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Integral based Load Frequency Control

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Abstract: ***The aim of this paper is to model, carry and analysis of Load frequency control in three area power system. Load frequency control of multi-area interconnected thermal generating areas means zeroing of the integral area control errors, so that system frequency and tie-line changes are maintained at their scheduled values. To achieve this, in this paper, Integral controller is used to determine dynamic frequency of the system using MATLAB.***
Keywords: load frequency control, dynamic analysis, integral controller.

I. INTRODUCTION

The large-scale power systems are normally composed of control areas (*i.e. multi-area*) or regions representing coherent groups of generators. The various areas are interconnected through tie-lines. The tie-lines are utilized for contractual energy exchange between areas and provide inter-area support in case of abnormal conditions. Without loss of generality we shall consider a three-area case connected by a tie line as illustrated in Fig. 2. The concepts and theory of three-area power system is also applicable to other multi-area power ststems i.e. four-area, five-area etc.
Fig. 1. Shows schematically the speed governing system of a steam turbine. The system consists of the following components:

A. Fly ball speed governor

This is the heart of the system which senses the change in speed (frequency). As the speed increases the fly balls move outwards and the point B on linkage mechanism moves downwards. The reverse happens when the speed decreases.

B. Hydraulic amplifier

It comprises a pilot valve and main piston arrangement. Low power level valve movement is converted into high power level piston valve movement. This is necessary in order to open or close the steam valve against high pressure steam.

C. Linkage mechanism

ABC is a rigid link pivoted at B and CDE is another rigid link pivoted at D. This link mechanism provides a movement to the control valve in proportion to change in speed. It also provides a feedback from the steam valve movement.

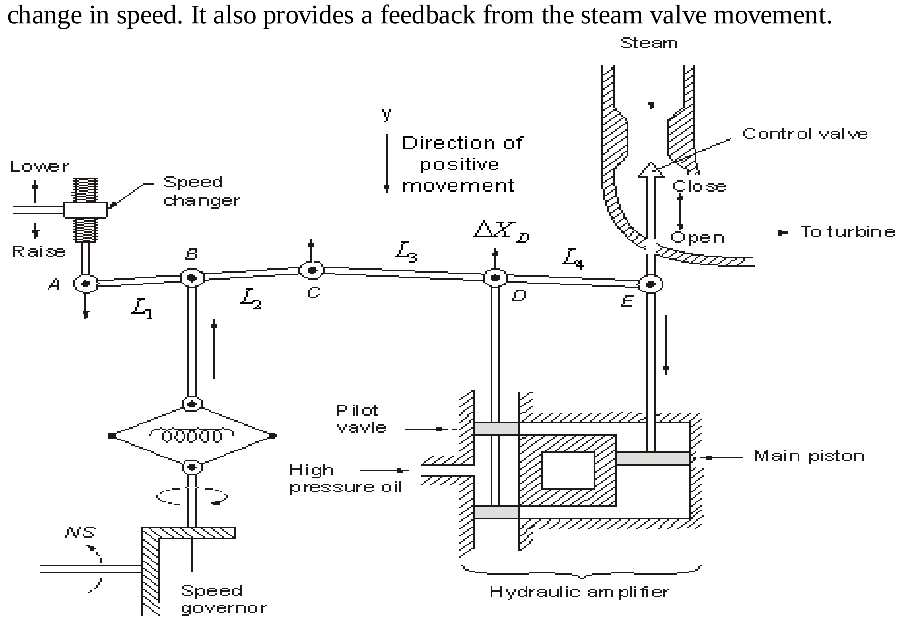

Fig. 1. Model of Turbine speed governing system

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D. Speed changer

It provides a steady state power output setting for the turbine. Its downward movement opens the upper pilot valve so that more steam is admitted to the turbine under steady conditions (hence more steady power output). The reverse happens for upward movement of speed changer.

Let the point A on the linkage mechanism be moved downwards by a small amount Δy_A. It is a command which causes the turbine power output to change and can therefore be written as

$$\Delta y_A = K_C \Delta P_C$$

Where ΔP_C is the commanded increase in power:

The command signal ΔP_C (i.e. Δy_E) sets into motion a sequence of events - The pilot valve moves upwards, high pressure oil flows on to the top of the main piston moving it downwards; the steam valve opening consequently increases, the turbine generator speed increases, i.e. the frequency goes up.

