PYP EE4530 NOV/DEC 12 Megarine Tee

1a) $I_{31} = [V_3 - V_1]/[0.01 + j0.03] = 0.4272\angle 150°$

$S_{31} = V_3 I_{31}^* = 0.4443\angle -150.9°$

$I_{32} = [V_3 - V_2]/[0.0125 + j0.025] = 2.806\angle -35.6°$

$S_{32} = V_3 I_{32}^* = 2.9187\angle 35.1°$

$S_3 = S_{31} + S_{32} = 2.4772\angle 36.158 = 2 + j1.4616$

$\therefore S_{3act} = 247.72\ MVA$ #, $Q_{g3} = 146.16\ MVar$ out of generator. #

b) $I_{21} = [V_2 - V_1]/[0.02 + j0.04] = 2.048\angle 146.5°$

$S_{21} = V_2 I_{21}^* = 1.99\angle -149.2°$

$I_{23} = -I_{32} = 2.806\angle 144.4°$

$S_{23} = V_2 I_{23}^* = 2.7265\angle -147.1°$

$\therefore S_{21act} = 199\ MVA$ #, $S_{23act} = 272.65\ MVA$ #

c) $S_{L23} = |I_{23}|^2 \times [0.0125 + j0.025]$

$= 0.09842 + j0.1968 = 0.22\angle 63.4°$

$\therefore S_{L23act} = 22\ MVA$, $P_{L23act} = 98.42\ MW$, $Q_{L23act} = 19.68\ MVar$ #

2) $R_A = 0.05$ Base of 200MW

$R_B = 0.08$ Base of 350MW

$D = 2$

$f_{o\,sys} = 50\,Hz$, $P_A = 100\,MW$, $P_B = 227.5\,MW$

$P_L = 35\,MW$

$R_{new} = R_{old}\left[\frac{S_{B\,new}}{S_{B\,old}}\right]$

$S_B = 350\,MVA$

$P_L = 0.1$, $R_{A\,new} = 0.05 \times \left[\frac{350}{200}\right] = 0.0875$

a i) $\Delta f = \frac{-\Delta P_L}{1/R_A + 1/R_B + D} = \frac{-0.1}{\frac{1}{0.0875} + \frac{1}{0.08} + 2} = -0.003857$

$\Rightarrow \Delta f_{act} = -0.1928\,Hz$

$\therefore f_{n\,sys} = f_{o\,sys} + \Delta f_{act} = 49.81\,Hz$ #

$\Delta P_A = -\Delta f / R_A = 0.04408 \Rightarrow \Delta P_{A\,act} = 15.428\,MW$

$\Delta P_B = -\Delta f / R_B = 0.04821 \Rightarrow \Delta P_{B\,act} = 16.874\,MW$

$P_{A\,new} = P_A + \Delta P_{A\,act} = 115.428\,MW$ #

$P_{B\,new} = P_B + \Delta P_{B\,act} = 244.374\,MW$ #

ii) Under power balance, $\Delta P_A + \Delta P_B = \Delta P_L$

But $\Delta P_A + \Delta P_B = 0.09229 \neq 0.1$

$\therefore$ The different is due to frequency sensitive load change

$D\Delta f = -0.007714$

Hence $\Delta P_A + \Delta P_B - \Delta f D = \Delta P_L = 0.1$ #

b) $ICR = \frac{dCR}{dP}$, $P_D = 210MW$

$ICR_A = 4.1 + 0.007 P_A$

$ICR_B = 4.8 + 0.014 P_B$

i) Lossless case:

$\lambda = ICR_A = ICR_B$

$P_A + P_B = P_D$

$4.1 + 0.007 P_A = 4.8 + 0.014[210 - P_A]$

$\Rightarrow \quad P_A = 173.3MW$ # $\quad \lambda = 5.313$ \$/MWHr #

$P_B = 36.7MW$ #

ii) Loss case: $P_{loss} = 0.001(P_A - 50)^2$

$4.1 + 0.007 P_A = \lambda\left(1 - \frac{\partial P_{loss}}{\partial P_A}\right) = \lambda(1 - 0.002P_A + 0.1)$ —①

$4.8 + 0.014 P_B = \lambda$ —②

$P_A + P_B = P_D + P_{loss}$ —③

Assume $\lambda = 6$,

From ①, $P_A = 131.6MW$

From ②, $P_B = 85.7MW$

Sub into ③, $P_A + P_B = 210 + [0.001(P_A - 50)^2]$

$217.3 \approx 216.7$

$\therefore \lambda$ is approximately \$6/MW-Hr #

iii) Since λ is constant, & loss factor is $\frac{1}{1 - \frac{\partial P_{loss}}{\partial P}} = L$, $ICR \times L = \lambda$

when L increase, ICR decrease hence P_g decrease.

