Date : Dec. 10, 2002 | Name : MIDTERM | Course : EECE 471E

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ANY ASSISTANCE ON THIS QUIZ OR EXAM.

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1)

$r = 0.1091\ \Omega/km$

a) $l = 2\times10^{-7} \ln \frac{D}{R_b} = 2\times10^{-7} \ln \frac{7.56}{0.0491} = 2\times10^{-7} \times 5.039 = 10.08\times10^{-4}$ (15.4)

$10.1\times10^{-4}\ H/km$

$D = \sqrt[3]{6\times6\times12} = 7.56$

$R_b = \sqrt{8.024\times300} = 49.06\ mm = 0.0491\ m$

$r' = 10.3\, e^{-\frac{1}{4}} = 8.024$ (radius)

$X_e = 50.08\times314.2\times10^{-7} = \boxed{0.317\ \Omega/km}$

$C = \frac{2\pi\times8.854\times10^{-12}}{\ln \frac{7.56}{\sqrt{10.3\times300}}} = \boxed{11.33\times10^{-12}\ F/m}$

$\sqrt{10.3\times300} = 0.0556$

$\ln 7.56 = 4.91$

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$Y_c = 314.2\times11.33\times10^{-12}\times10^{3} = \boxed{3.56\ \mu S/km}$

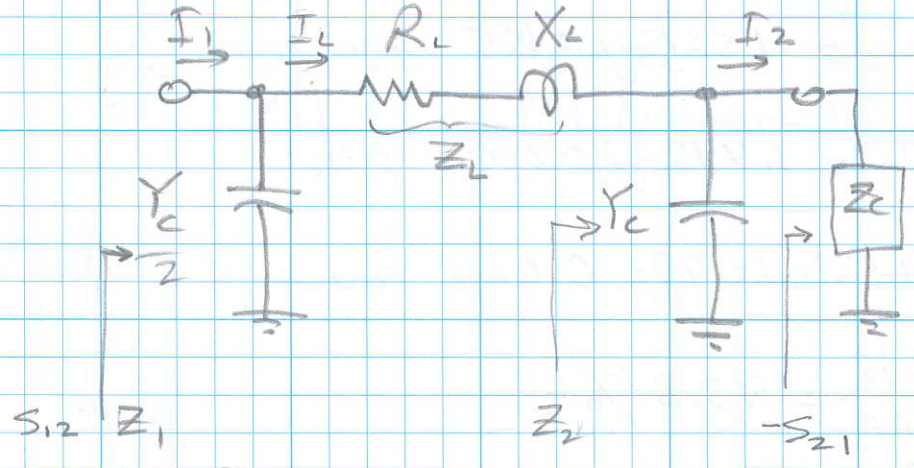
b) $z = 0.1091 + j0.317 = 0.335\angle 71$

$y = j3.56\times10^{-6} = 3.56\times10^{-6}\angle 90$

$\gamma = \sqrt{(0.335\angle 71)(3.56\times10^{-6}\angle 90)} = 1.09\times10^{-3}\angle 80.5$

c) $Z_c = \sqrt{\frac{z}{y}} = \frac{0.335\angle 71}{3.56\times10^{-6}\angle 90} = 306\angle -9.5^{\circ}\ \Omega$

d)



$$Z_b = \frac{(220)^2}{100} = 484\ \Omega$$

$$R_L = \frac{0.1091 \times 120}{484 \times 2} = 0.027\ p.u \qquad R + jX = 0.083\ \angle 71^\circ$$

$$X_L = \frac{0.317 \times 120}{484} = 0.0786\ p.u.$$

$$\frac{Y_c}{2} = \frac{3.56 \times 10^{-6} \times 120 \times 484}{2} = 0.1034\ p.u.$$

$$Z_c = \frac{306\ \angle -9.5^\circ}{484} = 0.632\ \angle -9.5^\circ = 0.6233 - j\,0.1043$$

e) $$Y_2 = \frac{Y_c}{2} + (Z_c)^{-1} = (j\,0.1034) + (0.623 - j\,0.104)^{-1} = 1.562 + j\,0.364$$

$$Z_2 = (Y_2)^{-1} = 0.607 - j\,0.142$$

$$V_2 = V_1 \times Z_2 / (Z_2 + Z_L) = 0.97 - j\,0.127 = 0.978\ \angle -7.5^\circ$$

$$I_2 = V_2 / Z_c = 1.548 + j\,0.0547 = 1.549\ \angle 2.024^\circ$$

$$I_1 = (V_1 - V_2) / Z_L = 1.561 + j\,0.155 = 1.569\ \angle 5.66^\circ$$

USE FOR ANSWER

$S_{12} = V_1 I_1^* = 1.561 - j0.155$ p.u.