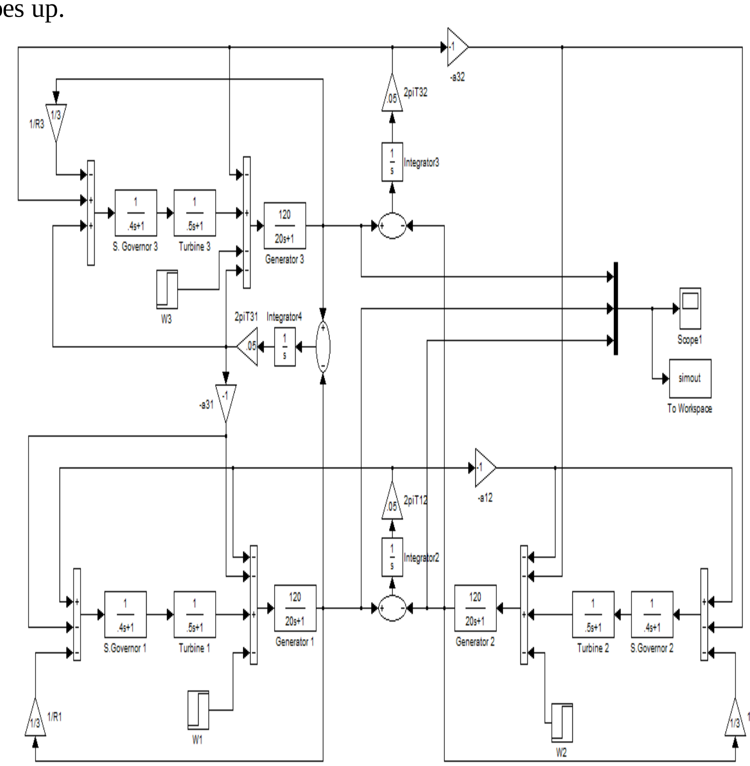

Fig.2. Block diagram of three-area load frequency control without controller

Load-frequency control (LFC) is a very important component in power system operation and control for supplying sufficient and reliable electric power with good quality. The objective of the LFC is to satisfy the following classical requirements in a multi-area interconnected power system :

1) Zero steady-state errors of tie-line exchanges and frequency deviations.
2) Optimal transient behaviour.
3) In steady state: the power generation levels should satisfy the optimal dispatch conditions.

Many investigations have been reported in the past pertaining to load frequency control of a multi-area interconnected power system. In the literature, some control strategies have been proposed based on classical linear control theory . However, because of the inherent characteristics of the changing loads, the operating point of a power system changes continuously during a daily cycle. Thus, a fixed controller may no longer be suitable in all operating conditions. There are some authors who have applied variable structure control to make the controller insensitive to system parameters change. However, this method requires information on the system states which are very difficult to know completely. The two area are connected through tie lines , if there is a disturbance in one area then other other area is also disturbed so it is necessary for the system to operate in a proper manner.

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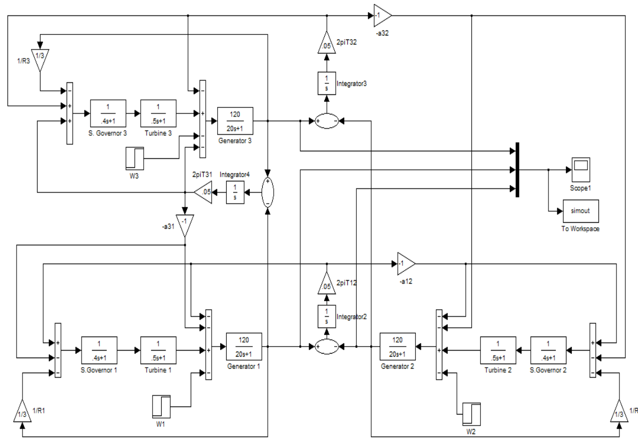

