AJAY KUMAR GARG ENGINEERING COLLEGE, GHAZIABAD

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

SESSIONAL TEST - 2
MODEL SOLUTION

COURSE:- B.Tech — Semester :- VII

Session:- 2017-18 — Section: EN-1, 2

Subject:- PSOC — SUB Code:- NEN-031

Section-A

QA. 1 why load Prediction is important ~~is necessary~~ in Power System.

Ans:- The operation and planning of a power utility company requires an adequate model for electric power load forecasting. Load forecasting plays a key role in helping an electric utility to make important decisions on power, load switching, voltage control, network configuration and infrastucture development.

2. What do you understand by penalty factor of economically operating power system!

Ans:- For optimal generation scheduling, equality constraint of meeting ~~to~~ the load demand with the transmission losses

$$\frac{\frac{dC_i}{dP_{Gi}}}{\left(1-\frac{dP_L}{dP_{Gi}}\right)} = \lambda \quad \text{or } (IC)_i\, L_i = \lambda$$

wher $L_i = 1\Big/\left(1-\frac{dP_L}{dP_{Gi}}\right)$ is called the penalty factor of the ith plant.

Thus, optimum generation allocation considering losses is obtained by operating all generators such as $IC_i \times L_i = \lambda$ For every generator.

3. Explain the advantage of PI controller in frequency Control.

Ans:- $$\Delta f \Big|_{\text{Steady state}} = \lim_{s \to 0} s\,\Delta F(s) = 0$$

Steady state change in frequency has been reduced to zero by addition of the integral controller

4. What do you mean by Free governor operation of a generator.

Ans:- When in situation in which the speed changer has a fixed setting (i.e $\Delta P_c = 0$) and the load demand changes. This is known as free governor operation.

5. What do you understand by droop characteristic of load Frequency Control?

Ans:- The drop or slop of this relationship is $-\left(\frac{1}{B+(1/R)}\right)$. Where power system parameter B is generally much smaller than $1/R$, so B is neglected in comparison; So, $\Delta f = -R(\Delta P_D)$, the droop of the load frequency curve is mainly determined by R, the speed governor regulation.

Section B

QB.(6) what is unit Commitment Problem? Discuss Constraints in unit Commitment.

Ans:- To determine which units of a plant that should operate for a particular load is the main Problem of unit Commitment. This problem is of importance for thermal plants as for other types of generation such as hydro, the operating cost and start-up times are negligible so that their on-off status is not important.

Constraints Are

(1) ~~Equality Const.~~

(1) Spinning Reserve:- is the extra generating Capacity that is available by increasing the Power output of generator that are already Connected to the power system. The generating Capacity available to the system operation within a short interval of time to meet demand in case generator goes down or there is another disruption ~~to~~ the supply.

(2) Thermal unit Constraints:-

(a) Minimum up time:- Once the unit is running, it should not be turned off immediatly.

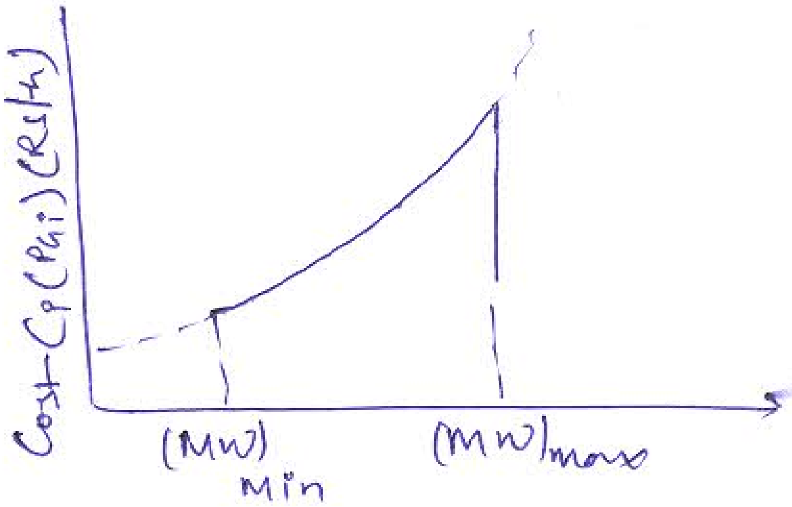
(b) Minimum Down time:- One the unit is decommited there is a minimum time before it can be recommitted.

