Load Freq. Control.

* Turbine Speed governing System

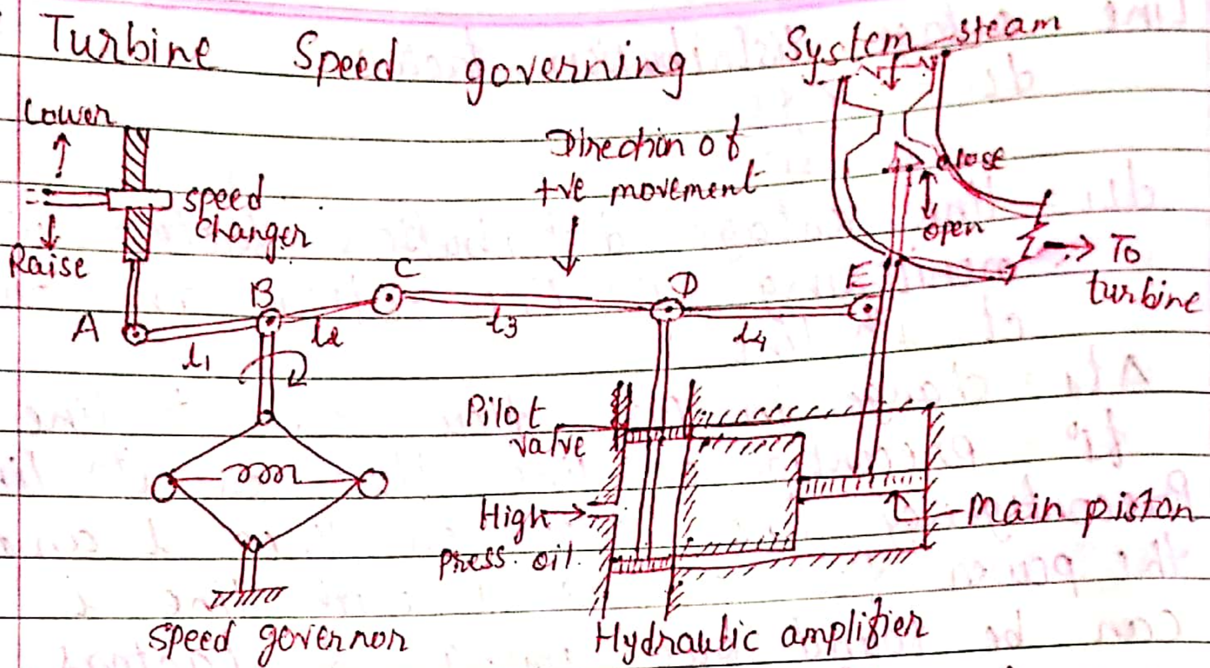


Fig shows schematically the speed governing sys. of a steam turbine. The sys. consists of the following components.

1) Fly ball speed governor:
This is the heart of the sys. which senses the change in speed. As the speed increases flyball move outwards and the point B on linkage mechanism moves downwards. The reverse happens when speed decreases.

2) Hydraulic amplifier -
It comprises a pilot valve and main piston arrangement. Low power level pilot 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.

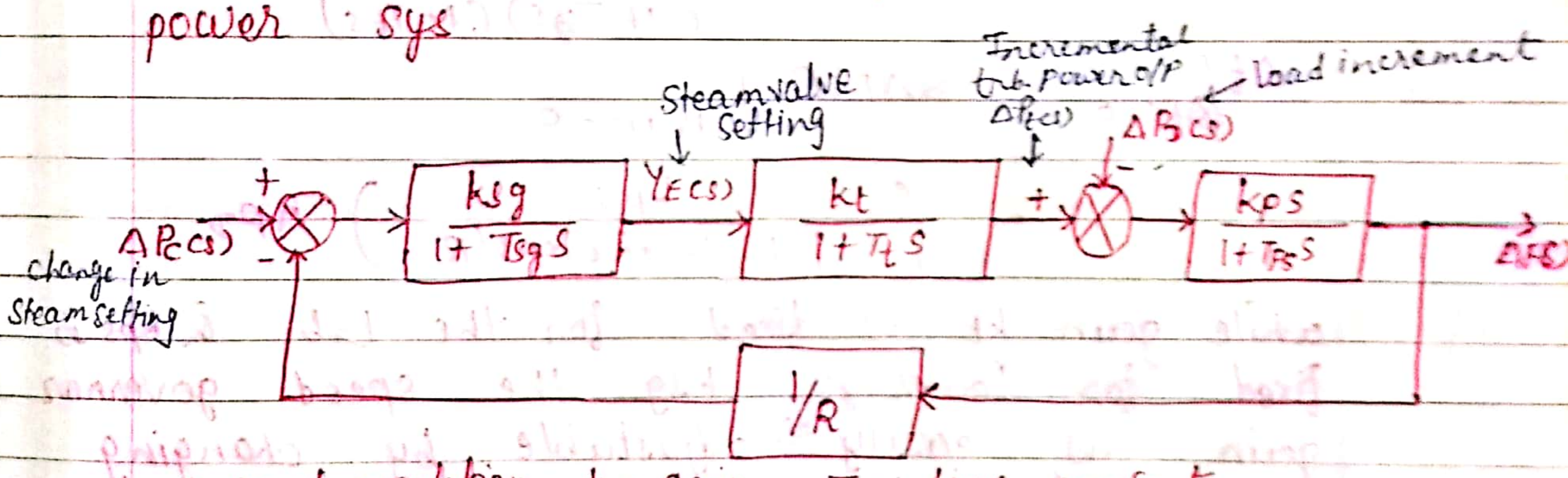
3) linkage mechanism:
ABC is a rigid link pivoted at B and CDE is another rigid link pivoted at D.