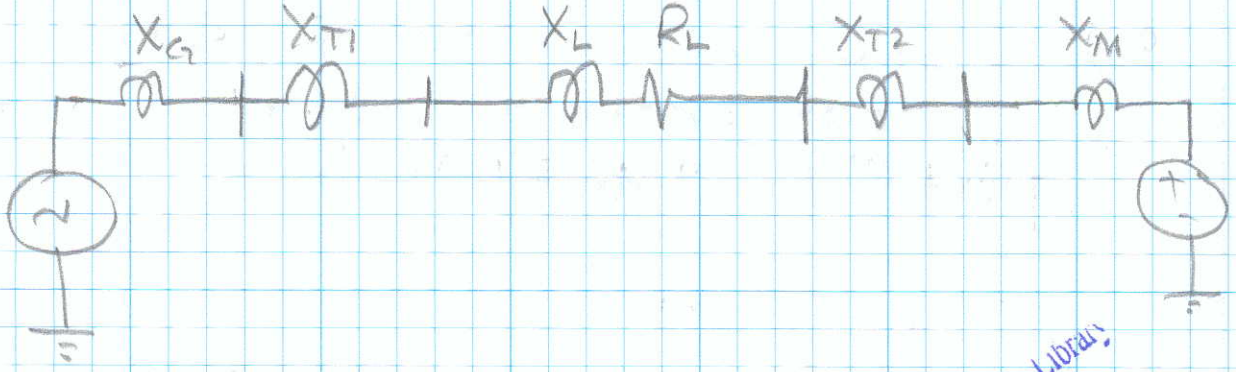
$-S_{21} = V_2 I_2^* = 1.495 - j0.250$ p.u.

$P_{Loss} = 1.561 - 1.495 = 0.066$ p.u. $= 6.6$ MW

$\eta = \frac{1.495}{1.561} = 95.8\%$

2.

b)



b) $MVA_B = 50$ MVA.

$X_G = 0.12$ p.u. no change

$$X_{T1} = X_{T1}^{o} \frac{Z_B^{o}}{Z_B^{n}} = X_{T1}^{o} \frac{(kV_B)^2}{MVA_B^{o}} \times \frac{MVA_B^{n}}{(kV_B)^2} = 0.1 \times \frac{50}{60} = 0.083 \text{ p.u.}$$

$$X_L = \frac{120}{(115)^2} \times 50 = 0.4536 \text{ p.u.}$$

$$R_L = \frac{24 \times 50}{(115)^2} = \frac{24}{264.5} = 0.09073 \text{ p.u.}$$

$$X_{T2} = 0.12 \times \frac{50}{40} = 0.15 \text{ p.u.}$$

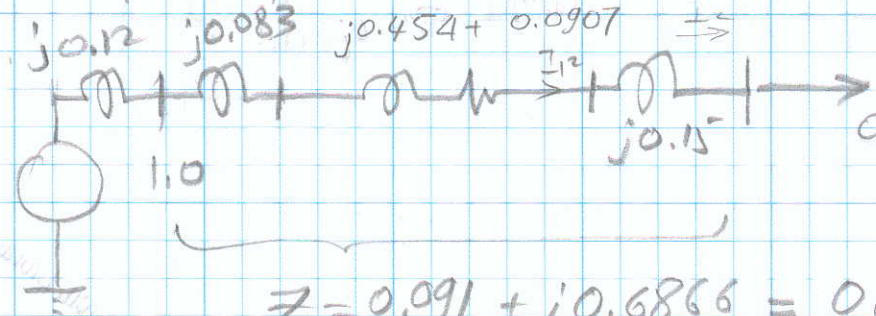
$$X_m = 0.08 \times \frac{50}{10} = 0.4 \text{ p.u. for each Motor}$$

$X_{MT} = 0.1333$ p.u. equivalent for all motors.

