PYP EE4530 NOV/DEC 11 Megarine Tee

1)

$R_1 = 0.05$ Base 10MW , $f_{1nl} = 1.02 = 51$ Hz
$R_2 = 0.05$ Base 5MW , $f_{2nl} = 1.01 = 50.5$ Hz

$S_B = 10$ MVA , $f_B = 50$ Hz

$$\Delta f = \frac{-\Delta P_L}{1/R_1 + 1/R_2 + D}$$ } only when ~~both~~ operate at same f_{sys}.

$R_{2new} = R_{2old} \times \left[\frac{S_{Bnew}}{S_{B old}}\right] = 0.05\left[\frac{10}{5}\right]$
$= 0.1$

$\Delta P_{L Total} = 1$, $\Delta P_{LA} = 0.1$

a) Since at initial, both does not operate at same frequency, $f_{1nl} > f_{2nl}$, there will be power generated by machine 1 before machine 2 connect.

$\therefore \Delta f_1 = \frac{-\Delta P_{L1}}{1/R_1 + D}$ where Δf_1 is the drop from 1.02 to 1.01

$\Rightarrow \Delta f_1(1/R_1 + D) = -\Delta P_{L1}$

$\Rightarrow (-0.01)\left(\frac{1}{0.05} + 1\right) = -\Delta P_{L1}$ $\Rightarrow \Delta P_{L1} = 0.21$

Remaining $\Delta P_L = \Delta P_{L Total} - \Delta P_{L1} = 0.79$

$$\therefore \Delta f_2 = \frac{-\Delta P_L}{1/R_1 + 1/R_2 + D} = \frac{-0.79}{1/0.05 + 1/0.1 + 1} = -0.02548$$

$\Rightarrow \Delta f_{2\,act} = -1.2742$ Hz

$\therefore f_{1\,sys} = f_{2nl} + \Delta f_{2\,act} = 49.2258$ Hz #

$$\Delta f_3 = \frac{-\Delta P_{LA}}{1/R_1 + 1/R_2 + D} = \frac{-0.1}{1/0.05 + 1/0.1 + 1} = -0.00323$$

$\Rightarrow \Delta f_{3\,act} = -0.1613$ Hz

$\therefore f_{2\,sys} = f_{1\,sys} + \Delta f_{3\,act} = 49.06$ Hz #

$P_{g1} = -\frac{1}{R_1}(\Delta f_1 + \Delta f_2 + \Delta f_3) = \frac{-1}{0.05}(-0.01 - 0.02548 - 0.00323) = 0.7742$

$P_{g2} = -\frac{1}{R_2}(\Delta f_2 + \Delta f_3) = \frac{-1}{0.1}(-0.02548 - 0.00323) = 0.2871$

$\therefore P_{g1\,act} = 7.742$ MW #

$P_{g2\,act} = 2.871$ MW #

b) Loss Case: $ICR = \frac{dCR}{dP}$, $P_1 + P_2 = P_D + P_{loss}$

$ICR_1 = 8 + 0.2P_1$ $\Rightarrow \lambda = 8 + 0.2P_1$

$ICR_2 = 6 + 0.4P_2$ $\Rightarrow \lambda\left(1 - \frac{\partial P_{loss}}{\partial P_2}\right) = 6 + 0.4P_2$

$P_{loss} = 0.015(P_2 - 4)^2$

$\frac{\partial P_{loss}}{\partial P_2} = 0.03P_2 - 0.12$

Since $P_1 = 5MW$ at optimal economic dispatch, both have same λ

$\lambda = 8 + 0.2(5) = 9$ \$/MWh #

$\lambda - \lambda\frac{\partial P_{loss}}{\partial P_2} = 6 + 0.4P_2$

$\lambda - 0.03\lambda P_2 + 0.12\lambda = 6 + 0.4P_2$

$9 - 0.03 \times 9 \times P_2 + 0.12 \times 9 = 6 + 0.4P_2$

$\Rightarrow P_2 = 6.09 MW$ #

$P_{loss} = 0.015[(6.09 - 4)]^2 = 0.06552 MW$ #

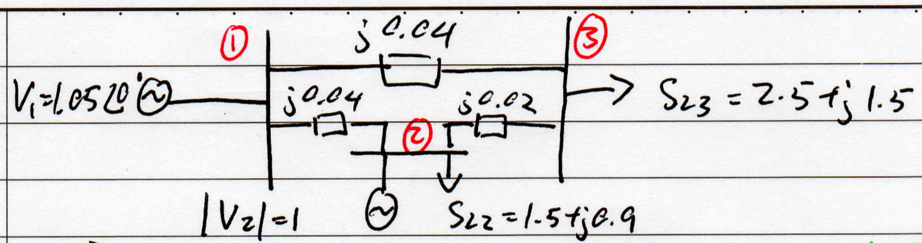
$P_1 + P_2 = P_D + P_{loss}$

$\Rightarrow P_D = P_1 + P_2 - P_{loss}$

$= 5 + 6.09 - 0.06552$

$= 11.02448 MW$ #

2)



