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Load Frequency Control in Two Area Power System

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ABSTRACT: This research project presents decentralized control scheme for Load Frequency Control in a multi-area Power System by appreciating the performance of the methods in a single area power system. A number of modern control techniques are adopted to implement a reliable stabilizing controller. A serious attempt has been undertaken aiming at investigating the load frequency control problem in a power system consisting of two power generation unit and multiple variable load units. The robustness and reliability of the various control schemes is examined through simulations.

KEYWORDS: Power System, Simulation ,Stabilizing Controller ,Investigating , Load Unit

I.INTRODUCTION

For large scale power systems which consists of inter-connected control areas, load frequency then it is important to keep the frequency and inter area tie power near to the scheduled values. The input mechanical power is used to control the frequency of the generators and the change in the frequency and tie-line power are sensed, which is a measure of the change in rotor angle. A well designed power system should be able to provide the acceptable levels of power quality by keeping the frequency and voltage magnitude within tolerable limits. Changes in the power system load affects mainly the system frequency, while the reactive power is less sensitive to changes in frequency and is mainly dependent on fluctuations of voltage magnitude. So the control of the real and reactive power in the power system is dealt separately. The load frequency control mainly deals with the control of the system frequency and real power whereas the automatic Voltage regulator loop regulates the changes in the reactive power and voltage magnitude. Load frequency control is the basis of many advanced concepts of the large scale control of the power system

Mathematical Modeling of Components used in Single area system :

- 1) Mathematical modeling of Generator
- 2) Mathematical modeling of Load
- 3) Mathematical modeling for Prime mover
- 4) Mathematical modeling for Governor

1) Mathematical Modeling of Generator

Applying the swing equation of a synchronous machine to small perturbation, we have:

$$\frac{2H}{\omega} \frac{d^2 \Delta \delta}{dt^2} = \Delta P_m - \Delta P_e$$

Or in terms of small deviation in speed

Taking Laplace Transform , we obtain

$$\frac{d\Delta \frac{\omega}{\omega_s}}{dt} = \frac{1}{2H} (\Delta P_m - \Delta P_e) \Delta \Omega(s) = \frac{1}{2Hs} [\Delta P_m(s) - \Delta P_e(s)].$$

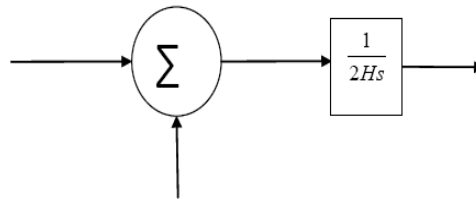


Fig (I) : Mathematical modeling block diagram for generator

2) Mathematical Modeling of Load :

The speed-load characteristic of the composite load is given by:

$$\Delta P_e = \Delta P_L + D \Delta \omega$$

Where

ΔP_L is the non-frequency- sensitive load change,

$D \Delta \omega$ is the frequency sensitive load change.

D is expressed as percent change in load by percent change in frequency.

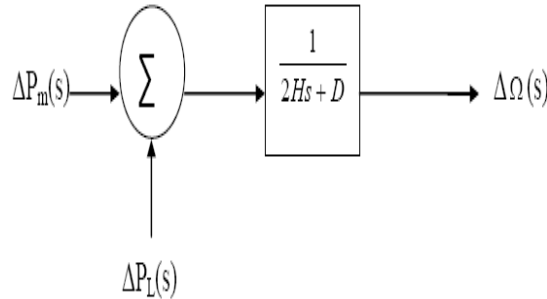


Fig (II) : Mathematical modeling Block Diagram for Load

3) Mathematical Modeling for Prime Mover:

- ❑ The source of power generation is commonly known as the prime mover. It may be hydraulic turbines at waterfalls, steam turbines whose energy comes from burning of the coal, gas and other fuels.
- ❑ The model for the turbine relates the changes in mechanical power output ΔP_m to the changes in the steam valve position ΔP_v .

$$G_T = \frac{\Delta P_m(s)}{\Delta P_v(s)} = \frac{1}{1 + \tau_T s}$$

Where T_t , the turbine constant is, in the range of **0.2 to 2.0** seconds.

4) Mathematical Modeling for Governor :

For stable operation, the governors are designed to permit the speed to drop as the load is increased.