Since L_A increase, P_A will decrease as observe from the 2 results. #

Method 2: Iteration

$$4.1 + 0.007 P_A^{k+1} = \lambda^k (1 - 0.002 P_A^k + 0.1) \quad -①$$
$$4.8 + 0.014 P_B^{k+1} = \lambda^k \quad -②$$

$$P_A^{k+1} + P_B^{k+1} = P_D + P_{loss}^k \quad -③$$

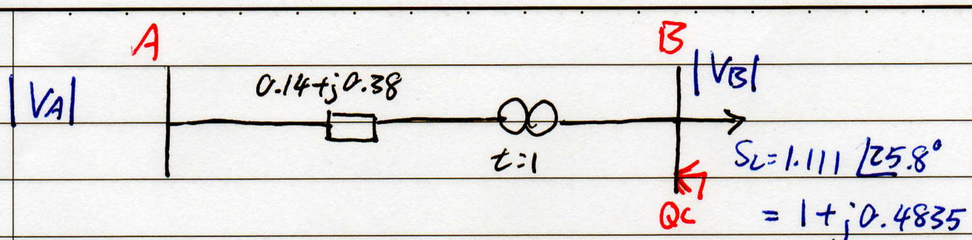
From ①, $P_A^{k+1} = [\lambda^k(1.1 - 0.002 P_A^k) - 4.1]/[0.007]$
From ②, $P_B^{k+1} = [\lambda^k - 4.8]/[0.014]$

∴ From ③,
$$[1.1\lambda^k - 0.002\lambda^k P_A^k - 4.1]/[0.007] + [\lambda^k - 4.8]/[0.014] = P_D + P_{loss}^k$$

Once λ^k is known, sub λ^k into eq ①, ② to find P_A^{k+1} & P_B^{k+1}
Once λ, P_A, P_B & P_{loss} converge, their final value can be known.

k	Pa	Pb	Ploss	λ
0	173.3	36.7	15.203	6.444
1	107.8	117.4	3.341	5.774
2	143.8	69.6	8.794	6.120
3	124.5	94.3	5.557	5.928
4	134.9	80.6	7.216	6.030
5	129.4	87.9	6.298	5.975
6	132.4	83.9	6.785	6.004
7	130.8	86.0	6.521	5.989
8	131.6	84.9	6.663	5.997
9	131.2	85.5	6.586	5.992
10	131.4	85.2	6.627	5.995
11	131.3	85.4	6.605	5.994
12	131.3	85.3	6.617	5.994
13	131.3	85.3	6.611	5.994
14	131.3	85.3	6.614	5.994
15	131.3	85.3	6.612	5.994
16	131.3	85.3	6.613	5.994
17	131.3	85.3	6.613	5.994

3)



$S_B = 100MVA$

$V_{B1} = 132kV$, $V_{B2} = 11kV$

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

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

a) $|V_B| = 1$, $t = 1$,

$$|V_A| - |V_B| = \frac{PR + QX}{|V_B|} \Rightarrow |V_A| = 1.32373 \Rightarrow V_A = 174.7 kV \#$$

b) $|V_B| = 1$, $t = 0.85$ $a = t$ (refer from Pri)

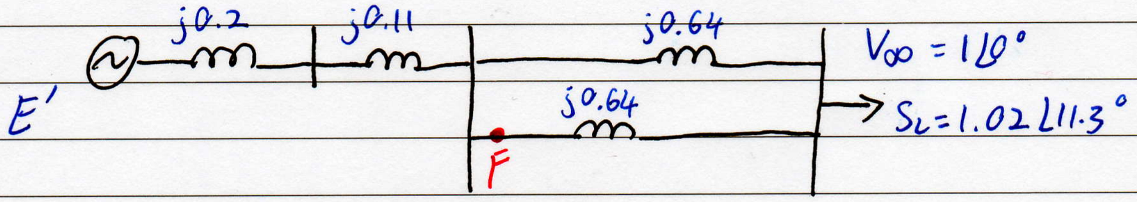
$$|V_A| - t|V_B| = \frac{PR + QX}{t|V_B|} \Rightarrow |V_A| = 1.231 \Rightarrow V_A = 162.5kV \#$$

c) $|V_A| = 1$, $|V_B| = 1$, $t = 0.85$, $Q = Q_L - Q_C$

$$|V_A| - t|V_B| = \frac{PR + X(Q_L - Q_C)}{t|V_B|} \Rightarrow Q_C = +0.5164 \text{ (into bus B)}$$

$\therefore Q_C = 0.5164$ ~~inductive~~ capacitative compensator. $\Rightarrow Q_{C act} = 51.64 MVar \#$

