PYP EE4530 NOV/DEC 15 Megarine Tee

1(a) $$Y_{bus} = \begin{bmatrix} 5.882352941-j23.42941176 & -5.882352941+j23.52941176 \\ -5.882352941+j23.52941176 & 5.882352941-j23.42941176 \end{bmatrix}$$

b) $S_2 = -1 - j0.5$

$$V_2' = \left[\left(\frac{S_2}{V_2^0}\right)^* - V_1 Y_{21} \right] \frac{1}{Y_{22}} = 0.973859318 - j0.036118332$$

c) $$\begin{bmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

$$S_1 = V_1 I_1^* = V_1 \left[Y_{11} V_1 + Y_{12} V_2 \right]^*$$
$$= 1.012294117 + j0.35467647$$

$$S_{loss} = P_{loss} + jQ_{loss} = S_1 + S_2$$
$$= 0.012294117 - j0.145323529$$

$$S_{G1} = S_1 + S_{D1}$$
$$= 1.212294117 + j0.40467647$$

d) $I_{12} = (V_1 - V_2)/Z_{12} = 1.012294118 - j0.45467647$

$I_{10} = V_1 Y_{10} = j0.1$

$I_{20} = V_2 Y_{20} = 0.0035945 + j0.097169$

$$\left.\begin{aligned} Q_{10} &= |I_{10}|^2 \times \frac{-1}{0.1} = -0.1 \\ Q_{20} &= |I_{20}|^2 \times \frac{-1}{0.1} = -\cancel{0.1}\,0.094547349 \\ Q_{12} &= |I_{12}|^2 \times 0.04 = 0.049258802 \end{aligned}\right\} Q_{loss} = -0.145288546$$

$\approx$ same as Q_{loss} from (c)

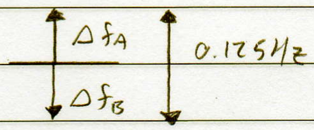
$Q_{loss} + Q_{D1} + Q_{D2} = 0.404711453 \approx$ same as Q_G from (c)

2 a) $\Delta P_{tieA} = \beta_A \Delta f - 0 = 10 \Rightarrow \beta_A \Delta f = 10$

$\Delta P_{tieB} = \beta_B \Delta f - 50 = -10 \Rightarrow \beta_B \Delta f = 40$

$\Rightarrow \Delta f = \frac{10}{\beta_A} \Rightarrow \beta_B = 4\beta_A$ — ①

After trip,



$$\Delta f_A = \frac{-(-10)}{\beta_A} = \frac{10}{\beta_A}$$

$$\Delta f_B = \frac{-(10)}{\beta_B} = \frac{-10}{\beta_B}$$

$$\Delta f_A - \Delta f_B = \frac{10}{\beta_A} + \frac{10}{\beta_B} = 0.125 \quad — ②$$

Sub ① into ②,

$$\frac{10}{\beta_A} + \frac{10}{4\beta_A} = 0.125$$

$$\frac{12.5}{\beta_A} = 0.125 \Rightarrow \beta_A = 100\ MW/Hz \ \#$$

$$\beta_B = 400\ MW/Hz \ \#$$

b) $ICR_1 = 5 + 0.016P_1$

$ICR_2 = 5.5 + 0.018P_2$

$ICR_3 = 4.5 + 0.014P_3$

$P_D = 550MW$

i) $P_1 = (\lambda - 5)/0.016$

$P_2 = (\lambda - 5.5)/0.018$

$P_3 = (\lambda - 4.5)/0.014$

$P_1 + P_2 + P_3 = P_D$

$(\lambda-5)/0.016 + (\lambda-5.5)/0.018 + (\lambda-4.5)/0.014 = 550$

$62.5\lambda - 312.5 + 55.6\lambda - 305.6 + 71.4\lambda - 321.4 = 550$

$\Rightarrow 189.5\lambda = 1489.5$

$\lambda = 7.86$

$\Rightarrow P_1 = 178.8MW$ #

$\Rightarrow P_2 = 131.1MW$ #

$\Rightarrow P_3 = 240.0MW$ #

ii) Since $P_2 < P_{2min}$, $\therefore$ Set $P_2 = 150MW$

$P_1 + 150 + P_3 = 550 \Rightarrow P_3 = 400 - P_1$ — (1)