The steady state characteristics of such governor is shown below

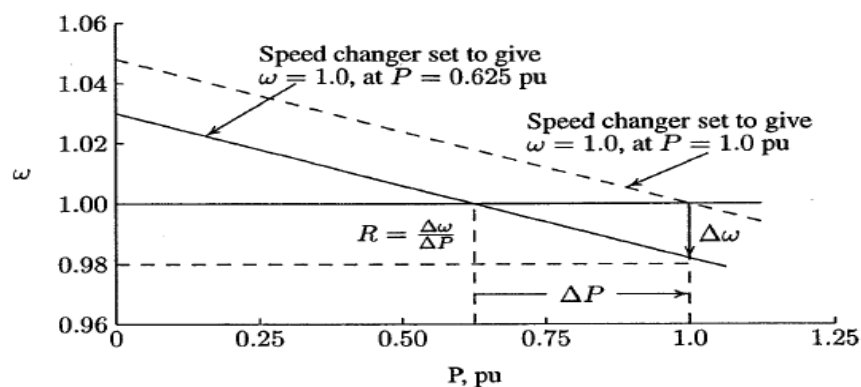


Fig (III)



The slope of the curve represents speed regulation **R**. Governors typically have a speed regulation of **5-6 %** from no load to full load.

$$\Delta P_g = \Delta P_{ref} - \frac{1}{R} \Delta f$$

Or in s- domain

$$\Delta P_g(s) = \Delta P_{ref} - \frac{1}{R} \Delta \Omega(s)$$

The command ΔP_g is transformed through hydraulic amplifier to the steam valve position command ΔP_V . We assume a linear relationship and consider simple time constant T_g we have the following s-domain relation:

$$\Delta P_V(s) = \frac{1}{1 + \tau_g s} \Delta P_g(s)$$

Combining all the block diagrams from earlier block diagrams for a single area system we get the following:

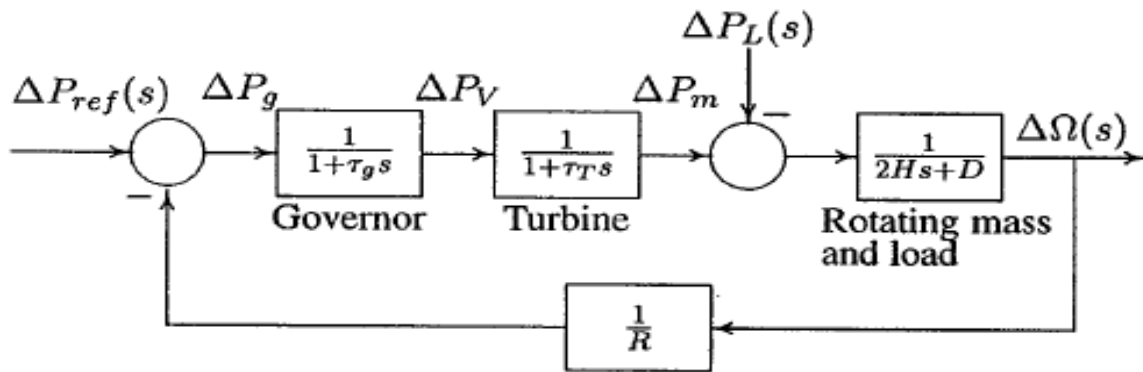


Fig (IV)

Mathematical Modeling of Block Diagram of single system consisting of Generator, Load, Prime Mover and Governor.