(iii) Crew Constraints :- If a plat consists of two or more units, they can not both be turned on at the same time since there are not enough crew members to attend bot unit while starting up.

(iv) Fuel Constraints.

(7) Explain i/p - output chr of thermal and hydro power plant.

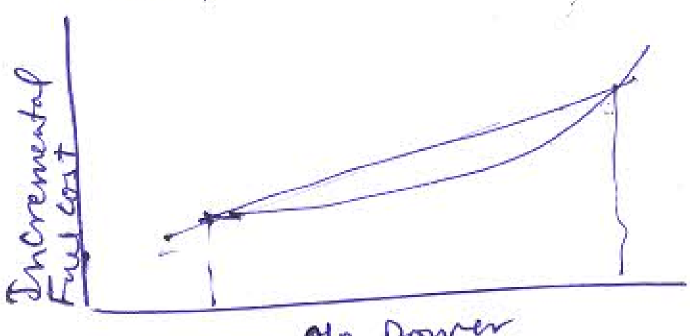
Ans: (a) Thermal i/p - output curve



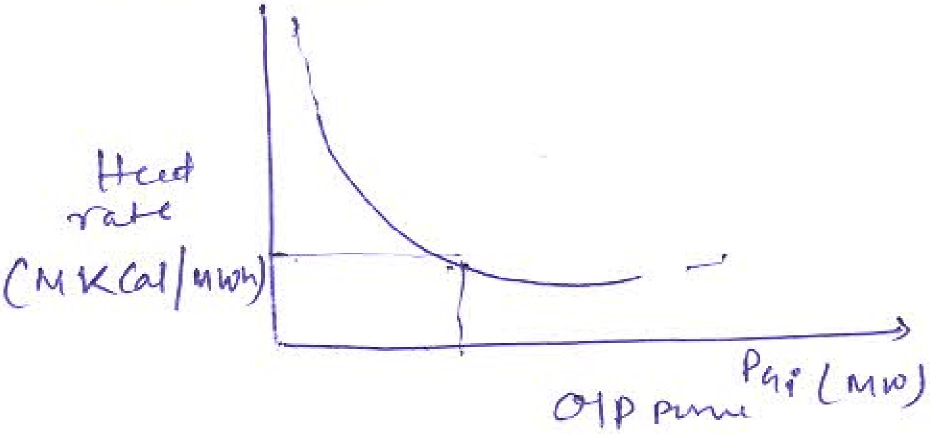
(b) Increment Fuel Cost

$$C_i(P_{Gi}) = Ka_i + Kb_i\, P_{Gi} + Kc_i\, P_{Gi}^2$$

$$\frac{dC_i}{dP_{Gi}} = Kb_i + 2\,Kc_i\, P_{Gi}$$

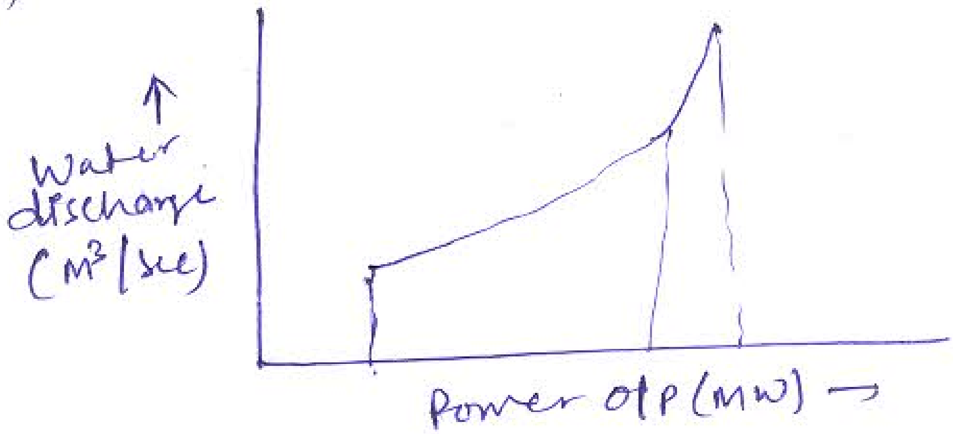


(c) <u>Heat-rate curve</u>

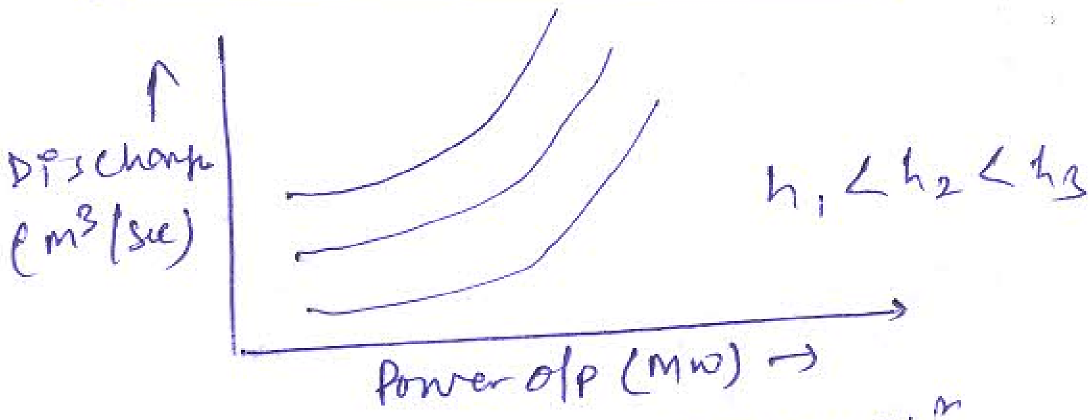


(2) <u>Ch^r of Hydro plants</u>

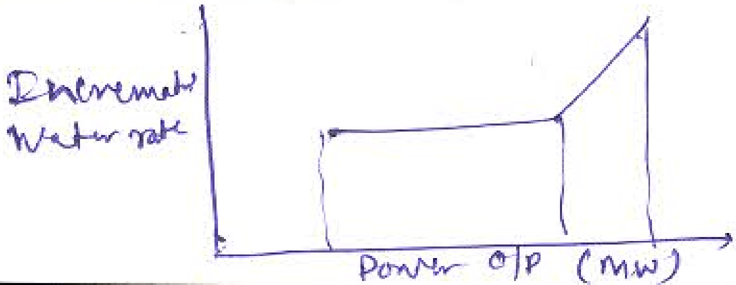
(a)