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 (link 4)

4) Speed changer:

It provides a steady state power o/p 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

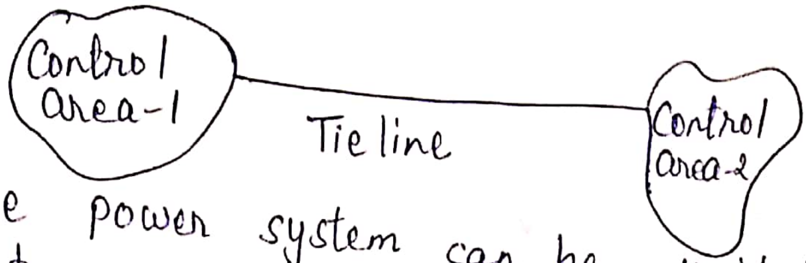
* Block dia of Load freq control of isolated power sys



R = Speed regulation, k = gain, T = time constant

A complete block diagram representation of an isolated power sys comprising t.b. gen, governor and load is easily obtained by combining the block diagram of individual component. The complete block dia with feedback loop is shown in fig.

area load freq. control



- A large power system can be divided into a no. of load freq. control areas interconnected by means of tie lines
- The control objective is to regulate the freq of each area to simultaneously regulate the tie line power
- It is assumed that each control area can be represented by an equivalent trb, gen & governor
- Power X'fer from area 1 is given by

$$P_{tie_1} = \frac{|V_1||V_2|}{X_{12}} \sin(\delta_1 - \delta_2) \quad (\delta_1, \delta_2 \text{ is power angles})$$

- For incremental changes in δ_1 and δ_2

$$\frac{\Delta P}{\Delta \delta} = \frac{|V_1||V_2|}{X_{12}} \cos(\delta_1 - \delta_2)$$

Hence, $\Delta P_{tie_1} = \frac{|V_1||V_2|}{X_{12}} \cos(\delta_1 - \delta_2)(\Delta\delta_1 - \Delta\delta_2)$

Now, per unit value of $\Delta P_{tie_1} = T_{12}(\Delta\delta_1 - \Delta\delta_2)$

$$T_{12} = \frac{|V_1||V_2|}{P_{r_1} X_{12}} \cos(\delta_1 - \delta_2)$$

Now, $\Delta\omega = \frac{d}{dt}\Delta\delta$

$2\pi\Delta f = \frac{d}{dt}\Delta\delta$

$\int 2\pi\Delta f = \int \frac{d}{dt}\Delta\delta$, $\quad 2\pi\int\Delta f_1 = \Delta\delta_1$

$\therefore \Delta P_{tie_1} = T_{12}(2\pi\int\Delta f_1 - 2\pi\int\Delta f_2)$

$= T_{12}\, 2\pi(\int\Delta f_1 - \int\Delta f_2)$

$\Delta P_{tie_2} = T_{21}\, 2\pi(\int\Delta f_2 - \int\Delta f_1)$

$\frac{T_{21}}{T_{12}} = \frac{P_{r_1}}{P_{r_2}} = a_{12}, \quad T_{12} a_{12} = T_{21}$

hence $\Delta P_{tie2} = a_{12} \Delta P_{tie1}$

From the eqⁿ of surplus power

$$\Delta P_G - \Delta P_D = \frac{2H}{f^0} \frac{d}{dt}(\Delta f) + B\Delta f \quad \text{(single area)}$$

For two area it is in p.u.

$$\Delta P_{G1} - \Delta P_{D1} = \frac{2H_1}{f^0} \frac{d}{dt}(\Delta f_1) + B_1 \Delta f_1 + \Delta P_{tie1}$$

