<u>Control Area Concept</u> – The analysis which has been done so far considers a single generator supplying power to a local area. However in reality several generators are operating in parallel to feed system load.

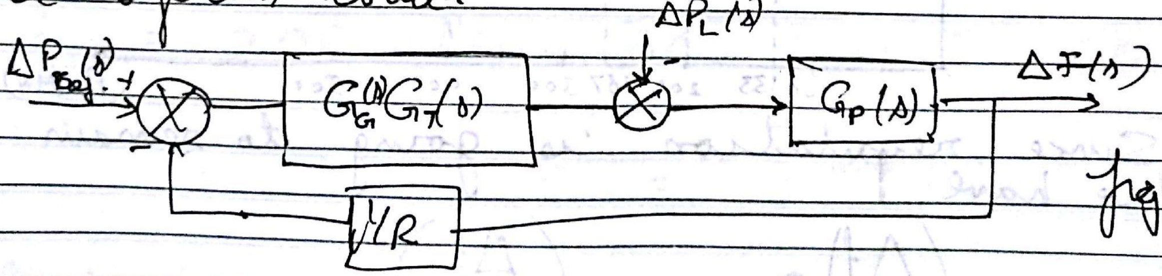

fig (A)

The LFC loop shown in fig (A) can be considered to represent the whole system, if individual control loops have the same regulation parameter and individual turbine generators have the same response characteristic.

Coherent Group — It is a group of these machines which move together i.e. moving in unison. It is very difficult to analyze which machines form a coherent group. Therefore generally all the machines in a power plant can be considered as a coherent group. In case of India, for the sake of simplicity and analysis, all the machines in a state board of electricity of one state are considered as a coherent group.

Each coherent group will be represented by a single machine. All the machines in a coherent group swing together in steady state as well as dynamic condition.

Proportional Plus Integral Control (PI Control)

The speed governing system installed on each machine is such that the steady state load frequency characteristic for a given speed changer setting has considerable droop. The frequency specifications are so stringent that it is expected that the steady change in frequency will be zero. Now in order to reduce frequency deviation resulting due to change in load to zero, a reset action must be provided.

This reset action can be achieved by the addition of an integral controller as the the secondary control loop. In the secondary control loop, the frequency error signal, after amplification, is integrated w.r.t. time and is fed to the speed changer to change the speed set point as shown in fig (B). The system now modifies to a PI control system.

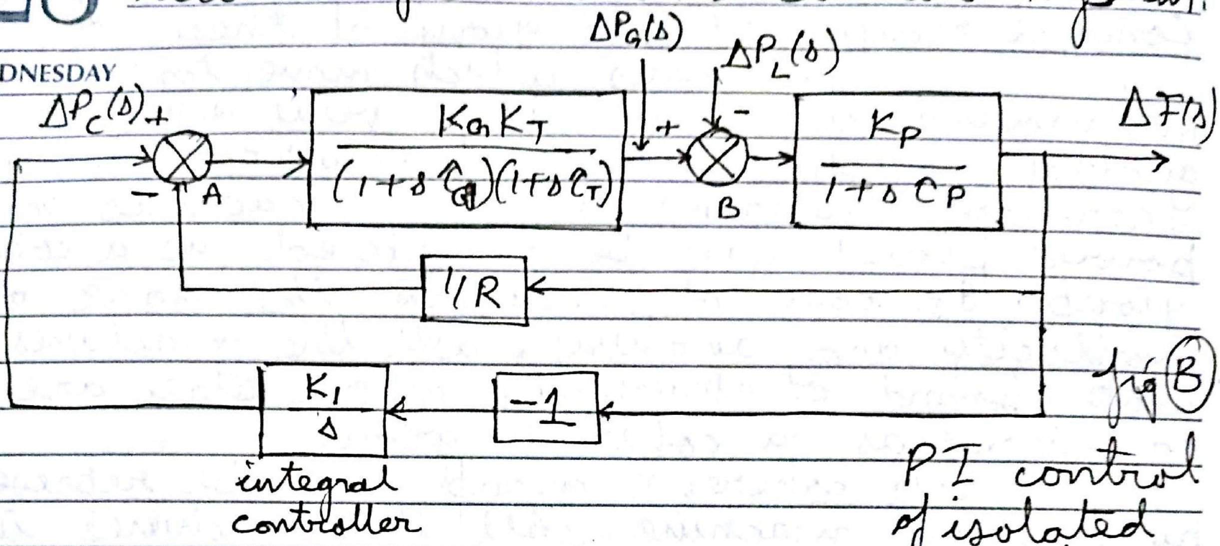

fig (B)
PI control of isolated system

$\boxed{-1}$ → this is taken because $\Delta f \uparrow\ \Delta P_c \downarrow$ and $\Delta f \downarrow\ \Delta P_c \uparrow$