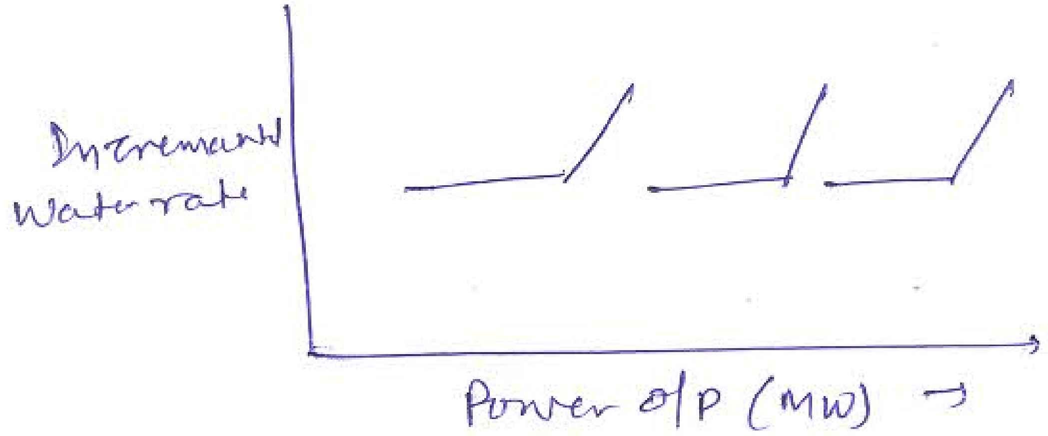
(b) <u>Effect of head on discharge</u>



(c) <u>Incremental water rate Ch^r</u>

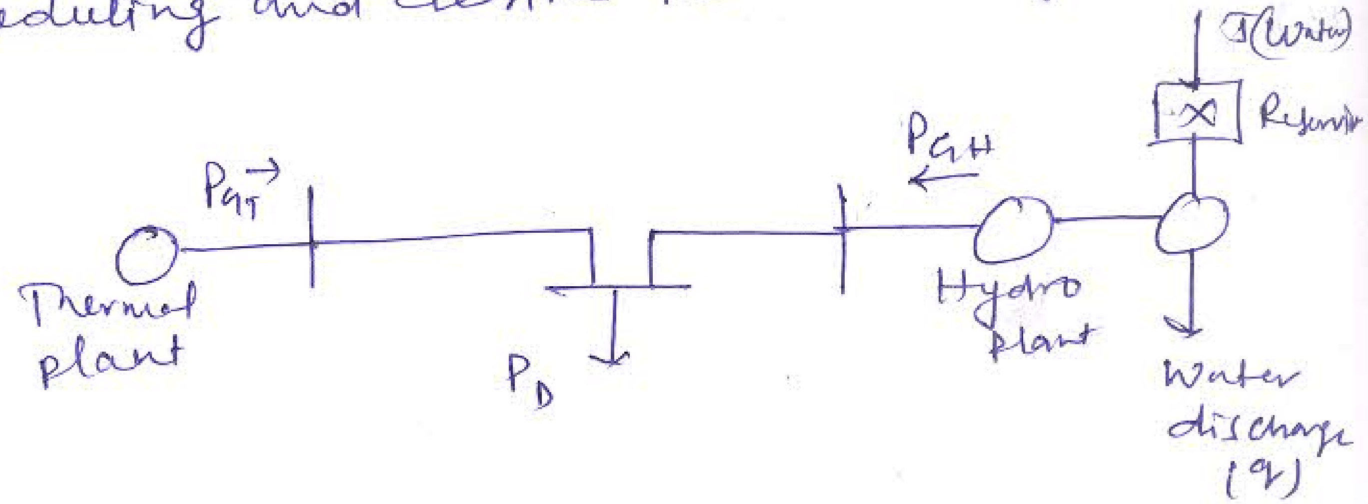


(d) Multiple unit operation incremental water-rate chr



(8). Explain the hydro-thermal economic load Scheduling and derive the necessary equations.

Ans:



operation of a system having both hydro and thermal plant is, however, far more complex as hydro plant have negligible operating cost, but are required to operate under constraints of the water available for hydro generation in a given period of time.

The problem is to determine $q(t)$, the water discharge (rate) so as to minimize the cost of thermal generation.

$$C_T = \int_0^T C'(P_{GT}(t))\, dt$$

Under the Following Constraints:

1. Meeting the load demand

$$P_{G_T}(t) + P_{G_H}(t) - P_L(t) - P_D(t) = 0$$

(2) water availability

$$X'(T) - X'(0) - \int_0^T J(t)\,dt + \int_0^T q(t)\,dt = 0$$

(3) Hydro generation $P_{G_H}(t)$, is a function of hydro discharge and water storage

$$P_{G_H}(t) = f\,(x'(t),\ q(t))$$

The Problem Can be handled conveniently by discritization

$$\min_{q^m (m=1,2,--M)} \Delta T \sum_{m=1}^{M} C'(P_{G_T}^m) = \min_{q^m (m=1,2,--M)} \sum_{m=1}^{M} C(P_{G_T}^m)$$

