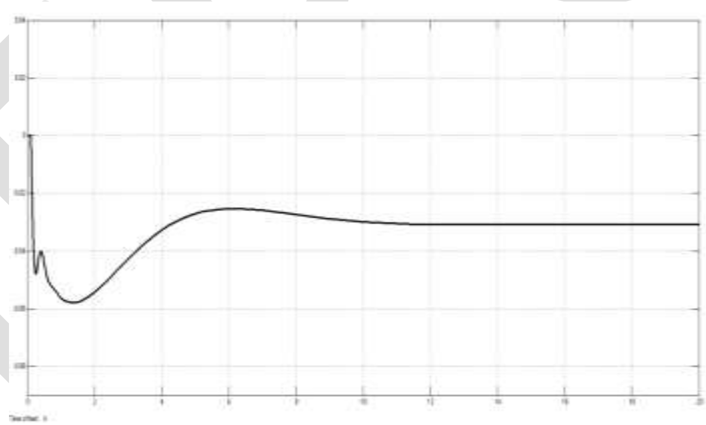

Fig 6.1. Response of Power System (prop. in forward & derivative in feedback path)

PROPORTIONAL PLUS INTEGRAL CONTROLLER

Here the two controllers together, i.e. proportional plus integral are used in forward path to arrive at appropriate control configurations which yields best response. The block diagram of the configuration is shown below:

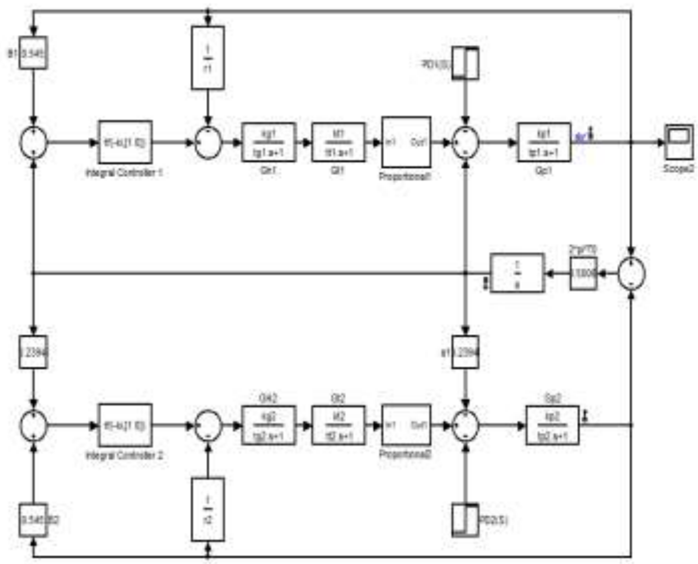

Figure 7. Block Diagram of Power System using proportional plus integral controller

Simulation Result:

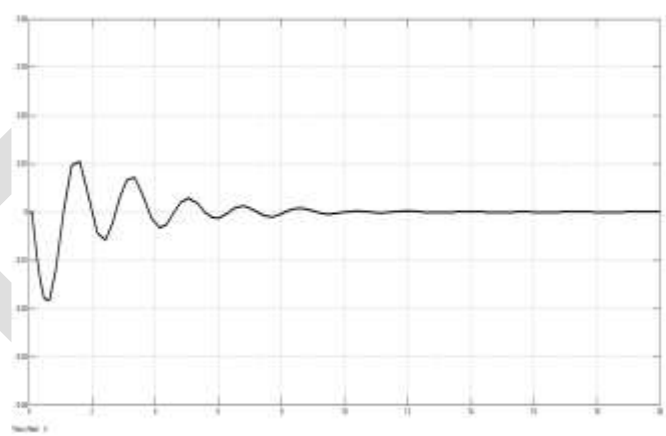

Fig 6.1. Response of Power System (prop. & integral in forward path)

INTEGRAL PLUS DERIVATIVE CONTROLLER

Here the two controllers together, i.e. integral plus derivative are used in forward path to arrive at appropriate control configurations which yields best response. The block diagram of the configuration is shown below:

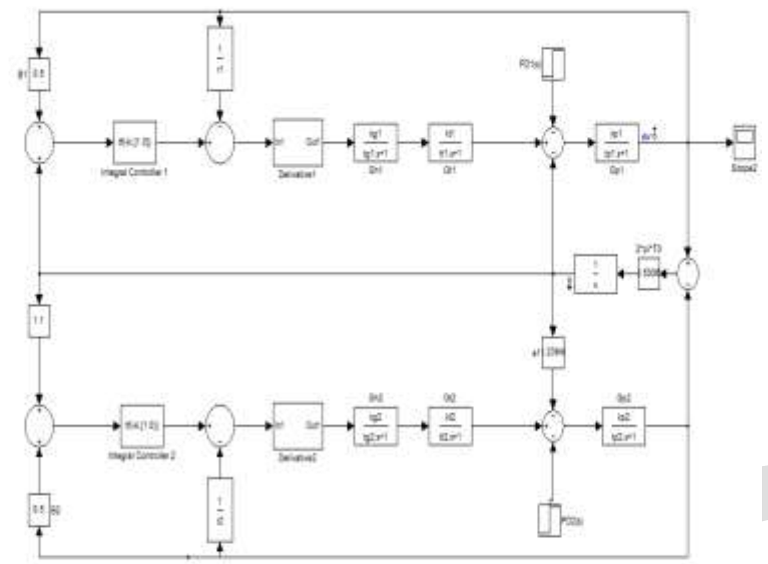

Figure 8. Block Diagram of Power System using integral plus derivative controller