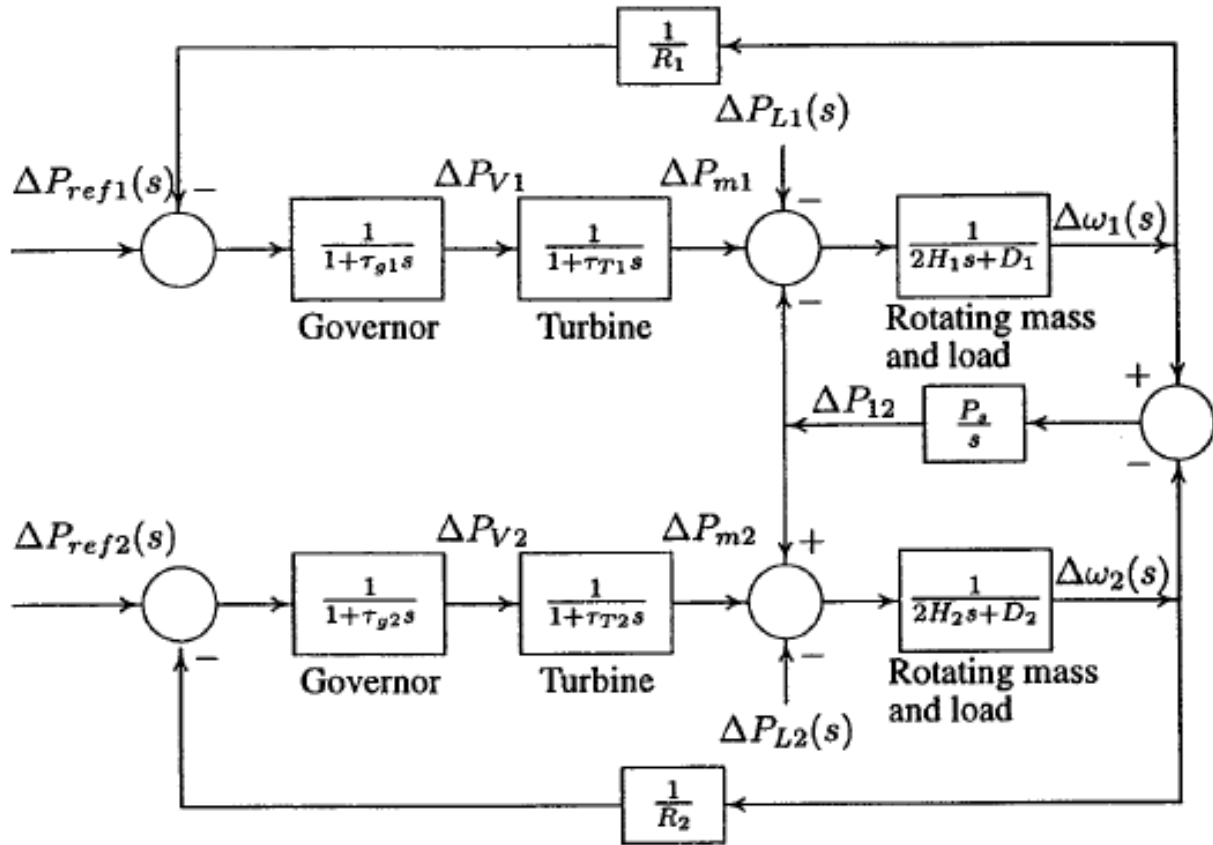


Fig (V): Mathematical Modeling of Block Diagram of single system consisting of Generator, Load, Prime Mover and Governor.

For a two area system, during normal operation the real power transferred over the tie line is given by –

$$P_{12} = (|E_1||E_2|\sin\delta_{12}) / X_{12}$$

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

For a small deviation in the tie-line flow

$$\begin{aligned} \Delta P_{12} &= (dP_{12}/d\delta_{12})_{\delta_{12}} \Delta \delta_{12} \\ &= P_s \Delta \delta_{12} \end{aligned}$$