$P_{g2} = 2.5, \quad -1 \leq Q_{g2} \leq 1$

$$\begin{bmatrix} Y_{11} & Y_{12} & Y_{13} \\ Y_{21} & Y_{22} & Y_{23} \\ Y_{31} & Y_{32} & Y_{33} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix}$$

$$Y_{bus} = \begin{bmatrix} -j50 & j25 & j25 \\ j25 & -j75 & j50 \\ j25 & j50 & -j75 \end{bmatrix}$$

$$S = VI^* = P + jQ$$

$$V_3 = \left[\left(\frac{S_3}{V_3} \right)^* - V_1 Y_{31} - V_2 Y_{32} \right] \frac{1}{Y_{33}}$$

$$V_2 = \left[\left(\frac{S_2}{V_2} \right)^* - V_1 Y_{21} - V_3 Y_{32} \right] \frac{1}{Y_{22}}$$

$$Q_2 = V_2 V_1 Y_{21} \sin(\delta_2 - \delta_1 - \gamma_{21}) + V_2 V_2 Y_{22} \sin(\delta_2 - \delta_2 - \gamma_{22}) + V_2 V_3 Y_{23} \sin(\delta_2 - \delta_3 - \gamma_{23})$$

Using G-S : $V_3^0 = 1\angle 0, \ \delta_2^0 = 0, \ Q_2^0 = 0$

$$V_3^{k+1} = \left[\left(\frac{S_3}{V_3^k} \right)^* - V_1 Y_{31} - V_2^k Y_{32} \right] \frac{1}{Y_{33}}$$

$$Q_2^{k+1} = V_2^k V_1 Y_{21} \sin(\delta_2^k - \delta_1 - \gamma_{21}) + V_2^k V_2^k Y_{22} \sin(\delta_2^k - \delta_2^k - \gamma_{22}) + V_2^k V_3^{k+1} Y_{23} \sin(\delta_2^k - \delta_3^{k+1} - \gamma_{23})$$

$$V_2^{k+1} = \left[\left(\frac{P_{g2} - P_{L2} + jQ_2^{k+1}}{V_2^k} \right)^* - V_1 Y_{21} - V_3^{k+1} Y_{23} \right] \frac{1}{Y_{22}}$$

$$V_3^1 = \left[\left(\frac{-2.5 - j1.5}{1\angle 0} \right)^* - 1.05\angle 0 \times j25 - 1\angle 0 \times j50 \right] \frac{1}{-j75} = 0.9972 \angle -1.9155° \ \#$$

$$Q_2^1 = 1.05 \times 25 \sin(-90°) + 75 \sin(90°) + 0.9972 \times 50 \sin(1.9155° - 90°)$$
$$= -1.0821$$

$$V_2^1 = \left[\left(\frac{2.5 - 1.5 + j(-1.0821)}{1\angle 0°} \right)^* - 1.05\angle 0° \times j25 - j50 \times 0.9972 \angle -1.9155° \right] \frac{1}{-j75} = 1\angle -0.509° \ \#$$

$$Q_{g2}^1 = Q_2^1 + Q_{L2} = (-1.0821) + 0.9$$
$$= -0.1821 \ \#$$

b) $I_{12} = (V_1 - V_2)/j0.04 = 1.2705 \angle -79.9°$

$I_{13} = (V_1 - V_3)/j0.04 = 1.5728 \angle -58°$

$S_{12} = V_1 I_{12}^* = 1.334 \angle 79.9° = 0.23394 + j1.31335$ #

$S_{13} = V_1 I_{13}^* = 1.651 \angle 58° = 0.87513 + j1.4005$ #

c) Since the network is inductive, ∴ Total real power supply by generator is equal to total load real power.