Simulation Result:

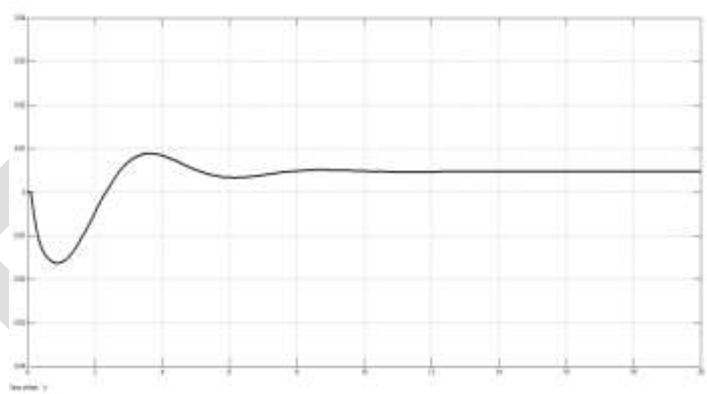

Figure 8.1 Response of Power System (integral & derivative in forward path)

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P.I.D (PROPORTIONAL PLUS INTEGRAL PLUS DERIVATIVE) CONTROL

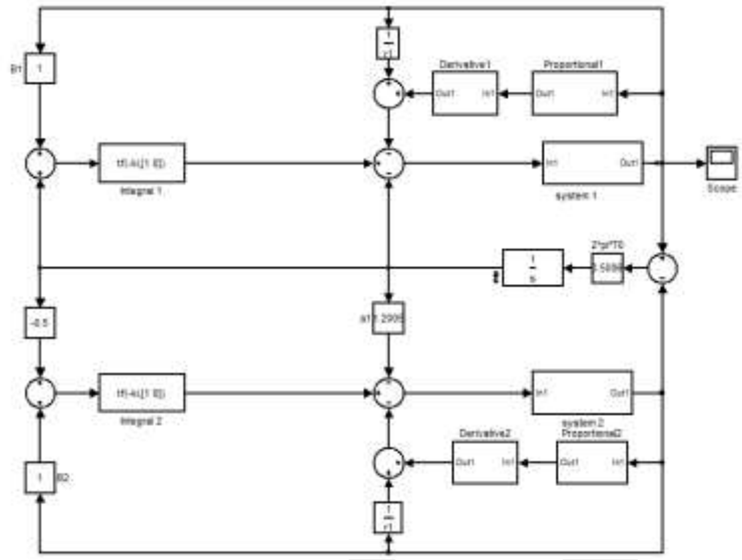

Figure 9. Block Diagram of Power System using proportional plus integral plus derivative controller

Simulation Result:

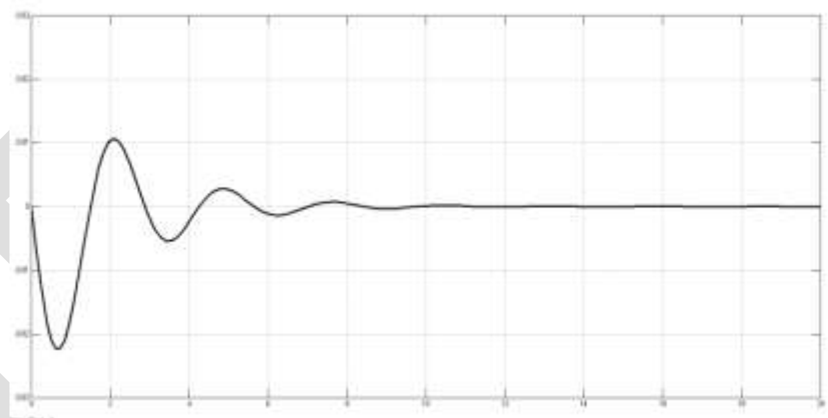

Figure 9.1 LFC Response of two area thermal plant with PID

CONCLUSION

This paper has been devoted to the active power and frequency control of single area thermal and hydro plant as well as two area thermal and hydro power systems. For this, proportional, conventional (integral) and derivative control configurations in various combinations are used and studied. Load frequency control of interconnected power systems when P. I. D. controller is implemented, yields low over shoot (less than 0.03 Hz), lesser transient oscillations and reduced settling time. Hence a better control of frequency and active power has been obtained during random load change.

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