Under the Following Constraint

1. Power balance eq^n

$$P_{G_T}^m + P_{G_H}^m - P_L^m - P_D^m = 0$$

2. Water Continuity equation

$$X'^m - X'^{(m-1)} - J^m \Delta T + q^m \Delta T = 0$$

3. Hydro generation in any Subinterval Can be expressed as

$$P_{G_H}^m = h_0 \{1 + 0.5e(X^m + X^{m-1})\} (q^m - \rho)$$

$h_0 = 9.81 \times 10^{-3} h_0'$

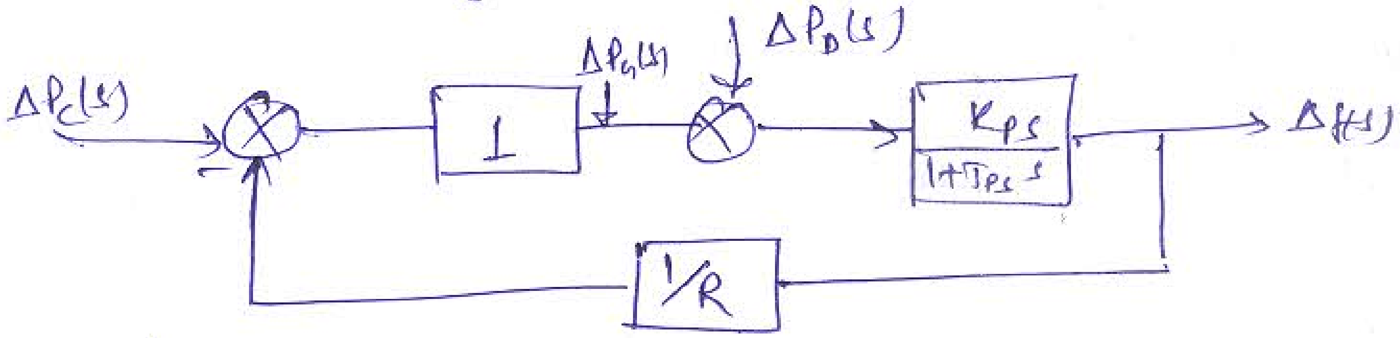
(9) Discuss Dynamic response for an isolated Power System.

Ans: To obtain dynamic response giving the change in freq^n as function of time for a step change in load.

The ch^r equation being of third order, dynamic response can only be obtain for a specific case. However, the ch^r equation can be approximated as first order by examining the relative magnitudes of the time constants involved.

Typical values of the time constants of load freq^n control system are

$$T_{sg} < T_t << T_{ps}$$



$$F(s)\Big|_{\Delta P_C(s)=0} = -\frac{K_{ps}}{(1+K_{ps}/R)+T_{ps}s} \times \frac{\Delta P_D}{s}$$

$$= -\frac{K_{ps}/T_{ps}}{s\left[s+\frac{R+K_{ps}}{RT_{ps}}\right]} \times \Delta P_D$$

$$\Delta f(t) = -\frac{R K_{ps}}{R + K_{ps}} \left\{ 1 - \exp\left[\frac{-t}{T_{ps}} \left(\frac{R}{R + K_{ps}} \right) \right] \right\} \Delta P_D$$

$$\Delta f \Big|_{\text{Steady State}} = -0.029 \text{ Hz}$$

When taking $R = 3$, $K_{ps} = 1/B = 100$, $T_{ps} = 20$,

$\Delta P_D = 0.01$ p.u.

Q 10. A 500 MW Generator is operating to a load of 20 MW. A load change of 1% cause the Frequency to change by 1%. If the system Frequency is 50 Hz, determine the value of ~~va~~ load damping Factor in per units.