$ICR_1 = ICR_3$

$5 + 0.016P_1 = 4.5 + 0.014P_3$ — (2)

Sub (1) into (2),

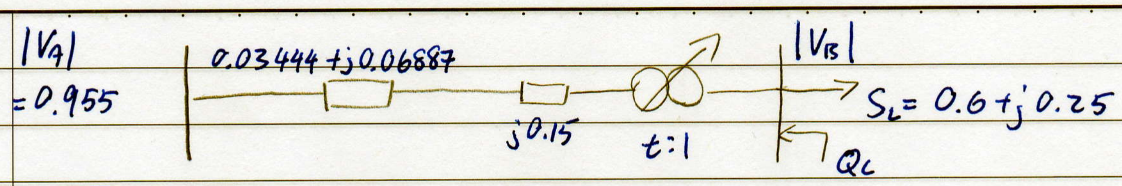
$5 + 0.016P_1 = 4.5 + 0.014(400 - P_1)$

$\Rightarrow P_1 = 170MW$ #

$P_3 = 230MW$ #

& $P_2 = 150MW$ #

3)



$S_b = 20 MVA$

$V_{b1} = 66 kV$, $V_{b2} = 11 kV$

$Z_{b1} = 217.8 \Omega$

a) $|V_B| = 1$, $Q_c = 0$,

$$|V_A| - t|V_B| = \frac{RP + QX}{t|V_B|}$$

$$0.955 - t = \frac{(0.03444)(0.6) + (0.25)(0.15 + 0.06887)}{t}$$

$$t^2 - 0.955t + 0.0753815 = 0$$

$$\Rightarrow t = 0.868 \text{ \#}, \quad 0.0868 \text{ (reject)}$$

b) When $t = 1$, $Q_c = 0$,

Since $|V_A|$, R, P, Q, X is fix, $t|V_B|$ must also be constant.

Let $k = t|V_B|$,

$$k^2 - 0.955k + 0.0753815 = 0$$

$$k = 0.868, \quad 0.0868 \text{ (reject)}$$

$$\Rightarrow t|V_B| = 0.868$$

$$S_{loss} = |I_A|^2 \times Z_{loss}, \quad |I_A|^2 = \frac{P_L^2 + Q_L^2}{t^2|V_B|^2}$$

$$\therefore |I_A|^2 = 0.561$$

$$\Rightarrow P_{loss\ actual} = |I_A|^2 \times (0.03444) \times S_b = 0.386\ MW \text{ \#}$$

$$Q_{loss\ actual} = |I_A|^2 \times (0.15 + 0.06887) \times S_b = 2.455\ MVar \text{ \#}$$

Since $t|V_B| = 0.868$, $\therefore |I_A|^2$ is always constant. Hence the loss cannot be reduced if the tap changing transformer is installed. #

c) $t = 0.9$, $|V_B| = 1$

$$|V_A| - t|V_B| = \frac{RP + X(Q_L - Q_c)}{t|V_B|}$$

$$0.955 - 0.9 = \frac{(0.03444)(0.6) + (0.15 + 0.06887)(0.25 - Q_c)}{0.9}$$

$Q_c = 0.11825$

$\Rightarrow Q_{c\,actual} = Q_c \times S_b = 2.365\ MVar$ #

4 a) $Z_1 = j0.2 + j0.21 + j(0.84)/2 = j0.83$

$I_0 = (S_0/V_0)^* = 1.02\angle -11.3^\circ$

$E = V_0 + I_0 Z_1 = 1.43\angle 35.4^\circ$

$\therefore P_{e1} = \left|\frac{E'V_0}{Z_1}\right| \sin\delta = 1.724 \sin\delta$ #