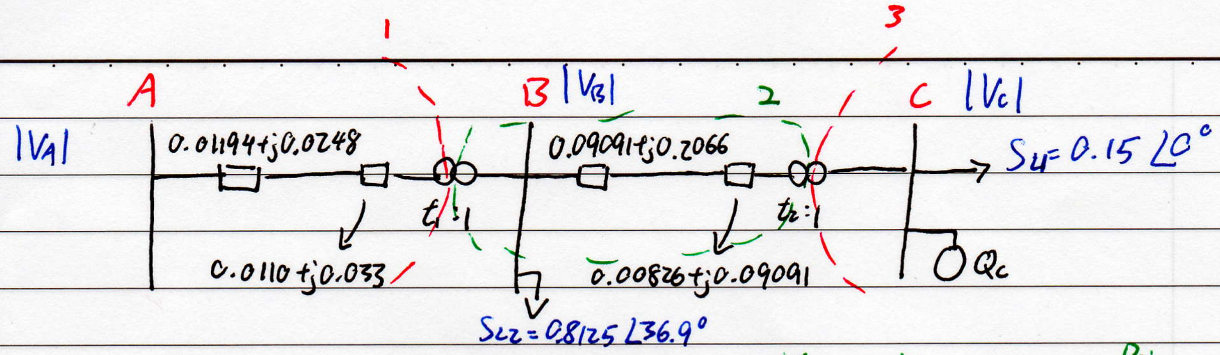
$P_{g1} + P_{g3} = (0.23394 + 0.87513 + 2.5) = 3.60907$

$P_{L2} + P_{L3} = (2.5 + 1.5) = 4$

$P_{g1} + P_{g3} \neq P_{L2} + P_{L3}$

∴ The values in (a) had not converge to final value. #

3)



$V_{pri} = a V_{sec}$, a is $\frac{pri}{sec}$ turn ratio

$Z_{pri} = a^2 Z_{sec}$

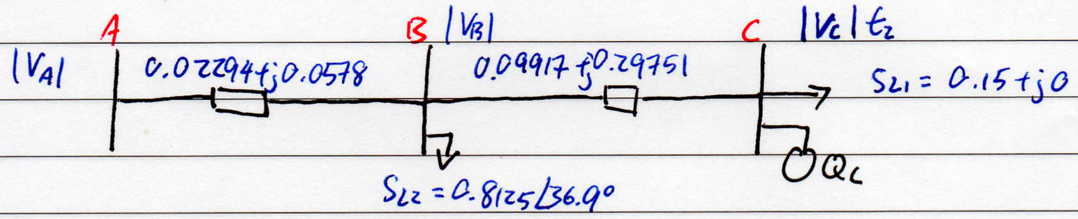
$S_B = 10\,MVA$

$V_{B1} = 33\,kV$ $\quad$ $V_{B2} = 11\,kV$ $\quad$ $V_{B3} = 0.415\,kV$

$Z_{B1} = 108.9\,\Omega$ $\quad$ $Z_{B2} = 12.1\,\Omega$ $\quad$ $Z_{B3} = 0.0172225$

a) $|V_C| = 1$, $t_1 = 1$, $t_2 = 0.97$, $Q_c = 0$

Since $t_1 = 1$,

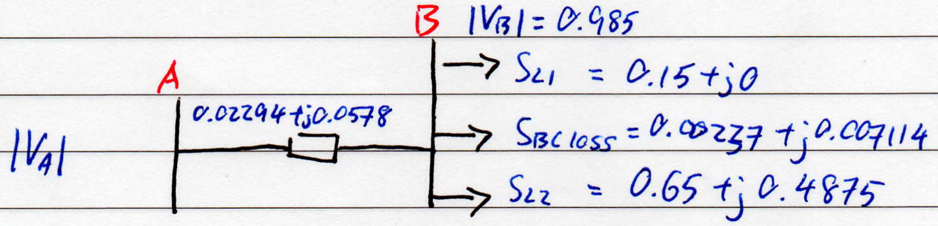


$$|V_B| - |V_C|t_2 = \frac{P_C R_{BC} + Q_C X_{BC}}{|V_C| t_2}$$

$$\Rightarrow |V_B| - 0.97 = \frac{(0.15)(0.09917) + 0}{0.97} \Rightarrow |V_B| = 0.985$$

$$I_{BC} = \left(\frac{S_C}{V_C}\right)^*, \quad |I_{BC}|^2 = \left|\frac{S_C}{V_C}\right|^2 = \frac{P_C^2 + Q_C^2}{|V_C|^2}, \quad S_{BC\,loss} = |I_{BC}|^2 \times Z_{BC}$$

$$\Rightarrow S_{BC\,loss} = \frac{(0.15)^2 + 0}{|V_C t|^2} \times \left[0.09917 + j0.29751\right] = 0.00237 + j0.007114$$