Soln

$$D = \frac{\partial P_D^0}{\partial f} = \frac{\cancel{1\% \text{ of } 500}}{1\% \text{ of } 50} = \frac{\cancel{5\,0}}{\cancel{.5}} = \cancel{10 \text{ MW/Hz}}$$

$$= \cancel{10}$$

$$= \frac{1\% \text{ of } 20}{1\% \text{ of } 50} = \frac{.2}{.5} = .4 \text{ MW/Hz}$$

$$B = \left(\frac{\partial P_D}{\partial f} \right) / P_r = \frac{.4}{500} = .0008 \text{ PU MW/Hz}$$

Ans.

Section - C

Q 11 Draw a ~~Define~~ Complete block Diagram of load freqⁿ Control of isolated Power System.

Ans:- Block, Speed governor

① change in reference power setting ΔP_{ref}
② change in speed of the generator Δf as measured by ΔX_B

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

So, taking Laplace transform

$$\Delta P_g(s) = \Delta P_{ref}(s) - \Delta f(s)/R$$

Hydraulic valve Actuator

The o/p of the hydraulic actuator is ΔP_V. This depends on the position of main piston. which in turn depends on the quality of oil flow in the piston

$$\Delta P_V = K_H . \int \Delta X_D dt$$

or link move downward resulting the change ΔX_D as negative

$$\Delta X_D = \Delta P_g - \Delta P_V$$

taking laplace

$$\Delta P_V(s) = K_H \Delta X_D(s)/s$$

$$\Delta X_D(s) = \Delta P_g(s) - \Delta P_V(s)$$

Turbine-generator:

Let the change in turbine power be ΔP_T and the corresponding change in generator power be ΔP_G.

$$\text{Accelerating Power} = \Delta P_T - \Delta P_G$$

$$\text{Laplace} = \Delta P_T(s) - \Delta P_G(s)$$

The turbine incremental power ΔP_T depends entirely upon the valve power increment ΔP_V and the chr of the turbine.

Taking transfer function with singe time const for the turbine

$$\Delta P_T(s) = G_T \cdot \Delta P_V(s) = \Delta P_V(s) \times \frac{1}{1+sT_T}$$

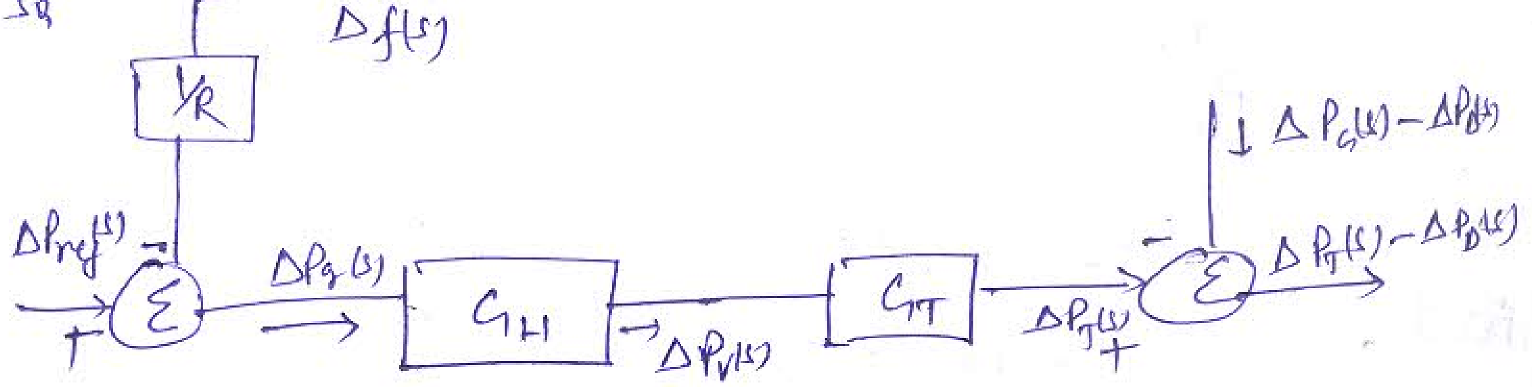
and. $\Delta P_G = \Delta P_D$ —— (I)

i.e $\Delta P_G(s) = \Delta P_D(s)$.

$$\text{Accelerating Power} = \Delta P_T(s) - \Delta P_G(s) \quad \text{—— (II)}$$

So. $\Delta P_T(s) = G_T \Delta P_V(s) = \Delta P_V(s) \times \frac{1}{1+sT}$.