b) $\delta_c = 900 \times (0.1)^2 + 35.4^\circ$

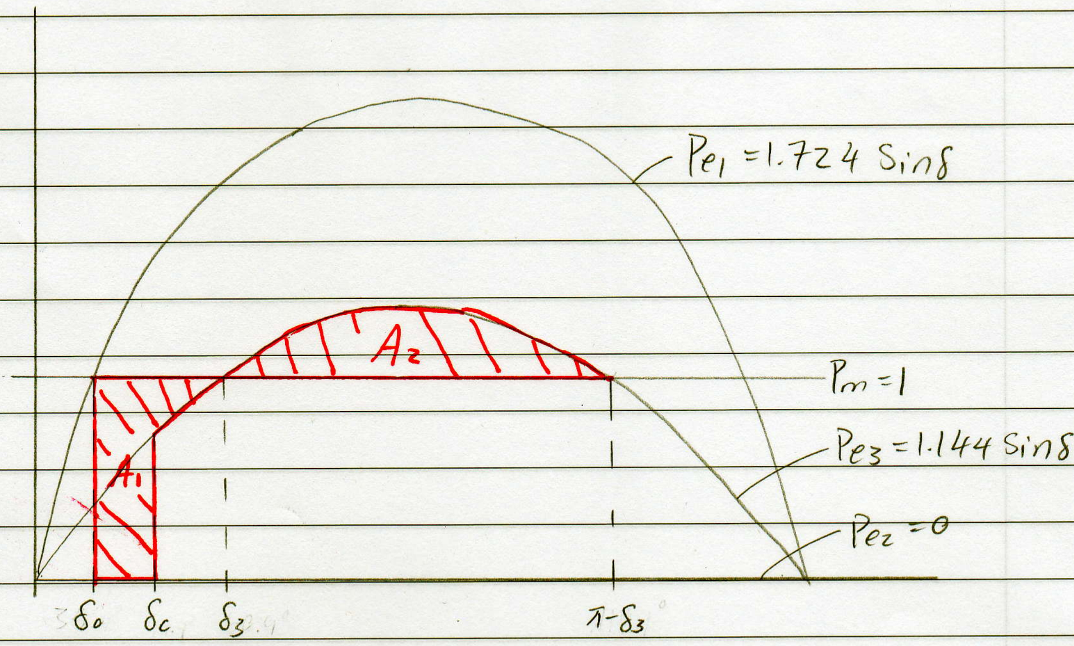
$= 44.4^\circ$

$\cancel{Z_2 =}\ P_{e2} = 0$

$Z_3 = j0.2 + j0.21 + j0.84 = j1.25$

$P_{e3} = \left|\frac{E'V_0}{Z_3}\right| \sin\delta = 1.144 \sin\delta$

$\delta_3 = \sin^{-1}\left(\frac{1}{1.144}\right) = 60.9^\circ$



$\delta_0 = 35.4^\circ$

$\delta_c = 44.4^\circ$

$\delta_3 = 60.9^\circ$

$\pi - \delta_3 = 119.1^\circ$

$$A_1 = \int_{\delta_0}^{\delta_c} (P_m - P_{e2})\,d\delta + \int_{\delta_c}^{\delta_3} (P_m - P_{e3})\,d\delta$$

$$= \int_{\delta_0}^{\delta_c} (1)\,d\delta + \int_{\delta_c}^{\delta_3} (1 - 1.144\sin\delta)\,d\delta$$

$$= [\delta]_{\delta_0}^{\delta_c} + [\delta + 1.144\cos\delta]_{\delta_c}^{\delta_3}$$

$$= [0.157] + [0.02699]$$

$$= 0.184$$

$$A_2 = \int_{\delta_3}^{\pi-\delta_3} (P_{e3} - P_m)\,d\delta$$

$$= \int_{\delta_3}^{\pi-\delta_3} (1.144\sin\delta - 1)\,d\delta$$

$$= [-1.144\cos\delta - \delta]_{\delta_3}^{\pi-\delta_3}$$

$$= 0.097$$

$A_1 > A_2 \quad \therefore$ Unstable. #