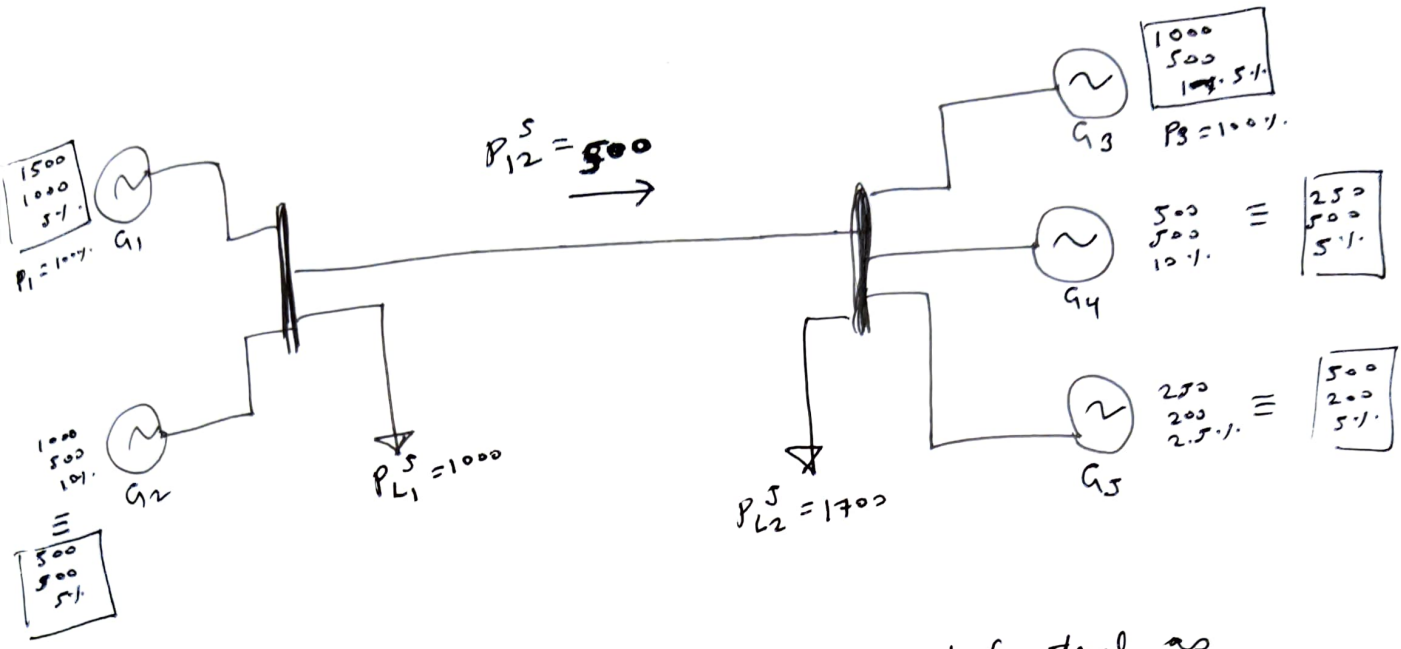
7.1.1



Note: G_4 will NOT participate in Droop Control as

$P_{G_4} = G_4$ already
↳ sys. rating

$G_{sys\,tem} = 1500 + 500 + 1000 + 0 + 500$

$\Rightarrow$ $G_{sys\,tem} = 3500\,MVA$

Scenario 2

P_{L_1} ↑ by +100 MW.

$P_{L_1}^2 = 1100\,MW$.

$$-\frac{1}{R_1}\underbrace{\Delta\omega_1}_{(\omega_1 - 1)} = \Delta P_{L_1}$$

$$\omega_1 - 1 = -0.05 \times \frac{(+100)\,MW}{3500\,MVA}$$

$$\omega_1 = \underbrace{0.9986\,pu}_{x} = 59.9143\,Hz$$

$\Delta P_L = \Delta P_{L_1} = +0.02857_{pu}$ ← y

$$\Delta P_{G_i} = \Delta P_{L_i}[pu] \times G_i \quad ; i = 1, 2, 3, 5$$

(G_i: Machine Rates)

Governor action

$\Delta P_{G_1} = +42.8571\,MW$
$\Delta P_{G_2} = +14.2857\,MW$
$\Delta P_{G_3} = +28.5714\,MW$
$\Delta P_{G_4} = 0\,MW$
$\Delta P_{G_5} = +14.2857\,MW$

Ans

7.1.2

$$ACE_1 = \underset{[pu]}{\Delta P_{net_1}} + \beta_1 \underset{[pu]}{\Delta \omega_1}$$

$$\text{or } ACE_1 = \left\{ \underset{[pu]}{P_1^a} - \underset{[pu]}{P_1^s} \right\} + \frac{1}{R_1} \underset{[pu]}{\Delta \omega_1}$$

$$\text{or } ACE_1 = \left\{ \left(\underset{[pu]}{P_{G_1}^a} + \underset{[pu]}{P_{G_2}^a} - \underset{[pu]}{P_{L_1}^a} \right) - \underset{[pu]}{P_{12}^s} \right\} + \frac{1}{R_1} \underset{[pu]}{\Delta \omega_1}$$

$$\text{or } ACE_1 = \left\{ \Delta P_{G_1} + \Delta P_{G_2} - \Delta P_{L_1} \right\} + \frac{1}{R_1} \Delta \omega_1$$

$$\Delta P_{G_1} \rightarrow \frac{y \times G_1}{G_{A_1}}, \quad \Delta P_{G_2} \rightarrow \frac{y \times G_2}{G_{A_1}}, \quad \Delta P_{L_1} \rightarrow \frac{y \times G_{sup}}{G_{A_1}}, \quad \frac{1}{R_1} \rightarrow 20, \quad \Delta \omega_1 \rightarrow (n-1)$$

or ~~$ACE_1 = -0.04082$~~

$$\text{or } \boxed{ACE_1 = -0.05_{pu}} \Rightarrow \underset{AGC}{\Delta P_{AGC_1}} = -ACE_1 \times G_1 = 100\,MW$$

$$\Rightarrow \Delta P_{G_1} = \Delta P_{AGC_1} \times 100\%$$

$$\text{or } \boxed{\Delta P_{G_1} = +100\,MW} \text{ Ans (AGC Action)}$$

$$ACE_2 = \underset{[pu]}{\Delta P_{net_2}} + \beta_2 \underset{[pu]}{\Delta \omega_2}$$

$$\text{or } ACE_2 = \left\{ \left(P_{G_3}^a + P_{G_4}^a + P_{G_5}^a - \underset{[pu]}{P_{L_2}^a} \right) - \underset{[pu]}{P_2^s} \right\} + \frac{1}{R_2} \Delta \omega_2$$

$$\text{or } ACE_2 = \left\{ \Delta P_{G_3} + \Delta P_{G_4} + \underset{[pu]}{\Delta P_{G_5}} - \underset{[pu]}{\Delta P_{L_2}} \right\} + \frac{1}{R_2} \Delta \omega_2$$

or ~~$ACE_2 =$~~

$$\text{or } ACE_2 = \left\{ \frac{y \cdot G_3}{G_{A_2}} + 0 + \frac{y \cdot G_5}{G_{A_2}} - 0 \right\} + 20(n-1)$$

$$\text{or } \boxed{ACE_2 = 0_{pu}}$$

Scenario 2

P_{L2} ↑ by $+100\,MW$

$P_{L2}^{a} = 1800\,MW$

$$\Delta P_{L(pu)} = \Delta P_{L2(pu)} = \frac{+100\,MW}{3500\,MVA} = +0.02857\ pu \quad (y)$$

$$\Delta\omega = \Delta\omega_2 = \Delta\omega_1 = -R_2 \Delta P_{L2(pu)} \quad (x)$$

$$\Rightarrow \omega_2 = \omega_1 = \omega = 0.99857\ pu = 59.9143\ Hz$$

$$\Delta P_{G_i}\ [MW] = \frac{-1}{R_i}(\omega_i - 1) \times G_i \quad i = 1,2,3,5$$

$$\Delta P_{L}\ [pu]$$

Governor action

$$\Delta P_{G_1} = \frac{-20(x-1)}{y} \times 1500 = +42.8571\ MW$$

$$\Delta P_{G_2} = \frac{-20(x-1)}{y} \times 500 = +14.2857\ MW$$

$$\Delta P_{G_3} = \frac{-20(x-1)}{y} \times 1000 = +28.5714\ MW$$

$$\Delta P_{G_4} = 0 = 0\ MW$$

$$\Delta P_{G_5} = \frac{-20(x-1)}{y} \times 500 = +14.2857\ MW$$

$$ACE_2 = \Delta P_{Net_2} + \beta_1 \Delta\omega_1$$

$$ACE_2 = \{\Delta P_{G_1} + \Delta P_{G_2} - \Delta P_{L_1}\} + \frac{1}{R_1}\Delta\omega_1$$

$$ACE_2 = \{y G_1 + y G_2\} \times y$$

$$ACE_2 = y - y = 0$$

$$\therefore ACE_2 = 0$$

$$ACE_2 = \underset{(pu)}{\Delta P_{Net_2}} + \overbrace{\underset{(pu)}{\beta_2 \Delta \omega_2}}^{-y}$$

$$\Rightarrow ACE_2 = \underset{(pu)}{\left\{ \Delta P_{G_3} + \Delta P_{G_4} + \Delta P_{G_5} - \Delta P_{L_2} \right\}} + \underbrace{\frac{1}{R_2}\Delta \omega_2}_{-y}$$

$$\Rightarrow ACE_2 = \left\{ \frac{G_3 y + G_4 \times 0 + G_5 y - G_{sys} y}{G_{Ar2}} \right\} - y$$

$$\Rightarrow ACE_2 = y \left\{ \frac{G_3 + G_5 - G_{sys}}{G_3 + G_5} \right\} - y$$

$$\Rightarrow \boxed{ACE_2 = -0.0667 \ pu}$$

$$\Rightarrow \Delta P_{G_{Ar2}} = -ACE_2 \times G_{Ar2}$$

$$\Rightarrow \Delta P_{G_{Ar2}} = 0.0667 \times 1500 \ MW$$

$$\Rightarrow \boxed{\Delta P_{G_{Ar2}} = +100 \ MW} \Rightarrow \boxed{\Delta P_{G_3} = +100 \ MW}$$

AGC Action

Ans

$\Rightarrow P_{G_3} = 100\%$.

Scenario 3

P_{L1} ↓es by 200MW ⇒ $\Delta P_{L1} = -200MW$

&&

P_{L2} ↑es by 100MW ⇒ $\Delta P_{L2} = +100MW$.

$\Delta P_L = \Delta P_{L1} + \Delta P_{L2} = -100MW$

$$\Delta P_L [pu] = \frac{-100MW}{~~3500~~ MVA \; 3750} = ~~-0.02857~~ \; -0.02667 \; pu \rightarrow y$$

$$\Delta \omega = -R \Delta P_L (pu)$$

$\Rightarrow \Delta\omega = 1.00133 pu$ = 60.08 Hz

$\Rightarrow \omega =$ ~~1.001428 pu~~ = ~~60.0857 Hz~~

$$\Delta P_{G_i} [MW] = \underbrace{-\Delta P_{L\,sys}}_{y} \times G_i \quad i = 1,2,3,5 \text{ and 4 too}$$

Governor action

ΔP_{G1} = ~~-42.8571~~ -40 MW

ΔP_{G2} = ~~-14.2857~~ -13.3333 MW

ΔP_{G3} = ~~-28.5714~~ -26.6667 MW

ΔP_{G4} = ~~0~~ -6.6667 MW

ΔP_{G5} = ~~-14.2857~~ -13.3333 MW

$$ACE_1 = \Delta P_{Net\,1}(pu) + \underbrace{\beta_1 \Delta\omega_1}_{-y\,(pu)}$$

$$\Rightarrow ACE_1 = \{\Delta P_{G1} + \Delta P_{G2} - \Delta P_{L1}\}(pu) - y$$

$\Rightarrow$ ~~$ACE_1 = yG_1 + yG_2 + \ldots$~~

$$\Rightarrow ACE_1 = \left\{\frac{yG_1 + yG_2 + 200MW}{G_1+G_2}\right\} - y = y - y + \frac{200}{G_1+G_2} \rightarrow (G_1+G_2)$$

$\Rightarrow ACE_1 =$ ~~+0.08~~ ~~+0.1 pu~~ +0.1 pu $\Rightarrow \Delta P_{G\,Area\,1} = -ACE_1 \times G_{Area\,1}$

$\Rightarrow \Delta P_{G\,A1} = -200MW \Rightarrow \Delta P_{G1} = -200MW$ @ $P_{G1} = 100\%$.

7.3.2

$$ACE_2 = \underset{[pu]}{\Delta P_{Net\,2}} + \underset{[pu]}{\overbrace{\beta_2 \Delta \omega_2}^{-y}}$$

or $ACE_2 = \left\{ \Delta P_{G_3} + \Delta P_{G_4} + \Delta P_{G_5} - \Delta P_{L2} \right\}_{[pu]} - y$

or $ACE_2 = \left\{ \frac{y G_3 + \cancel{\emptyset}\ yG_4 + y G_5 - 100\,MW}{G_{Area\,2}} \right\} - y$

$G_{Area\,2} \rightarrow G_3 + G_5 + G_4$

or $ACE_2 = \left\{ \frac{y G_3 + y G_5 + yG_4 - 100\,MW}{G_3 + G_5 + G_4} \right\} - y$

or $ACE_2 = \cancel{y} - \frac{100\,MW}{G_3 + G_5 + G_4} \cancel{-y}$

or $\boxed{ACE_2 = -0.05714\ pu}$ ~~$-0.0667\ pu$~~ $\Rightarrow \Delta P_{G\,Area\,2} = -ACE_2 \times G_{Area\,2}$ ($G_{Area\,2} = G_3 + G_5 + G_4$)

or $\boxed{\Delta P_{G\,Area\,2} = +100\,MW}$

$\Rightarrow \boxed{\Delta P_{G_3} = +100\,MW}$ Ans

@ $P_{G_3} = 100\%$

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