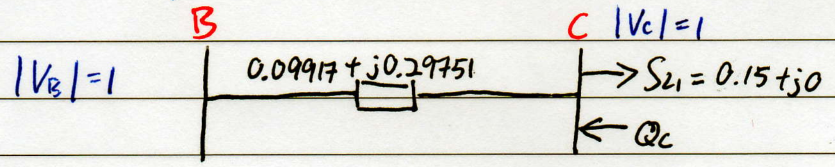


$$|V_A| - |V_B| = \frac{P_T R_{AB} + Q_T X_{AB}}{|V_B|}$$

$$\Rightarrow |V_A| - 0.985 = \frac{(0.15+0.00237+0.65)(0.02294) + (0+0.007114+0.4875)(0.0578)}{0.985}$$

$\Rightarrow |V_A| = 1.0327$ #

b) $t_1 = 1$, $t_2 = 1$, $|V_B| = 1$, $|V_B| = 1$, Q_c into bus C



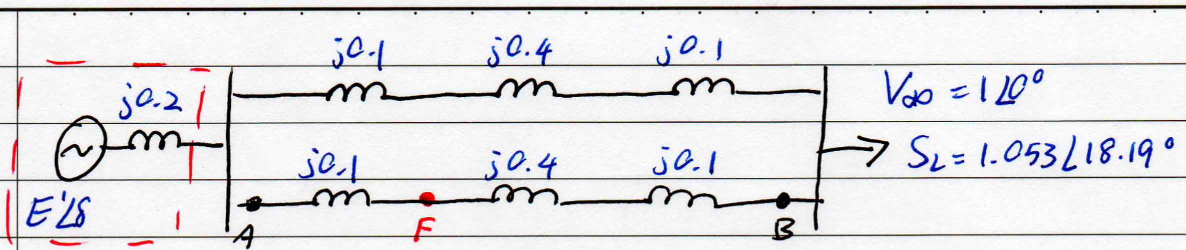
$$|V_B| - |V_C| = \frac{P_{21} R_{BC} + Q_{21} X_{BC}}{|V_C|} \qquad Q = Q_{21} - Q_c$$

$\Rightarrow 1 - 1 = (0.15)(0.09917) + (0 - Q_c)(0.29751)$

$Q_c = 0.05$

$\therefore Q_{c\,act} = 0.5$ MVar capacitative compensator. #

4)



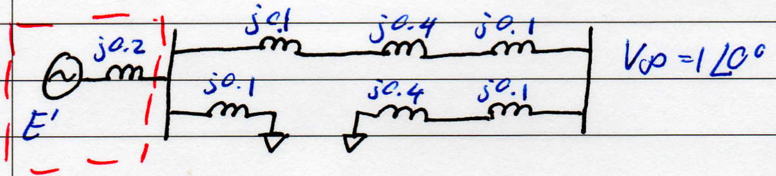
a) $I_L = \left(\frac{S_L}{V_\infty}\right)^* = 1.053\angle{-18.19^\circ}$

$Z_{T_1} = j0.2 + [j0.1 + j0.4 + j0.1]/2 = j0.5$

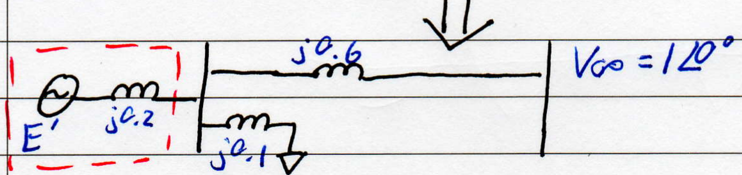
$E'\angle\delta = V_\infty + I_L Z_{T_1} = 1.267\angle 23.25^\circ$ $\quad |E'|$ is constant

$P_{e_1} = \left|\frac{E' V_\infty}{Z_{T_1}}\right| \sin\delta = 2.534 \sin\delta$ # (Pre fault)

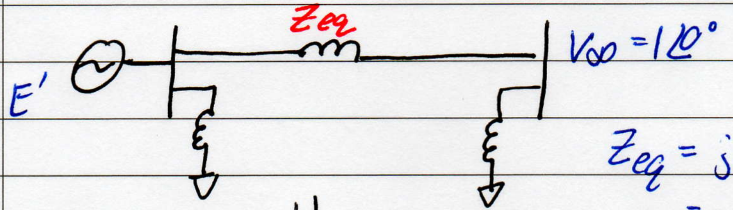
b)