The tie-line power deviation then takes on the form,

$$\Delta P_{12} = P_s (\Delta \delta_1 - \Delta \delta_2)$$

II.SIMULATION DIAGRAM

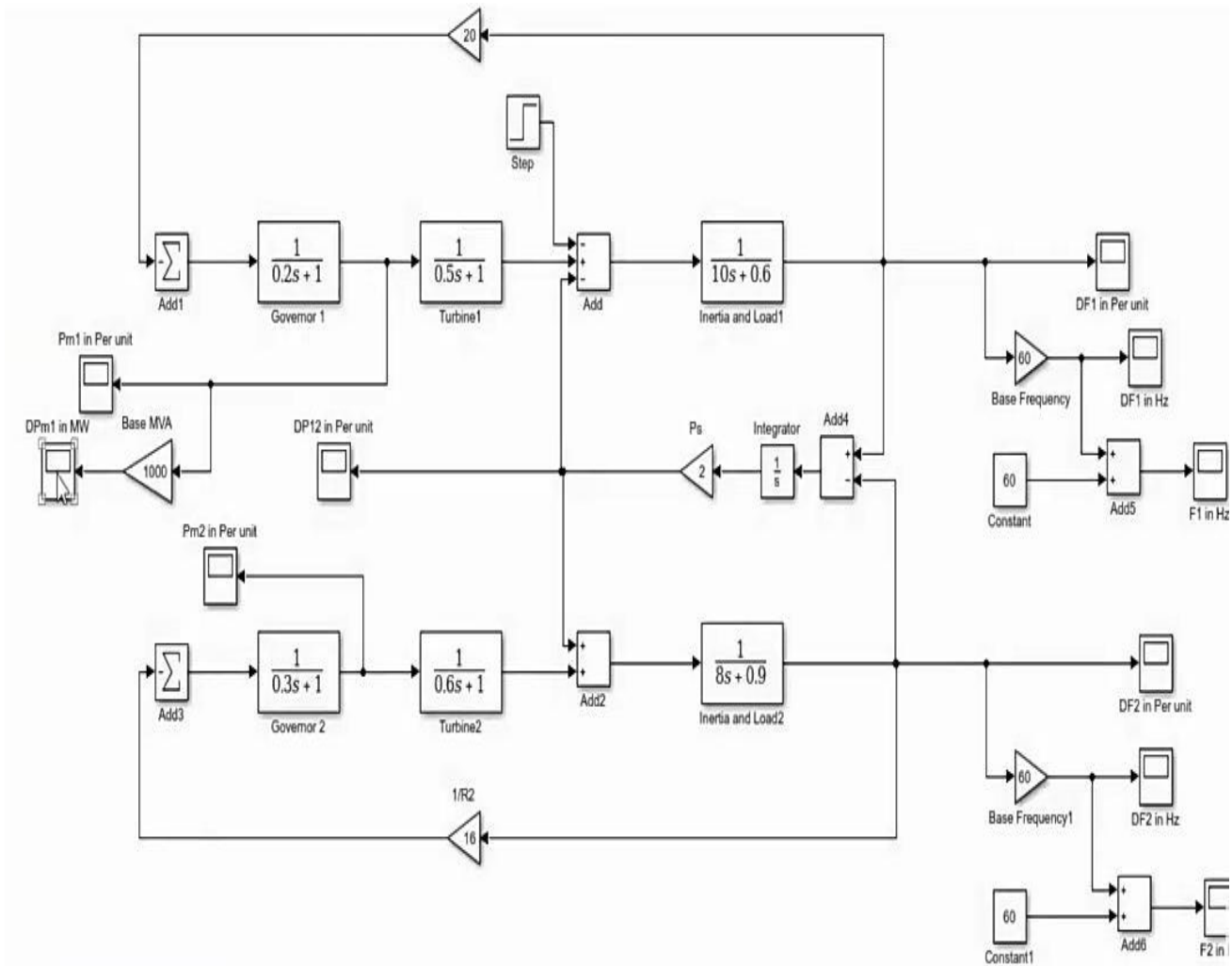
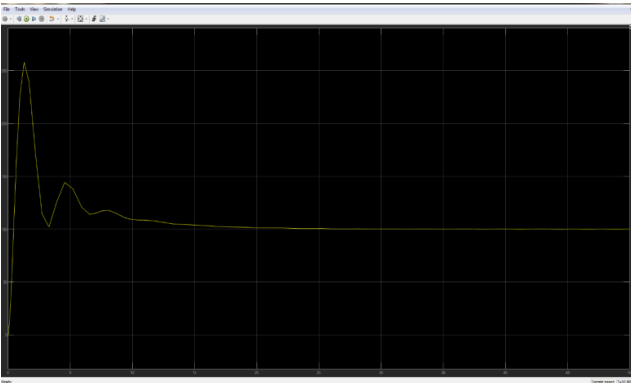