a)

Base	Gen	Line	Motor
V_B (kV)	13	115	11
S_B (MVA)	50	50	50
I_B (kA)	2.22	0.251	2.624
Z_B (Ω)	3.38	264.5	2.42

c) $V_G = 1.0$ p.u. $\qquad V_2 \angle \theta_2$



$$Z = 0.091 + j0.6866 = 0.6926 \angle 82.45^\circ$$

$$Y = 0.190 - j1.43$$

i) $-S_{21} = V_2 I_{12}^* = 0.48 + j0.30$ but $I_{12} = (V_1 - V_2)Y \Rightarrow$

$= V_2 (V_1^* - V_2^*) Y^* = (V_2 V_1^* - |V_2|^2) Y^* = 0.48 + j0.3 \Rightarrow$

$$\left(V_2 (\cos\theta_{21} + j \sin\theta_{21}) - V_2^2\right)(0.19 + j1.43) = 0.48 + j0.3$$

Real part is: $\left(V_2 \cos\theta_{21} - V_2^2\right) \times 0.19 - V_2\, 1.43 \sin\theta_{21} = 0.48$ *

Imaginary : $\left(V_2 \cos\theta_{21} - V_2^2\right) \times 1.43 + V_2\, 0.19 \sin\theta_{21} = 0.3$

This is a non-linear system of 2 equations in 2 unknowns to be solved by iterations.

ii) Model Motor as an impedance: $Z_M = 1/(0.48 - j0.3) = 0.848 + j0.53$

$V_2 = V_1 Z_M/(Z + Z_M) = 0.61 - j0.226 = 0.651 \angle -20.3^\circ$

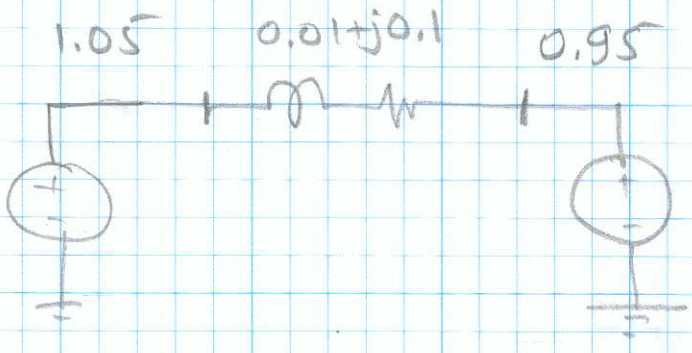
$I_1 = I_2 = V_1/(Z + Z_M) = 1/(0.939 + j1.217) = 0.397 - j0.515$

$S_1 = V_1 I_1^* = 0.397 + j0.515$ p.u.

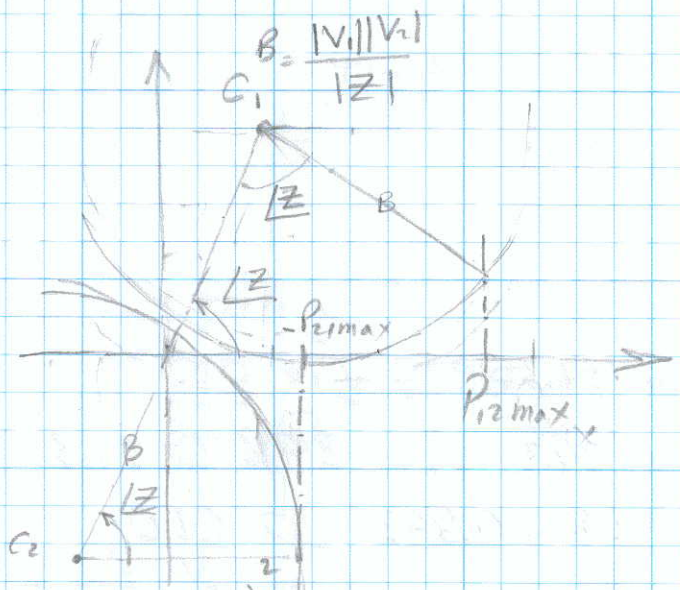
$S_1 = S_{1(p.u.)} \cdot S_{Base} = 19.87 + j25.75$

It can also be solved using The Circle diagram as explained in Midterm of 2001.