4)



a) $I_L = \left(\frac{S_L}{V_\infty}\right)^* = 1.02\angle -11.3°$

$Z_{T_1} = j0.2 + j0.11 + [j0.64]/2 = j0.63$

$E'\angle\delta = V_\infty + I_L Z_{T_1} = 1.29\angle 29.2°$ E' is constant

$P_{e1} = \left|\frac{E'V_\infty}{Z_{T_1}}\right| \sin\delta = 2.0476 \sin\delta$ * (Before)

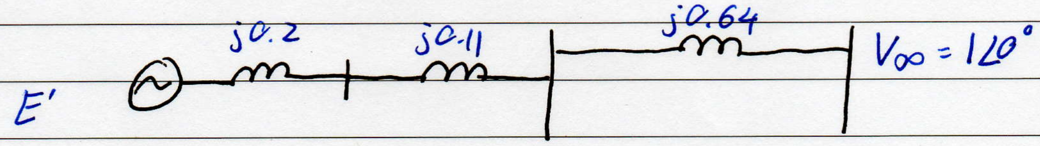
b) $\frac{\omega_s P_m}{4H} = 15.708\ \text{rad/s}^2$, $\delta_c = \frac{\omega_s P_m}{4H} t_c^2 + \delta_0$ rad.

$\delta_0 = 29.2° = 0.5096$ rad , $t_c = 0.12$ s

$\delta_c = 15.708 \times (0.12)^2 + 0.5096 = 0.7358$ rad

Since 3-phase to ground fault occur at bus,

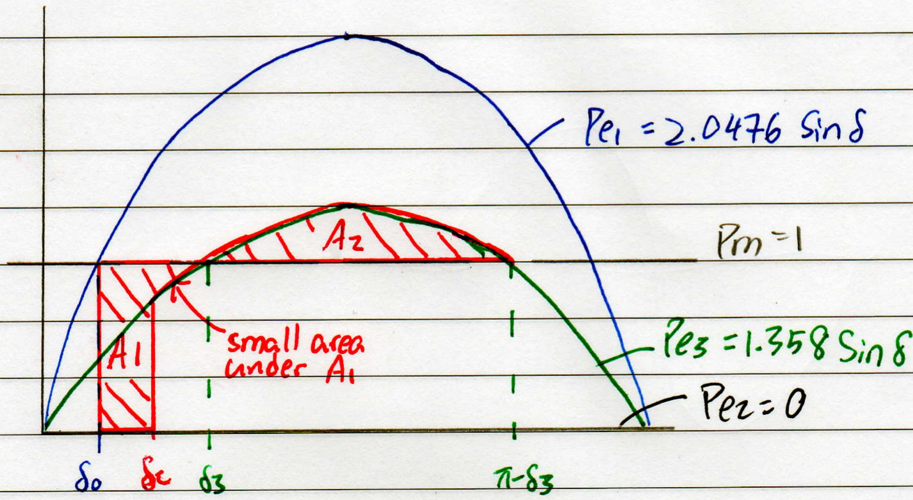
$\Rightarrow P_{e2} = 0 \sin\delta$ (During)



$Z_{T2} = j0.2 + j0.11 + j0.64 = j0.95$

$P_{e3} = \left|\frac{E'V_\infty}{Z_{T2}}\right| \sin\delta = 1.358 \sin\delta$ (After)

$\delta_3 = \sin^{-1}\left(\frac{1}{1.358}\right) = 0.827$ rad.



$$A_1 = \int_{\delta_0}^{\delta_c} (P_m - P_{e2})\, d\delta + \int_{\delta_c}^{\delta_3} (P_m - P_{e3})\, d\delta = \int_{\delta_0}^{\delta_c} (1-0)\, d\delta + \int_{\delta_c}^{\delta_3} (1 - 1.358 \sin\delta)\, d\delta$$

$$= \left[\delta\right]_{\delta_0}^{\delta_c} + \left[\delta + 1.358\cos\delta\right]_{\delta_c}^{\delta_3} = 0.2262 + \cancel{(-0.0879)}\ 0.004$$

$$= \cancel{0.1383}\ 0.2302$$

$$A_2 = \int_{\delta_3}^{\pi-\delta_3} (P_{e3} - P_m)\, d\delta = \int_{\delta_3}^{\pi-\delta_3} (1.358 \sin\delta - 1)\, d\delta$$

$$= \left[-1.358\cos\delta - \delta\right]_{\delta_3}^{\pi-\delta_3}$$

$$= 0.3513$$

$A_2 > A_1$ ∴ The system is stable #

c) Increase P_{e3max} so that A_2 can be increased #