Fig.3. Simulation model without controller

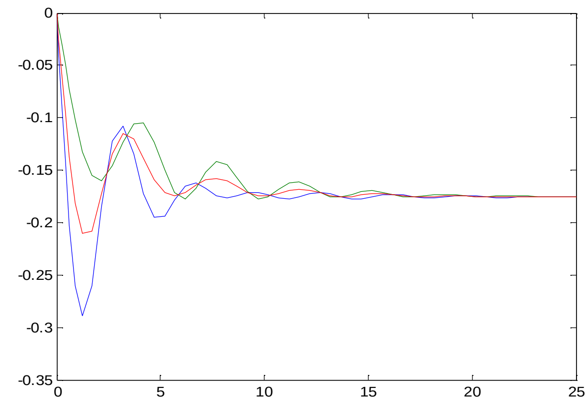

Fig.4..Dynamic response without controller

E. Block Diagram of Three-Area LFC with Integral Controller:

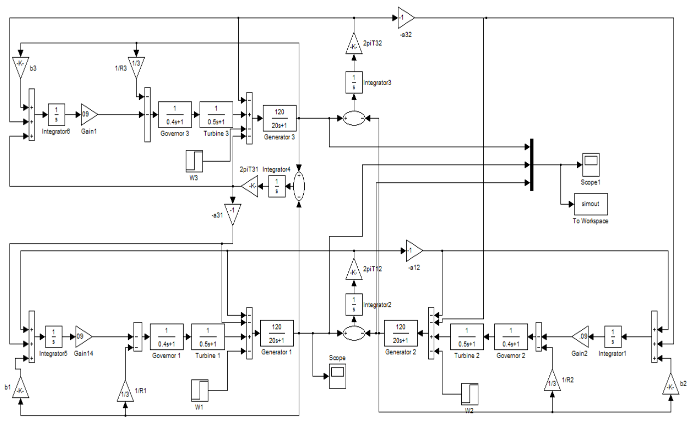

Fig.5.Simulation model with integral controller

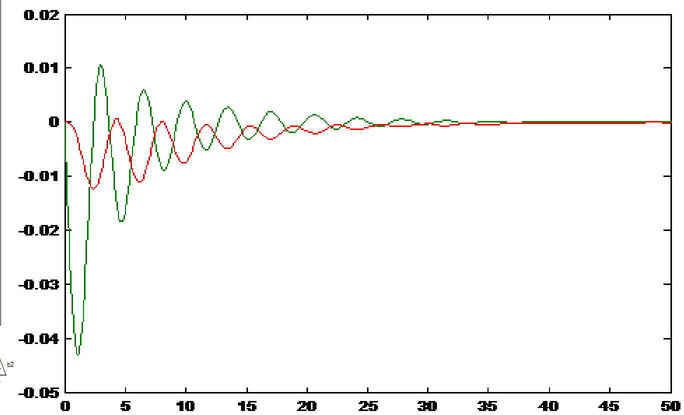

Fig.6.Dynamic response with integral controller

F. Comparison between simulation model with integral controller and without integral controller

For Δf_1	With Integral Controller	
	Simulik	Workspace
Settling Time (s)	35.0	35.0
Peak overshoots (pu)	-0.0286	-0.0416
Freq. Error Δf_{ss} (pu)	0	0

For Δf_1	Without Integral Controller	
	Simulik	Workspace
Settling Time (s)	23.5	35.0
Peak overshoots (pu)	-0.0286	-0.0286
Freq. Error Δf_{ss} (pu)	-0.0188	-0.0188

II. CONCLUSION

In this Paper we use Integral controller for Improving the stability of the system. When We compare the both System .i.e system with Integral controller or with Integral controller, we find that Integral controller remove the steady state error and reduce the Peak overshoot.

A. Nomenclature

f_i Nominal system frequency of i^{th} area. [Hz]

Δf_i Incremental frequency deviation of i^{th} area. [Hz pu]

ΔP_{Di} Incremental load demand change of i^{th} area. [pu MW]

T_{sgi} Speed governor time constant of i^{th} area [sec.]

K_{sgi} Gain of speed governor of i^{th} area

R_i Governor Speed regulation of the of i^{th} area

T_{ti} Turbine time constant of i^{th} area.

K_{ti} Gain of turbine of i^{th} area

K_{psi} Gain of power system (generator load) of i^{th} area

$$K_{psi} = \frac{1}{B}$$

T_{psi} Power system time constant of i^{th} area

$$T_{psi} = \frac{2H_i}{B_i f_i^0}$$

H_i Inertia constant of i^{th} area [MW-sec/MVA]

ΔP_{Gi} Incremental generator power output change of i^{th} area [pu MW]

K_{ii} Gain of integral controller of i^{th} area

ACE_i Area control error of i^{th} area

u_i Control input of i^{th} area

w_i Disturbance vector of i^{th} area

$\Delta P_{tie,ij}$ Incremental tie line power change of i^{th} & j^{th} area [pu MW]

B. System Data

f_i = 50 [H_Z]

P_{ri} = 2000 [MW]

P_{rj} = 2000 [MW]

T_{sgi} = 0.08 [sec.]