Fig (VI) : Simulation Digram

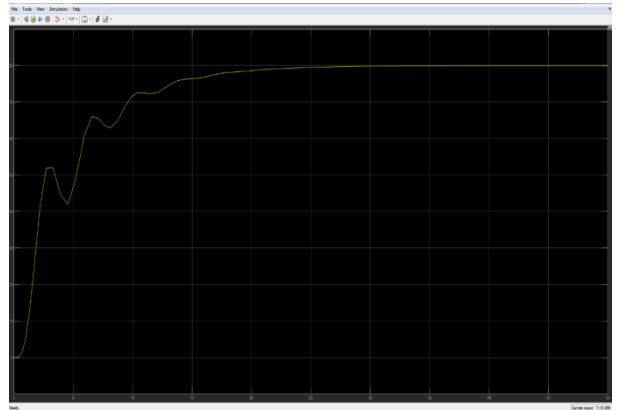


III.RESULTS

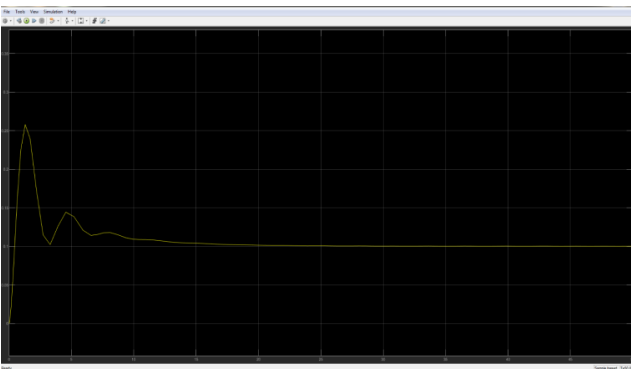


Change in mechanical power for area 1 (MW)

$$\Delta P_{m1}=100\text{MW}\Delta P_{m2}=80\text{MW}$$

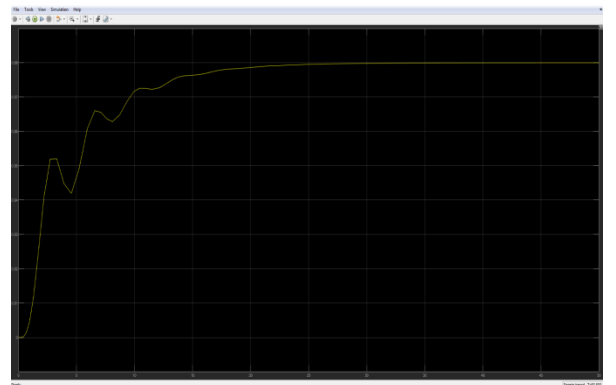


Change in mechanical power for area 2(MW)

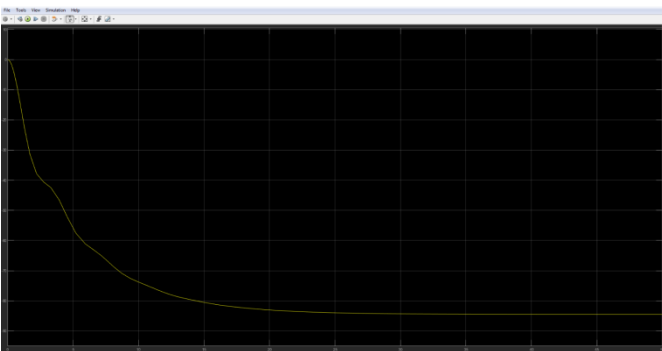


Change in mechanical power in per unit for area 1

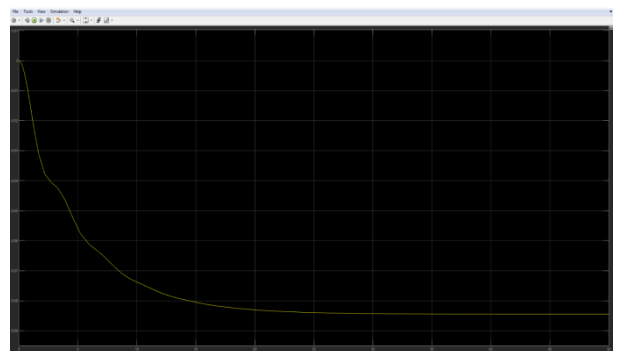
$$\Delta P_{m1}=0.1\text{pu}\Delta P_{m2}=0.08\text{pu}$$



Change in mechanical power in per unit for area 2

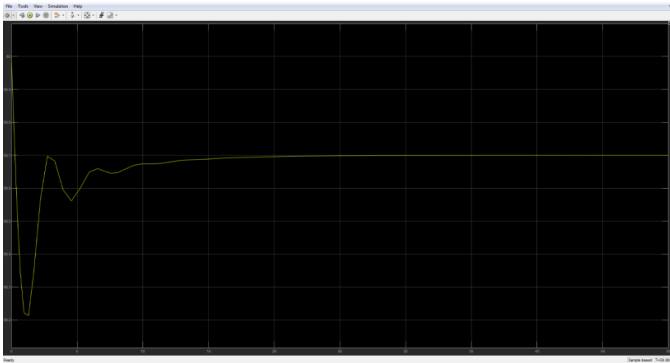


Change in tie line power (MW)