Taking laplace x'form

$$\Delta P_{G1}(s) - \Delta P_{D1}(s) = \frac{2H_1}{f^0} s(\Delta F_1(s)) + B_1 \Delta F_1(s) + \Delta P_{tie1}(s)$$

Rearranging the eqⁿ

$$\Delta P_{G1}(s) - \Delta P_{D1}(s) = \Delta F_1(s)\left(\frac{2H_1}{f^0}s + B_1\right) + \Delta P_{tie1}(s)$$

$$\Delta F_1(s) = \frac{[\Delta P_{G1}(s) - \Delta P_{D1}(s) - \Delta P_{tie1}(s)]}{\left(\frac{2H_1}{f^0}s + B_1\right)}$$

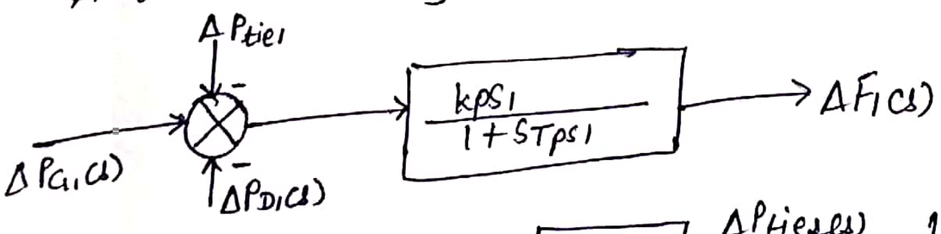
$$= \Delta P_{G1}(s) - \Delta P_{D1}(s) - \Delta P_{tie1}(s) \cdot \left(\frac{1/B_1}{\frac{2H_1}{B_1 f^0}s + 1}\right)$$

$$\Delta F_1(s) = [\Delta P_{G1}(s) - \Delta P_{D1}(s) - \Delta P_{tie1}(s)] \frac{k_{ps1}}{1 + sT_{ps1}} \quad \text{---} (1)$$

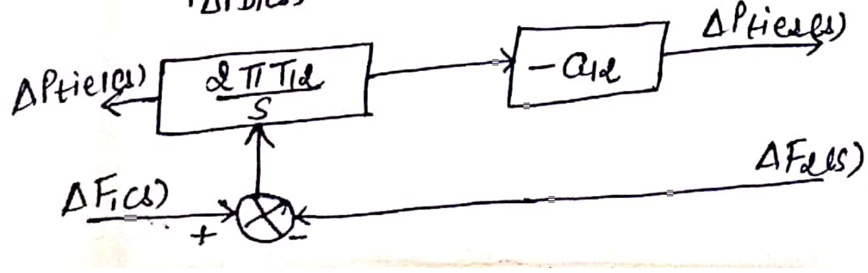
$$\left(\because k_{ps1} = 1/B_1, \quad T_{ps1} = 2H_1/B_1 f^0\right)$$

$$\Delta P_{tie1} = \frac{2\pi T_{12}}{s}\left(\frac{\Delta F_1(s)}{s} - \frac{\Delta F_2(s)}{s}\right) \quad \text{----} (2)$$

$$\Delta P_{tie2} = -\frac{2\pi a_{12} T_{12}}{s}(\Delta F_1(s) - \Delta F_2(s)) \quad \text{———} (3)$$

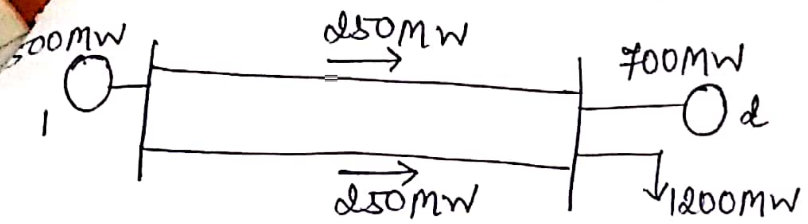


Blockdia representation of eqⁿ (1)



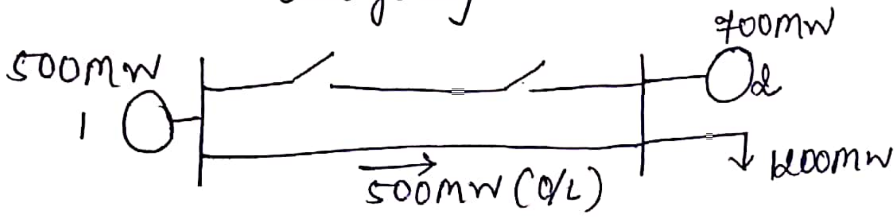
Representation of eqⁿ (2) & (3)