Now at summer point A input

$$\Delta I_A(s) = \Delta P_C(s) - \frac{1}{R}\Delta F(s)$$

$$\Delta I_A(s) = -\frac{K_1}{s}\cdot\Delta F(s) - \frac{1}{R}\Delta F(s)$$

$$\Delta I_A(s) = -\left(\frac{K_1}{s} + \frac{1}{R}\right)\Delta F(s)$$

$$\Delta P_G(s) = \frac{K_G K_T}{(1+s\tau_G)(1+s\tau_T)}\cdot I_A(s)$$

$$\Delta P_G(s) = \frac{-K_G K_T}{(1+s\tau_G)(1+s\tau_T)}\left(\frac{K_1}{s} + \frac{1}{R}\right)\Delta F(s)$$

Now input at summer point B

$$\Delta I_B(s) = \Delta P_G(s) - \Delta P_L(s)$$

$$\Delta I_B(s) = \frac{-K_G K_T}{(1+s\tau_G)(1+s\tau_T)}\left(\frac{K_1}{s}+\frac{1}{R}\right)\Delta F(s) - \Delta P_L(s)$$

Now ~~G(s)~~ we have

$$\Delta F(s) = \frac{K_P}{(1+s\tau_P)} \times \Delta I_B(s)$$

$$\Delta F(s) = \frac{K_P}{(1+s\tau_P)} \times \left[\frac{-K_G K_T}{(1+s\tau_G)(1+s\tau_T)}\left(\frac{K_1}{s}+\frac{1}{R}\right)\Delta F(s) - \Delta P_L(s)\right]$$

or $$\Delta F(s) = \frac{-K_G K_T}{(1+s\tau_G)(1+s\tau_T)}\left(\frac{K_1}{s}+\frac{1}{R}\right)\left(\frac{K_P}{1+s\tau_P}\right)\Delta F(s) - \frac{K_P}{(1+s\tau_P)}\Delta P_L(s)$$

or $$\Delta F(s)\left[1 + \left(\frac{K_G K_T}{(1+s\tau_G)(1+s\tau_T)}\right)\left(\frac{K_1}{s}+\frac{1}{R}\right)\left(\frac{K_P}{(1+s\tau_P)}\right)\right] = -\frac{K_P}{(1+s\tau_P)}\Delta P_L(s)$$

or $$\Delta F(s) = \frac{-K_P/(1+s\tau_P)}{1 + \frac{K_G K_T K_P}{(1+s\tau_G)(1+s\tau_T)(1+s\tau_P)} \times \frac{RK_1+s}{Rs}} \Delta P_L(s)$$

30 FRIDAY JUNE 2000

$$\text{or } \Delta F(s) = \frac{-K_p/\cancel{(1+s\tau_p)}}{\dfrac{sR(1+s\tau_G)(1+s\tau_T)(1+s\tau_p)+K_GK_TK_p(s+RK_1)}{sR(1+s\tau_G)(1+s\tau_T)\cancel{(1+s\tau_p)}}} \cdot \Delta P_L$$

$$\therefore \Delta F(s) = \frac{-K_p \cdot sR(1+s\tau_G)(1+s\tau_T)}{sR(1+s\tau_G)(1+s\tau_T)(1+s\tau_p)+K_GK_TK_p(s+RK_1)} \cdot \Delta P_L(s)$$

$$\text{or } \Delta F(s) = \frac{-sRK_p(1+s\tau_G)(1+s\tau_T)}{sR(1+s\tau_G)(1+s\tau_T)(1+s\tau_p)+K_GK_TK_p(s+RK_1)} \cdot \Delta P_L(s)$$

For a step change in load i.e. $\Delta P_L(s) = \frac{\Delta P_L}{s}$ the steady state error in frequency is given by

$$\Delta f_{ss} = \lim_{s\to 0} s \cdot \Delta F(s)$$

$$= \lim_{s\to 0} s \cdot \frac{-sRK_p(1+s\tau_G)(1+s\tau_T)}{sR(1+s\tau_G)(1+s\tau_T)(1+s\tau_p)+K_GK_TK_p(s+RK_1)} \cdot \frac{\Delta P_L}{s}$$

$$= \lim_{s\to 0} \frac{-sRK_p(1+s\tau_G)(1+s\tau_T)}{sR(1+s\tau_G)(1+s\tau_T)(1+s\tau_p)+K_p(s+RK_1)} \cdot \Delta P_L$$

$$= \frac{-0}{0+K_pRK_1} \cdot \Delta P_L$$

$$\boxed{\Delta f_{ss} = 0}$$

REMIND ME

JUN 2000

S		11	25
M		12	26
T		13	27
W		14	28
T	01	15	29
F	02	16	30
S	03	17	
S	04	18	
M	05	19	
T	06	20	
W	07	21	
T	08	22	
F	09	23	
S	10	24	