3)



a)



$$C_1 = \frac{(1.05)}{0.1} \angle 84.3 = 10.97 \angle 84.3$$

$$C_2 = -\frac{(0.95)^2}{0.1005} \angle 84.3 = -8.98 \angle 84.3 = 8.98 \angle -95.7^\circ$$

$$B = \frac{|V_1||V_2|}{|Z|} = 9.925$$

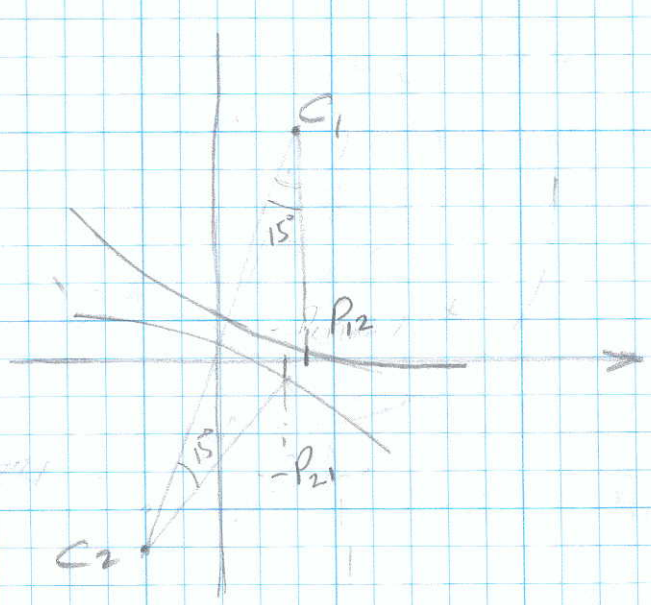
$$-P_{1max} = 9.925 - 8.98 \times \cos 84.3 = 9.079 \text{ p.u.}$$

$$P_{12max} = C_{1R} + B\cos\theta = 10.97 \times \cos 84.3 + 9.925 \times \cos 11.4$$

$$\theta = 180 - 2\angle Z = 11.4 = 10.82 \text{ p.u.}$$

b) $\theta = 84.3^\circ$

c)



When $\theta = 15^\circ$

$$-P_{21} = B\cos(84.3-15) - C_{2R}$$
$$= 9.925\cos(84.3-15) - 8.98\cos 84.3$$
$$= 3.508 - 0.892 = 2.616$$

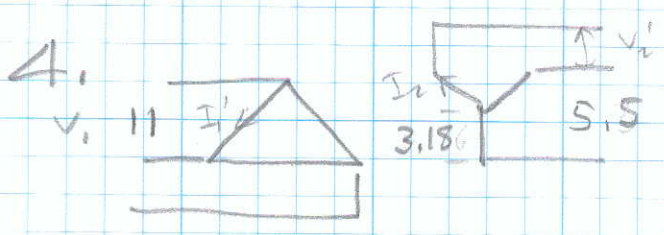
$$P_{12} = 10.97\cos 84.3 + 9.925\cos(-95.7+15)$$
$$80.7$$

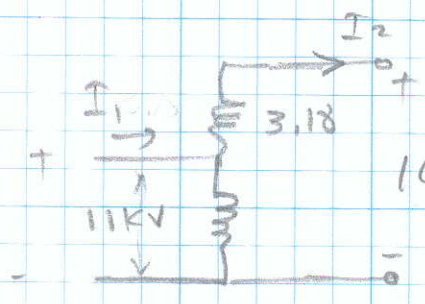
$$= 2.693$$

$$\Delta P = 2.693 - 2.616 = 0.143 \text{ p.u.}$$

$$\eta = \frac{2.616}{2.693} = 0.97 = 97\%$$

4.





Current ratings:

$$I_2 = \frac{500}{5.5 \times \sqrt{3}} = 52.5\ A.$$

$$V_1 I_1' = \frac{V_2'}{\sqrt{3}} I_2 \Rightarrow I_1' = \frac{V_2'}{\sqrt{3}\, V_1} \times I_2 = \frac{5.5}{\sqrt{3}\ 11} \times 52.5 = 15.15\ A.$$

$$\therefore I_1 = 15.15 + 52.5 = 67.66\ A$$

$$KVA = 2233\ KVA.$$