Example of diff power sys. state

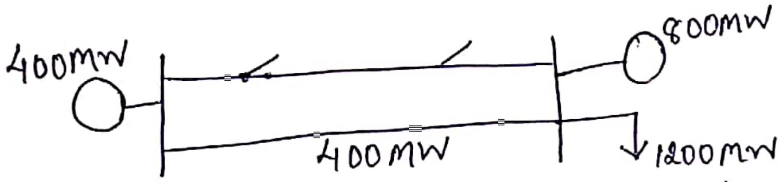


Secure state (double ckt line carry max 400MW)

↓ Contigency

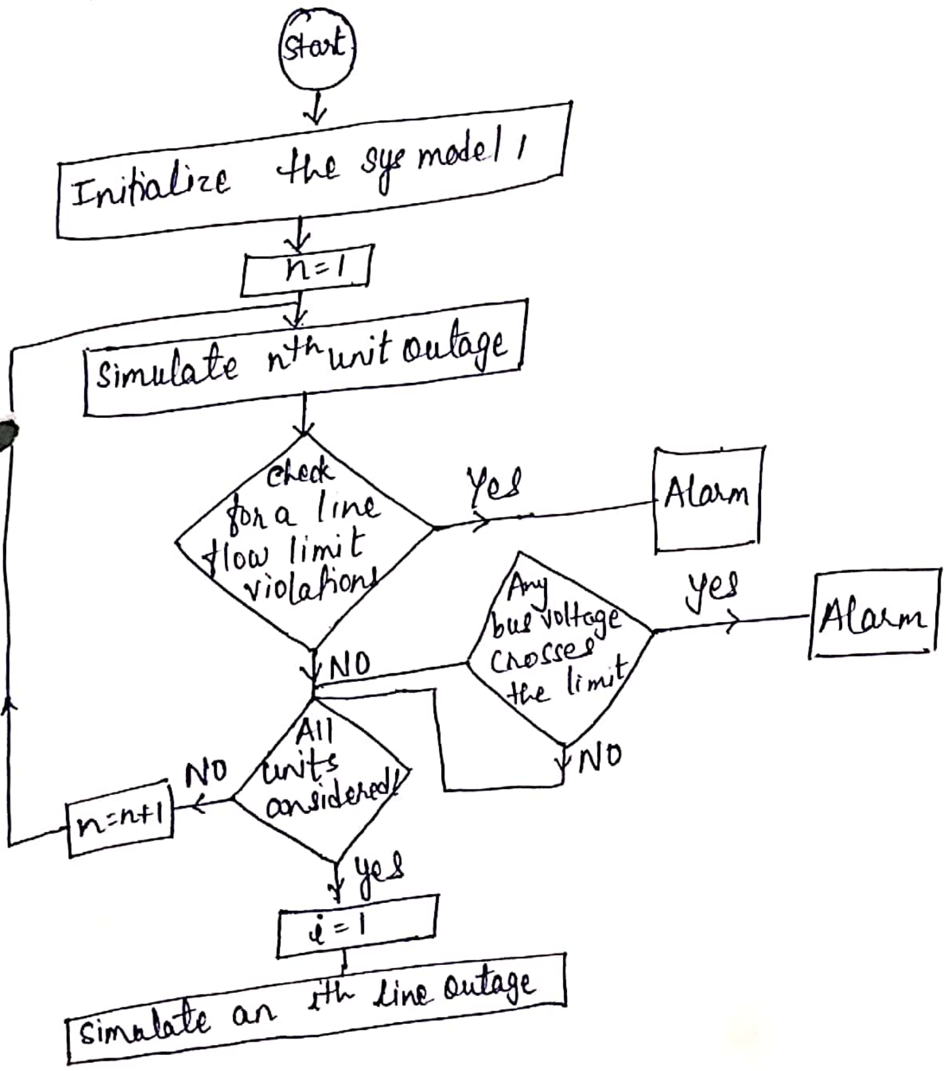


correctively secure / correctable emergency



secure

⇒ Flow chart for contigency analysis



...ity factors:

...e problem of studying thousands of possible outages becomes very difficult to solve if it is desired to present the results quickly.

- One of the easiest way to provide a quick calculation of possible overloads is to use linear sensitivity factors.

1. Generation shift factors
2. line outage distribution factor

1. The generation shift factors are designated α_{li} and have the following definition:

$$\alpha_{li} = \frac{\Delta f_l}{\Delta P_i} \qquad \begin{array}{l} l = \text{line index} \\ i = \text{bus index} \end{array}$$

Δf_l = change in megawatt power flow on line l when a change in generation ΔP_i occurs at bus i

ΔP_i = change in generation at bus i