So



Q12 A Two bus system is shown in figure. If 100 MW is transmitted from plant 1 to the load, a transmission loss of 10 MW is incurred. Find the required generation for each plant and the power received by the load when the λ is Rs 25/MWh.

Also consider the system with a load of 237.04 MW at bus 2. Find the optimum load distribution between the two plant (1) when losses are included but not coordinated and (2) when losses are coordinated. Also find the savings in rupees per hour when losses are Co-ordinated.

$$\frac{dC_1}{dP_{G_1}} = 0.02 P_{G_1} + 16 \quad Rs/MWh$$

$$\frac{dC_2}{dP_{G_2}} = 0.04 P_{G_2} + 20 \quad Rs/MWh$$

Soln :- Since the load is at bus '2' alone, P_2 will not have any effect on P_L. therefore

$$B_{22} = 0 \text{ and } B_{12} = 0 = B_{21}$$

$$P_L = B_{11} P_1^2$$

$$P_{D_1} = 0, \quad P_{G_1} = P_1$$

$$P_{G_1} = 100\,MW, \quad P_L = 10\,MW$$

$$10 = B_{11}(100)^2 \text{ or } B_{11} = 0.001\,(MW)^{-1}$$

For plant 1

or $$0.002 P_{G_1} + 16 = \lambda(1 - dP_L/dP_1)$$

$$= \lambda(1 - 2B_{11}P_1) = \lambda(1 - 2B_{11}P_{G_1})$$

and For plant '2' becomes

$$0.04 P_{G2} + 20 = \lambda(1 - dP_L/dP_2)$$

$$\lambda(1-0) = \lambda$$

Substituting the value of B_{11} and $\lambda = 25$ we get

$$P_{G1} = 128.57 \text{ MW}$$

$$P_{G2} = 125.00 \text{ MW}$$

transmission loss.

$$P_L = B_{11} P_1^2 = 0.001 \times (128.57)^2$$

$$= 16.53 \text{ MW}$$

$$P_{D2} = P_{G1} + P_{G2} - P_L = 128.57 + 125 - 16.53$$

$$= 237.04 \text{ MW}$$

if the transmission loss is not co-ordinated

$$0.02 P_{G1} + 16 = 0.04 P_{G2} + 20 \quad \text{(I)}$$

$$P_{G1} + P_{G2} = 0.001 P_1^2 + 237.04$$

$$= 0.001 P_{G1}^2 + 237.04 \quad \text{(II)}$$

Solving eqn (I) & eqn (II)

$P_{G1} = 275.18$ MW and $P_{G2} = 37.59$ MW

also when loss co-ordinated.

$P_{G1} = 128.57$ MW, $P_{G2} = 125$ MW

loss co-ordinated causes the load on plant 1, to reduce from 275.18 MW to 128.57 MW. therefore saving of Fuel Cost at plat 1, due to loss co-ordination

$$\int_{128.57}^{275.18} (0.02 P_{G_1} + 16)\, dP_{G_1} = 0.01 P_{G_1}^2 + 16 P_{G_1} \Big|_{128.57}^{275.18}$$

$$= \text{Rs } 2{,}937.69/h$$

at plant 2, the load increased from 37.59 MW to 125 MW due to loss coordinated

$$\int_{125}^{37.59} (0.04 P_{G_2} + 20)\, dP_{G_2} = 0.02 P_{G_2}^2 + 20 P_{G_2} \Big|_{125}^{37.59}$$

$$= -2{,}032.43/h$$

Saving $\quad 2{,}937.69 - 2{,}032.43$

$= \underline{905.26/h}$ Ans: