

EE 523 Home Work 5

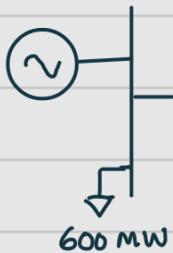
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1)

Area 1

1500 MVA
1000 MW
 $R_1 = 5\gamma$



$$P_{Tie,12} = 400 \text{ MW}$$

Area 2

1000 MVA
500 MW
 $R_2 = 5\gamma$



$$\textcircled{a} \Delta P_{L_1} = +100 \text{ MW}$$

$$\Delta P = \frac{100}{2500} = \underline{\underline{0.04 \text{ pu}}}$$

$$\Delta f = R \Delta P = (0.05)(-0.04) = \underline{\underline{-0.002 \text{ pu}}} = -0.002 \times 60 = \underline{\underline{-0.12 \text{ Hz}}}$$

$$f_{\text{new}} = 60 - 0.12 = \underline{\underline{59.88 \text{ Hz}}} = \underline{\underline{0.998 \text{ pu}}}$$

$$\Delta P_{G_1} = \frac{\Delta f}{R_1} = \frac{0.002}{0.05} = \underline{\underline{0.04 \text{ pu}}} = (0.04)(1500) = \underline{\underline{60 \text{ MW}}}$$

$$\Delta P_{G_2} = \frac{\Delta f}{R_2} = \frac{0.002}{0.05} = \underline{\underline{0.04 \text{ pu}}} = (0.04)(1000) = \underline{\underline{40 \text{ MW}}}$$

$$P_{Tie,12}^{\text{actual}} = 360 \text{ MW}$$

Area 1

$$P_{\text{Net},1}^{\text{contract}} = 400 \text{ MW} = \frac{400}{1500} = \underline{\underline{0.2667 \text{ pu}}}$$

$$P_{\text{Net},1}^{\text{actual}} = 360 \text{ MW} = \frac{360}{1500} = \underline{\underline{0.24 \text{ pu}}}$$

$$\Delta P_{\text{Net},1} = 0.24 - 0.2667 = \underline{\underline{-0.0267 \text{ pu}}}$$

$$ACE_1 = \Delta P_{Net,1} + B_1 (f_1^{\text{act}} - 1)$$

$$= -0.0267 + \frac{1}{0.05} (0.998 - 1)$$

$$\underline{\underline{ACE_1}} = -0.0667 \text{ pu} = -0.0667 \times 1500 = \underline{\underline{-100 \text{ MW}}}$$

Negative sign indicates that Area 1 is underproducing 100MW.

\therefore Area 1 should increase schedule by 100 MW

Area 2

$$P_{Net,2}^{\text{contract}} = -400 \text{ MW} = \frac{-400}{1000} = -0.4 \text{ pu}$$

$$P_{Net,2}^{\text{actual}} = -360 \text{ MW} = \frac{-360}{1000} = -0.36 \text{ pu}$$

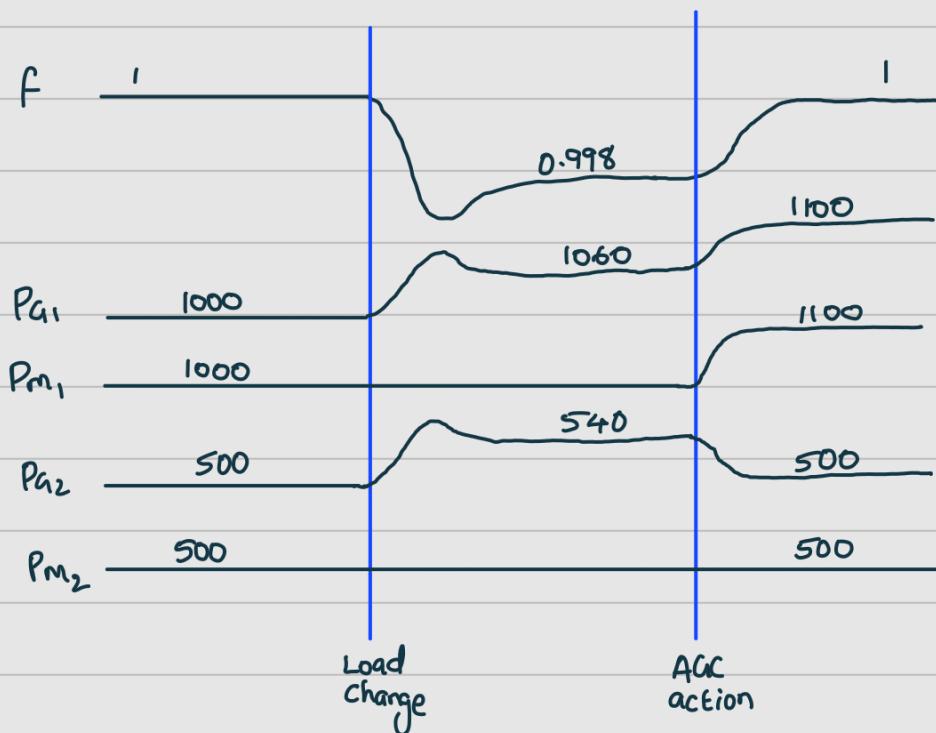
$$\Delta P_{Net,2} = -0.36 - (-0.4) = 0.04 \text{ pu}$$

$$ACE_2 = \Delta P_{Net,2} + B_2 (f_2^{\text{act}} - 1)$$

$$= 0.04 + \frac{1}{0.05} (0.998 - 1)$$

$$ACE_2 = 0$$

\therefore No correction needed for Area 2



$$(b) \Delta P_{L_2} = 100 \text{ MW}$$

$$\Delta P = \frac{100}{2500} = \underline{\underline{0.04 \text{ pu}}}$$

$$\Delta f = R \Delta P = (0.05)(-0.04) = \underline{\underline{-0.002 \text{ pu}}} = -0.002 \times 60 = \underline{\underline{-0.12 \text{ Hz}}}$$

$$f_{\text{new}} = 60 - 0.12 = \underline{\underline{59.88 \text{ Hz}}} = \underline{\underline{0.998 \text{ pu}}}$$

$$\Delta P_{G_1} = \frac{\Delta f}{R_1} = \frac{0.002}{0.05} = \underline{\underline{0.04 \text{ pu}}} = (0.04)(1500) = \underline{\underline{60 \text{ MW}}}$$

$$\Delta P_{G_2} = \frac{\Delta f}{R_2} = \frac{0.002}{0.05} = \underline{\underline{0.04 \text{ pu}}} = (0.04)(1000) = \underline{\underline{40 \text{ MW}}}$$

$$P_{\text{Tie}_{12}}^{\text{actual}} = 460 \text{ MW}$$

Area 1

$$P_{\text{Net},1}^{\text{contract}} = 400 \text{ MW} = \frac{400}{1500} = \underline{\underline{0.2667 \text{ pu}}}$$

$$P_{\text{Net},1}^{\text{actual}} = 460 \text{ MW} = \frac{460}{1500} = \underline{\underline{0.3066 \text{ pu}}}$$

$$\Delta P_{\text{Net},1} = 0.3066 - 0.2667 = \underline{\underline{0.04 \text{ pu}}}$$

$$\begin{aligned} \text{ACE}_1 &= \Delta P_{\text{Net},1} + B_1 (f_1^{\text{act}} - 1) \\ &= 0.04 + \frac{1}{0.05} (0.998 - 1) \\ &= \underline{\underline{0}} \end{aligned}$$

\therefore No correction needed for Area 1

Area 2

$$P_{Net_2}^{\text{Contract}} = -400 \text{ MW} = -\frac{400}{1000} = -0.4 \text{ pu}$$

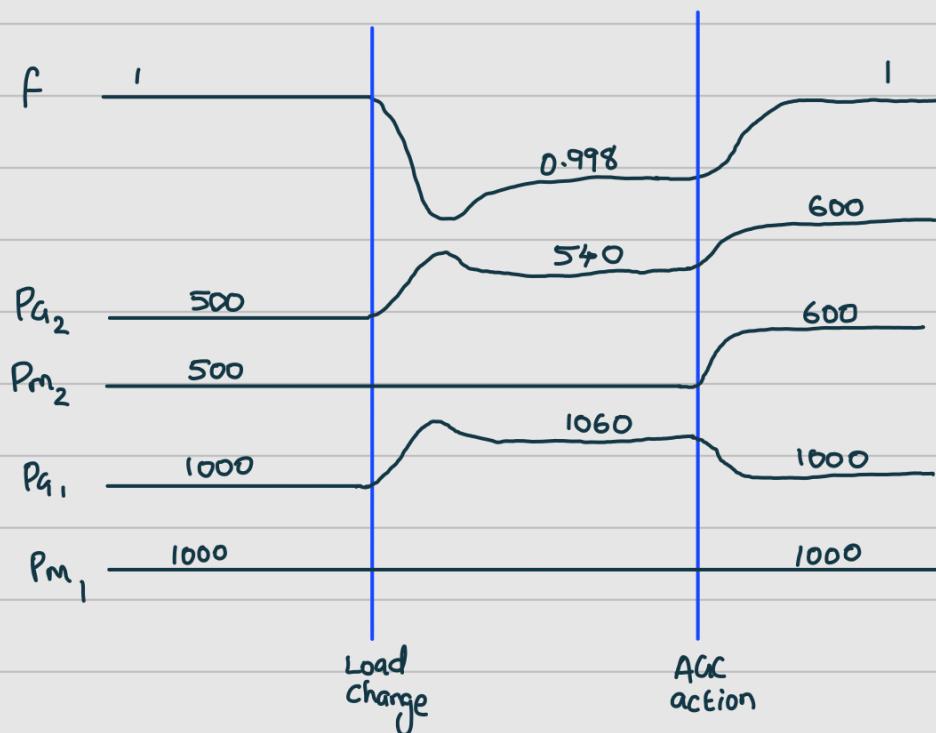
$$P_{Net_2}^{\text{actual}} = -460 \text{ MW} = -\frac{460}{1000} = -0.46 \text{ pu}$$

$$\Delta P_{Net_2} = -0.46 - (-0.4) = -0.06 \text{ pu}$$

$$\begin{aligned} ACE_2 &= \Delta P_{Net_2} + B_2 (f_2^{\text{act}} - 1) \\ &= -0.06 + \frac{1}{0.05} (0.998 - 1) \\ ACE_2 &= \underline{-0.1 \text{ pu}} = -0.1 \times 1000 = \underline{\underline{-100 \text{ MW}}} \end{aligned}$$

∴ Area 2 is underproducing 100 MW.

Area 2 should increase schedule by 100 MW



$$\textcircled{c} \quad \Delta P_{L_1} = -100 \text{ MW} \quad \Delta P_{L_2} = 50 \text{ MW} \quad \Delta P = -100 + 50 = -50 \text{ MW}$$

$$\Delta P = \frac{-50}{2500} = \underline{\underline{-0.02 \text{ pu}}}$$

$$\Delta f = R \Delta P = (0.05)(0.02) = \underline{\underline{0.001 \text{ pu}}} = 0.001 \times 60 = \underline{\underline{0.06 \text{ Hz}}}$$

$$f_{\text{new}} = 60 + 0.06 = \underline{\underline{60.06 \text{ Hz}}} = \underline{\underline{1.001 \text{ pu}}}$$

$$\Delta P_{G_1} = -\frac{\Delta f}{R_1} = -\frac{0.001}{0.05} = \underline{\underline{-0.02 \text{ pu}}} = (0.02)(1500) = \underline{\underline{-30 \text{ MW}}}$$

$$\Delta P_{G_2} = \frac{\Delta f}{R_2} = \frac{0.001}{0.05} = \underline{\underline{0.02 \text{ pu}}} = (0.02)(1000) = \underline{\underline{-20 \text{ MW}}}$$

$$P_{\text{Tie}_{12}}^{\text{actual}} = 470 \text{ MW}$$

Area 1

$$P_{\text{Net}_1}^{\text{contract}} = 400 \text{ MW} = \frac{400}{1500} = \underline{\underline{0.2667 \text{ pu}}}$$

$$P_{\text{Net}_1}^{\text{actual}} = 470 \text{ MW} = \frac{470}{1500} = \underline{\underline{0.3133 \text{ pu}}}$$

$$\Delta P_{\text{Net}_1} = 0.3133 - 0.2667 = \underline{\underline{0.0466 \text{ pu}}}$$

$$\text{ACE}_1 = \Delta P_{\text{Net}_1} + B_1 (f_1^{\text{act}} - 1)$$

$$= 0.0466 + \frac{1}{0.05} (1.001 - 1)$$

$$\text{ACE}_1 = 0.0466 + 0.0666 = 0.0666(1500) = 100 \text{ MW}$$

\therefore Area 1 is over producing 100 MW.

Area 1 should reduce production by 100 MW

Area 2

$$P_{Net_2}^{\text{Contract}} = -400 \text{ MW} = -\frac{400}{1000} = -0.4 \text{ pu}$$

$$P_{Net_2}^{\text{actual}} = -470 \text{ MW} = -\frac{470}{1000} = -0.47 \text{ pu}$$

$$\Delta P_{Net_2} = -0.47 - (-0.4) = -0.07 \text{ pu}$$

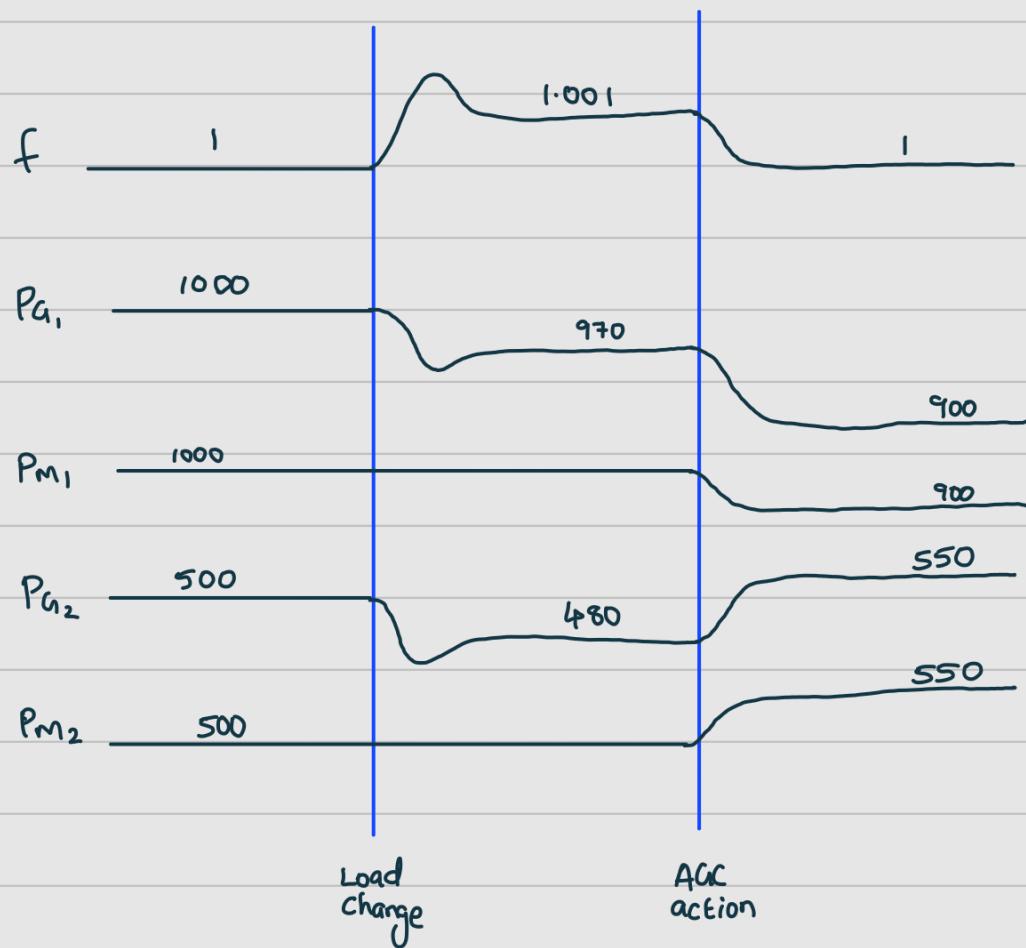
$$ACE_2 = \Delta P_{Net_2} + B_2 (f_2^{\text{act}} - 1)$$

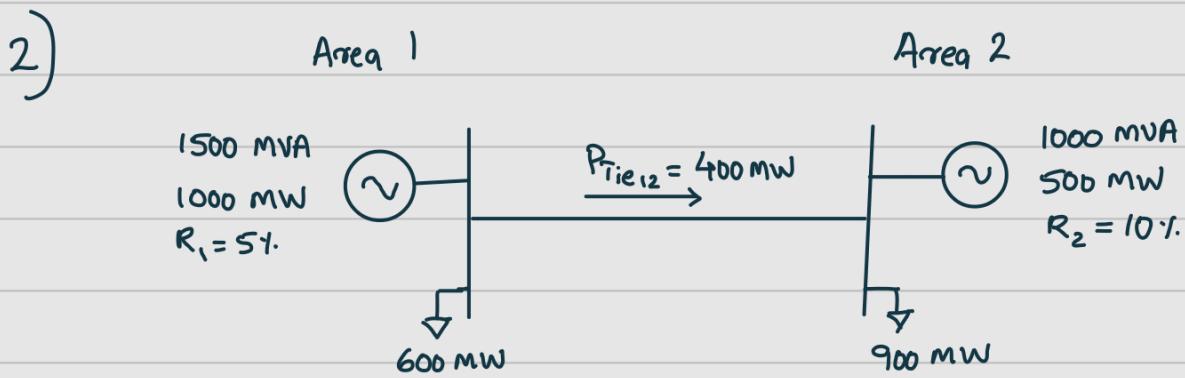
$$= -0.07 + \frac{1}{0.05} (1.001 - 1)$$

$$ACE_2 = \underline{-0.05 \text{ pu}} = -0.05 \times 1000 = \underline{-50 \text{ MW}}$$

\therefore Area 2 is underproducing 50 MW.

Area 2 should increase schedule by 50 MW

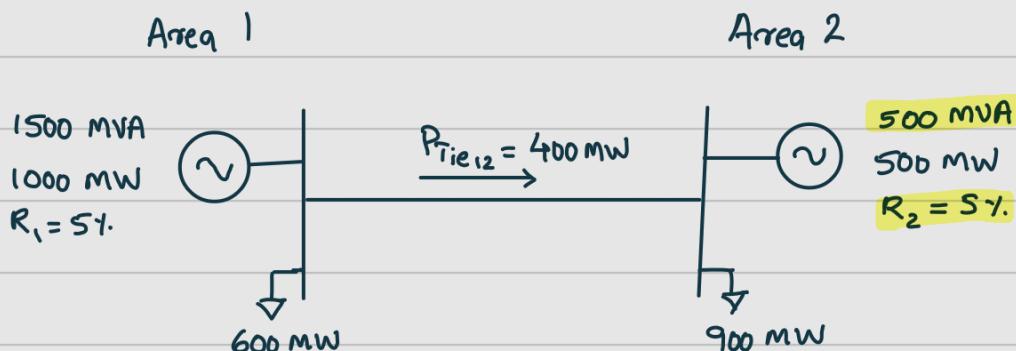




Updating droop of Area 2 $\rightarrow 5\%$.

$$R_2 = \frac{0.1}{2} = 0.05$$

$$\therefore \text{Capacity} = \frac{1000}{2} = \underline{\underline{500 \text{ MVA}}}$$



ⓐ $\Delta P_L = +100 \text{ MW}$

$$\Delta P = \frac{100}{2000} = \underline{\underline{0.05 \text{ pu}}}$$

$$\Delta f = R \Delta P = (0.05)(-0.05) = -0.0025 \text{ pu} = (-0.0025)(60) = \underline{\underline{-0.15 \text{ Hz}}}$$

$$f_{\text{new}} = 60 - 0.15 = \underline{\underline{59.85 \text{ Hz}}} = \underline{\underline{0.9975 \text{ pu}}}$$

$$\Delta P_{a1} = \frac{\Delta f}{R_1} = \frac{0.0025}{0.05} = \underline{\underline{0.05 \text{ pu}}} = (0.05)(500) = \underline{\underline{75 \text{ MW}}}$$

$$\Delta P_{a2} = \frac{\Delta f}{R_2} = \frac{0.0025}{0.05} = \underline{\underline{0.05 \text{ pu}}} = (0.05)(500) = \underline{\underline{25 \text{ MW}}}$$

$$P_{tie12}^{\text{actual}} = 375 \text{ MW}$$

Area 1

$$P_{Net,1}^{\text{contract}} = 400 \text{ MW} = \frac{400}{1500} = \underline{\underline{0.2667 \text{ pu}}}$$

$$P_{Net,1}^{\text{actual}} = 375 \text{ MW} = \frac{375}{1500} = \underline{\underline{0.25 \text{ pu}}}$$

$$\Delta P_{Net,1} = 0.25 - 0.2667 = \underline{\underline{-0.0167 \text{ pu}}}$$

$$\begin{aligned} ACE_1 &= \Delta P_{Net,1} + B_1 (f_1^{\text{act}} - 1) \\ &= -0.0167 + \frac{1}{0.05} (0.9975 - 1) \end{aligned}$$

$$\underline{\underline{ACE_1 = -0.0667 \text{ pu}}} = -0.0667 \times 1500 = \underline{\underline{-100 \text{ MW}}}$$

Negative sign indicates that Area 1 is underproducing 100 MW.
 \therefore Area 1 should increase schedule by 100 MW

Area 2

$$P_{Net,2}^{\text{contract}} = -400 \text{ MW} = \frac{-400}{500} = -0.8 \text{ pu}$$

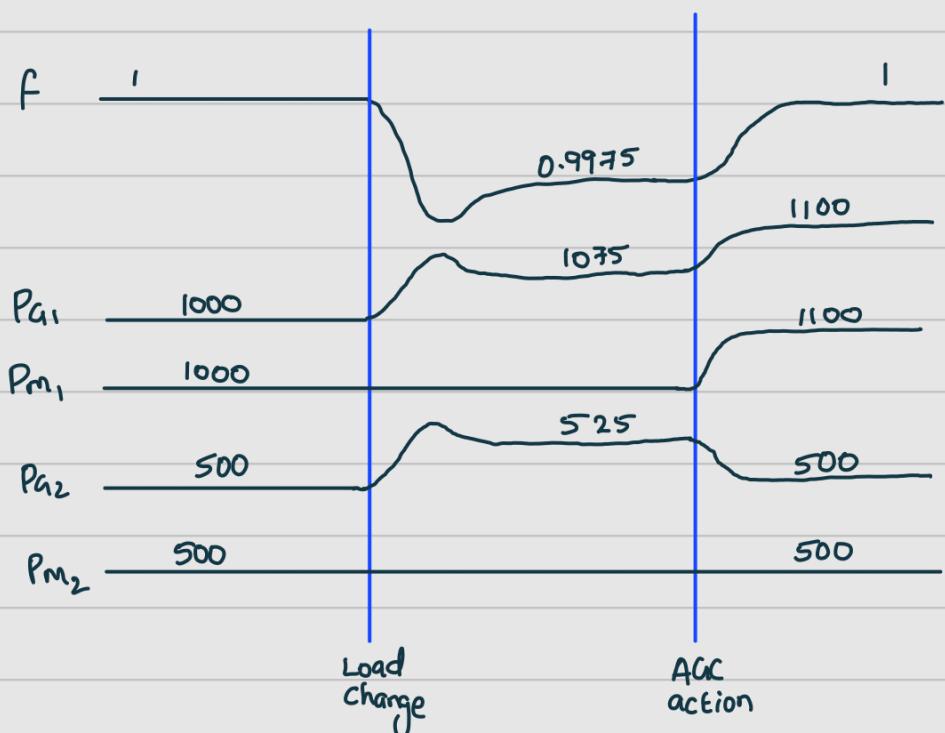
$$P_{Net,2}^{\text{actual}} = -375 \text{ MW} = \frac{-375}{500} = -0.75 \text{ pu}$$

$$\Delta P_{Net,2} = -0.75 - (-0.8) = 0.05 \text{ pu}$$

$$\begin{aligned} ACE_2 &= \Delta P_{Net,2} + B_2 (f_2^{\text{act}} - 1) \\ &= 0.05 + \frac{1}{0.05} (0.9975 - 1) \end{aligned}$$

$$ACE_2 = 0$$

\therefore No correction needed for Area 2



$$(b) \Delta P_{L_2} = 100 \text{ MW}$$

$$\Delta P = \frac{100}{2000} = \underline{\underline{0.05 \text{ pu}}}$$

$$\Delta f = R \Delta P = (0.05)(-0.05) = \underline{\underline{-0.0025 \text{ pu}}} = -0.0025 \times 60 = \underline{\underline{-0.15 \text{ Hz}}}$$

$$f_{\text{new}} = 60 - 0.15 = \underline{\underline{59.85 \text{ Hz}}} = \underline{\underline{0.9975 \text{ pu}}}$$

$$\Delta P_{G_1} = \frac{\Delta f}{R_1} = \frac{0.0025}{0.05} = \underline{\underline{0.05 \text{ pu}}} = (0.05)(1500) = \underline{\underline{75 \text{ MW}}}$$

$$\Delta P_{G_2} = \frac{\Delta f}{R_2} = \frac{0.0025}{0.05} = \underline{\underline{0.05 \text{ pu}}} = (0.05)(1000) = \underline{\underline{25 \text{ MW}}}$$

$$P_{\text{Tie}_{12}}^{\text{actual}} = 475 \text{ MW}$$

Area 1

$$P_{\text{Net}_1}^{\text{contract}} = 400 \text{ MW} = \frac{400}{1500} = \underline{\underline{0.2667 \text{ pu}}}$$

$$P_{\text{Net}_1}^{\text{actual}} = 475 \text{ MW} = \frac{475}{1500} = \underline{\underline{0.3166 \text{ pu}}}$$

$$\Delta P_{Net_1} = 0.3166 - 0.2667 = \underline{\underline{0.05 \text{ pu}}}$$

$$ACE_1 = \Delta P_{Net_1} + B_1 (f_1^{\text{act}} - 1)$$

$$= 0.05 + \frac{1}{0.05} (0.9975 - 1) = \underline{\underline{0}}$$

\therefore No correction needed for Area 1

Area 2

$$P_{Net_2}^{\text{contract}} = -400 \text{ MW} = \frac{-400}{500} = -0.8 \text{ pu}$$

$$P_{Net_2}^{\text{actual}} = -475 \text{ MW} = \frac{-475}{500} = -0.95 \text{ pu}$$

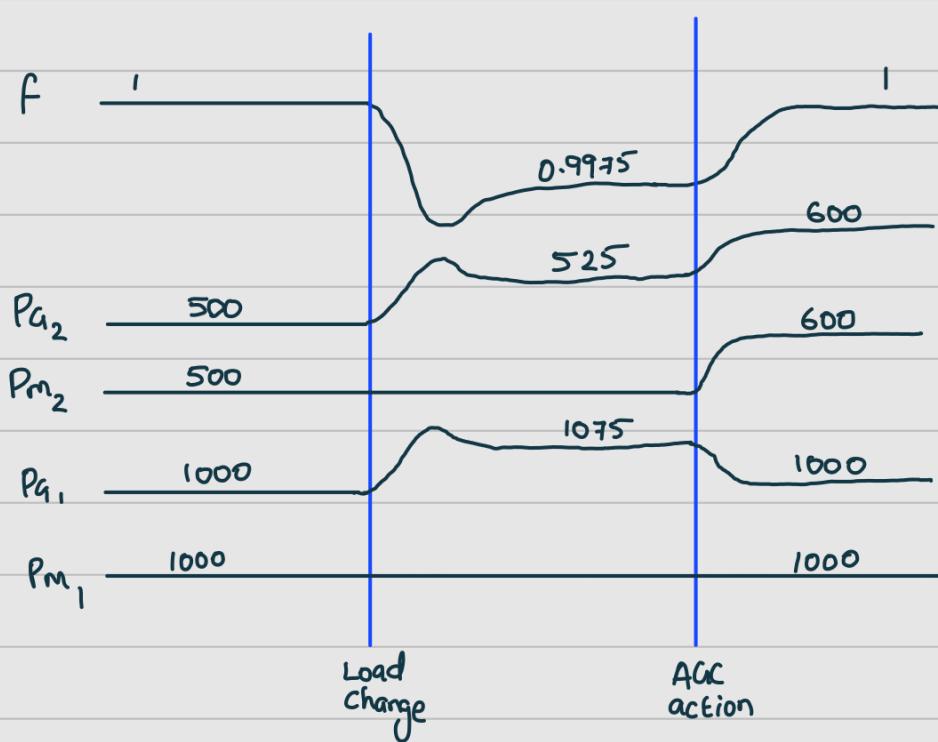
$$\Delta P_{Net_2} = -0.95 - (-0.8) = -0.15 \text{ pu}$$

$$ACE_2 = \Delta P_{Net_2} + B_2 (f_2^{\text{act}} - 1)$$

$$= -0.15 + \frac{1}{0.05} (0.9975 - 1)$$

$$ACE_2 = \underline{\underline{-0.2 \text{ pu}}} = -0.2 \times 500 = \underline{\underline{-100 \text{ MW}}}$$

\therefore Area 2 is underproducing 100 MW. Area 2 should increase schedule by 100 MW



$$\textcircled{c} \quad \Delta P_{L_1} = -100 \text{ MW} \quad \Delta P_{L_2} = 50 \text{ MW} \quad \Delta P = -100 + 50 = -50 \text{ MW}$$

$$\Delta P = \frac{-50}{2000} = \underline{\underline{-0.025 \text{ pu}}}$$

$$\Delta f = R \Delta P = (0.05)(0.025) = \underline{\underline{0.00125 \text{ pu}}} = 0.00125 \times 60 = \underline{\underline{0.075 \text{ Hz}}}$$

$$f_{\text{new}} = 60 + 0.075 = \underline{\underline{60.075 \text{ Hz}}} = \underline{\underline{1.00125 \text{ pu}}}$$

$$\Delta P_{G_1} = -\frac{\Delta f}{R_1} = -\frac{0.00125}{0.05} = \underline{\underline{-0.025 \text{ pu}}} = (-0.025)(1500) = \underline{\underline{-37.5 \text{ MW}}}$$

$$\Delta P_{G_2} = \frac{\Delta f}{R_2} = \frac{0.00125}{0.05} = \underline{\underline{0.025 \text{ pu}}} = (-0.025)(500) = \underline{\underline{-12.5 \text{ MW}}}$$

$$P_{\text{Tie}_{12}}^{\text{actual}} = 462.5 \text{ MW}$$

Area 1

$$P_{\text{Net},1}^{\text{contract}} = 400 \text{ MW} = \frac{400}{1500} = \underline{\underline{0.2667 \text{ pu}}}$$

$$P_{\text{Net},1}^{\text{actual}} = 462.5 \text{ MW} = \frac{462.5}{1500} = \underline{\underline{0.30833 \text{ pu}}}$$

$$\Delta P_{\text{Net},1} = 0.30833 - 0.2667 = \underline{\underline{0.04167 \text{ pu}}}$$

$$ACE_1 = \Delta P_{\text{Net},1} + B_1 (f_1^{\text{act}} - 1)$$

$$= 0.04167 + \frac{1}{0.05} (1.00125 - 1)$$

$$ACE_1 = 0.0666 \text{ pu} = 0.0666(1500) = 100 \text{ MW}$$

\therefore Area 1 is over producing 100 MW.

Area 1 should reduce production by 100 MW

Area 2

$$P_{Net_2}^{contract} = -400 \text{ MW} = -\frac{400}{500} = \underline{\underline{-0.8 \text{ pu}}}$$

$$P_{Net_2}^{actual} = -462.5 \text{ MW} = -\frac{462.5}{500} = \underline{\underline{-0.925 \text{ pu}}}$$

$$\Delta P_{Net_2} = -0.925 - (-0.8) = \underline{\underline{-0.125 \text{ pu}}}$$

$$\begin{aligned} ACE_2 &= \Delta P_{Net_2} + B_2 (f_2^{\text{act}} - 1) \\ &= -0.125 + \frac{1}{0.05} (1.00125 - 1) \end{aligned}$$

$$ACE_2 = \underline{\underline{-0.1 \text{ pu}}} = -0.1 \times 500 = \underline{\underline{-50 \text{ MW}}}$$

∴ Area 2 is underproducing 50 MW.

Area 2 should increase schedule by 50 MW