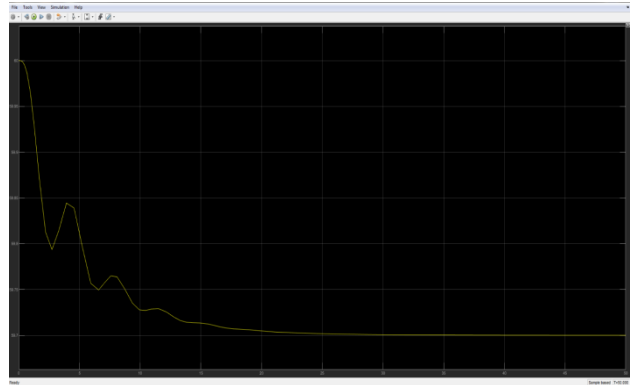
Change in tie line power in (P.u)

$$\Delta P_{12} = -84.5 \text{ MW} \quad \Delta P_{12} = -0.0845 \text{ pu}$$

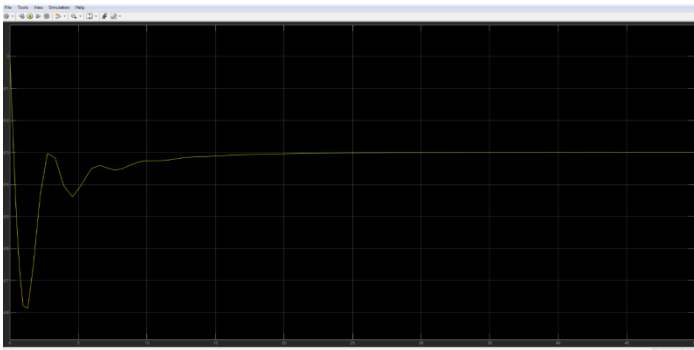


Actual load frequency in area 1(Hz)

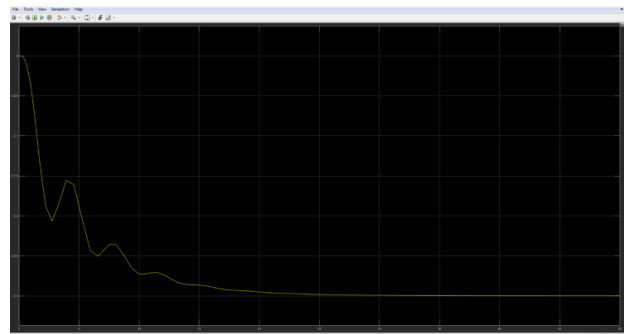
Frequency=59.7 Hz



Actual load frequency in area 2(Hz)



Frequency deviation in Hz of area 1



Frequency deviation in Hz of area 2

Deviation in frequency=0.3

Thus we verified the results of simulink model with mathematical solution.

IV.CONCLUSION

- We noted that Load of 187.5 MW is changed in Area 1 power system. However, from the results, it has been observed that both generators have enhanced their generation to meet the increased load demand.
- Practically this is not true. In the real practice, if sudden load is changed in any area, then each area has to absorb its own changes or in other words, it has to be supplied by the generator of that area only.
- It means that for a load change of 187.5 MW, the change in mechanical power of area 1 should be increased to 187.5 MW only. Whereas, the change in mechanical power of area 2 must remain zero.
- Furthermore, change in tie line power should also remain zero. To do this, we need to do some changes in the model in such a way that change of load in any area may cause the change of generation in that area only.
- Furthermore, it may be noted that frequency of the system has reached up to 59.7 Hz. It has not recovered to 60 Hz. Due to which despite of 187.5 MW change in load, only 180 MW of load has been supplied by both generators.
- It still lacks 7.5 MW. When frequency will recover to 60 Hz, both generators will be able to supply the whole



187.5 MW. It means that we need to use some controlling techniques in order to bring the frequency to its nominal value of 60 Hz.

- Moreover, it may be noted that change in mechanical power of generator 2 is 80 MW. It means that 80 MW of power is supplied from area 2 to area 1 through tie line. However, the simulation results have shown that the tie line power flow is 84.5 MW.
- Now, question may arise that how it is possible? The answer to this question is that 80 MW is supplied from Area 2, whereas 4.5 MW of power is reduced in area 2 due to frequency drop. It is because frequency stays at 59.7 Hz.
- This reduction in frequency causes the reduction in load, due to which this additional power of 4.5 MW also flows towards Area 1. Therefore, overall 84.5 MW of power flows from tie line.

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