⇓

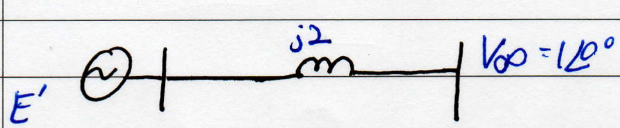


⇓ Y-Δ transformation

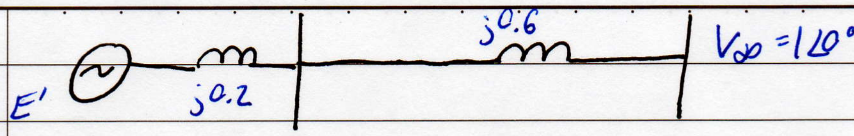


$Z_{eq} = j0.2 + j0.6 + \frac{j0.2 \times j0.6}{j0.1}$
$= j2$

⇓



$P_{e2} = \left|\frac{E' V_\infty}{Z_{eq}}\right| \sin\delta = 0.6335 \sin\delta$ (During Fault)

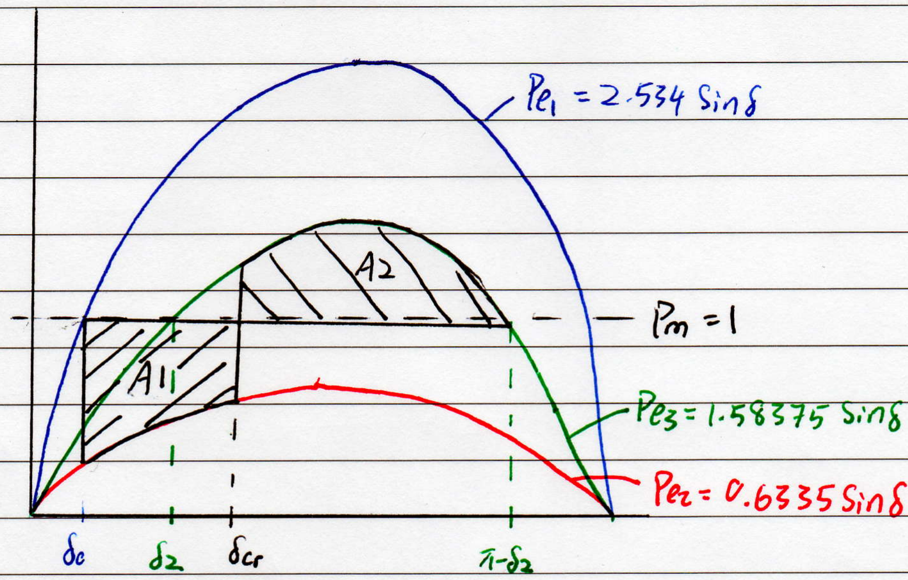


$$Z_{T3} = j0.2 + j0.6 = j0.8$$

$$P_{e3} = \left|\frac{E' V_\infty}{Z_{T3}}\right| \sin\delta = 1.58375 \sin\delta$$ (Post fault)

$\delta_0 = 23.25° = 0.4058\,\text{rad}$, $\delta_2 = \sin^{-1}\left(\frac{1}{1.58375}\right) = 39.15 = 0.6834\,\text{rad}$

$A_1 = A_2$



$$A_1 = \int_{\delta_0}^{\delta_{cr}} (P_m - P_{e2})\,d\delta = \int_{\delta_0}^{\delta_{cr}} (1 - 0.6335\sin\delta)\,d\delta = \left[\delta + 0.6335\cos\delta\right]_{\delta_0}^{\delta_{cr}}$$

$$A_2 = \int_{\delta_{cr}}^{\pi-\delta_2} (P_{e3} - P_m)\,d\delta = \int_{\delta_{cr}}^{\pi-\delta_2} (1.58375\sin\delta - 1)\,d\delta = \left[-1.58375\cos\delta - \delta\right]_{\delta_{cr}}^{\pi-\delta_2}$$

$$\left[\delta_{cr} + 0.6335\cos\delta_{cr} - \delta_0 - 0.6335\cos\delta_0\right] = \left[-1.58375\cos(\pi-\delta_2) - \pi + \delta_2 + 1.58375\cos\delta_{cr} + \delta_{cr}\right]$$

$$0.6335\cos\delta_{cr} - 0.98785 = 1.58375\cos\delta_{cr} - 1.2301$$

$$0.95025\cos\delta_{cr} = 0.24225$$

$$\Rightarrow \delta_{cr} = 1.313\,\text{rad} = 75.23°$$ #

c) Decrease P_m will increase A_2 & decrease A_1
Use capacitative line to decrease line impedance hence increase P_{max}. #