T_{psi} = 20 [sec.]

T_{ti} = 0.03 [sec.]

R_i = 2.4 [H_Z .pu /MW]

T_{ij} = 0.08674

a_{ij} = 1

K_{ii} = 0.671

K_{psi} = 120 [H_Z .pu /MW]

b_i = 0.425 [pu MW/H_Z]

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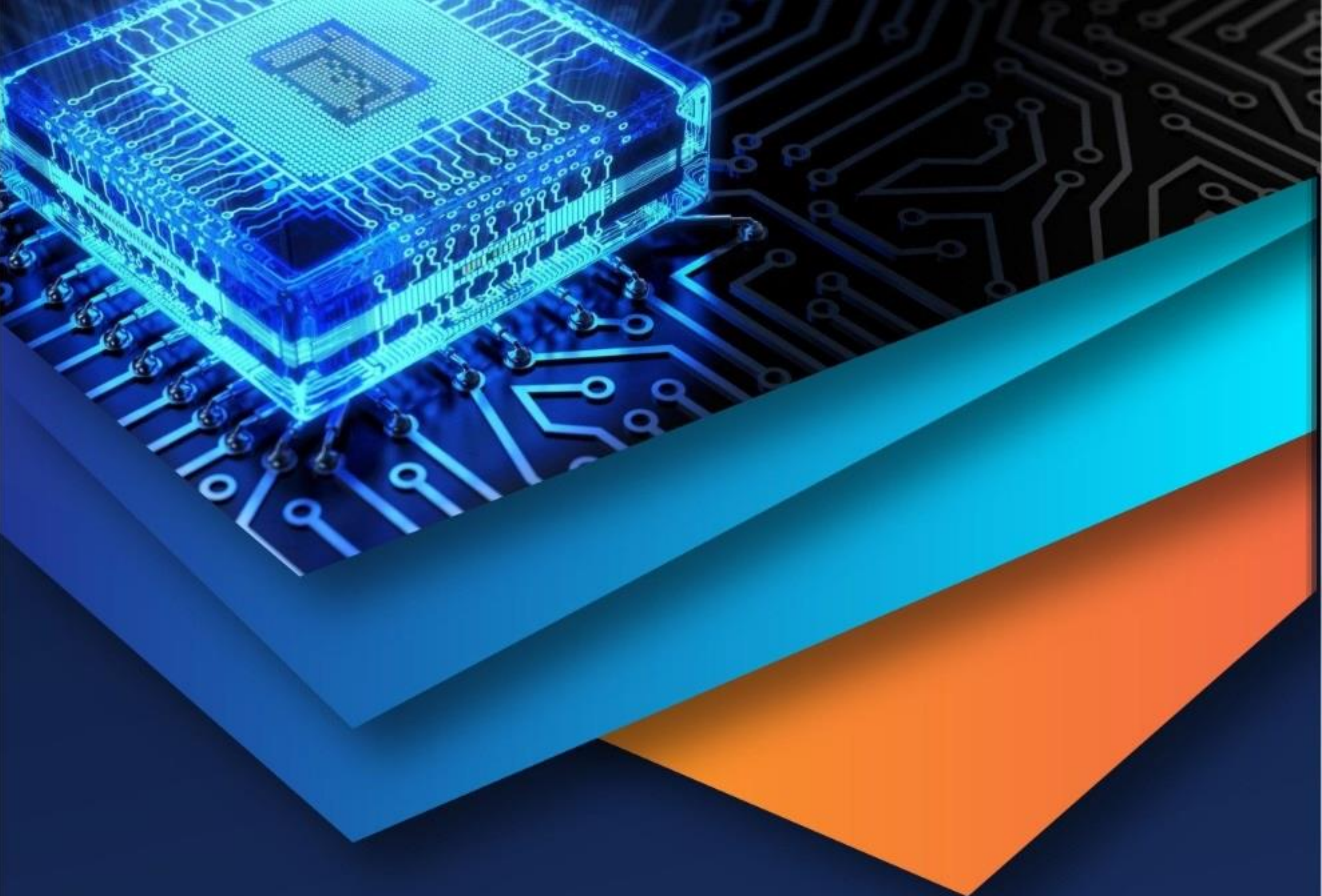

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