University of Jordan

Electrical Eng. Dept

EE 0933481 Power Systems (1) | **First Exam.**

Time: 75 minutes | **25-10-2016**

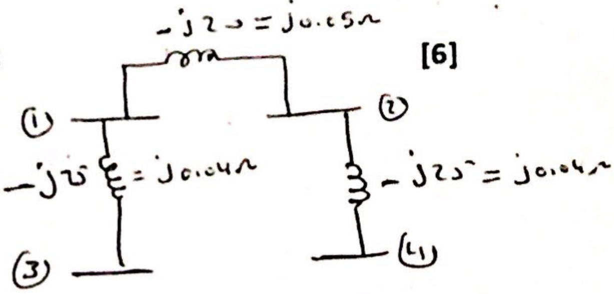
الاسم: رقم التفقد( ) الرقم الجامعي

Q1)a- If the 1st and 2nd rows of a given Bus Admittance Matrix are as follows, draw the corresponding Reactance Diagram.

1st Row: -j45 j20 j25 0

2nd Row: j20 -j45 0 j25 **[6]**

The system has 4 busbars



b-The power system showing Fig. 1 has the following data:

G: 300 MVA, 20 kV, X=20%

T_1: 350 MVA, (20 Δ/220 Y) kV, X=10%

T_2: 300 MVA, (220 Y/13.2 Δ) kV, X=10%

By using the PU system and selected Base values at the generator as 18 kV and 300 MVA, evaluate the followings when the generator is supplying its ratings at 0.8 PF lagging:

i)The voltage at point l. **[12]**

ii) The total current supplied to the motors M_1 and M_2 . **[4]**

i) (1) $X_G = j0.2 \times \left(\frac{20}{18}\right)^2 \times \left(\frac{300}{300}\right) = \boxed{j0.247}$

(2) $E = \frac{20}{18} = \boxed{1.1\angle 0°}$

(3) $X_{T_1} = j0.1 \times \left(\frac{20}{18}\right)^2 \times \frac{300}{350} = \boxed{j0.105}$

Fig. 1

ii) The motor currents are on the LV side and assuming + ve ph. sequence

$I_{M_1M_2} = 0.9\angle -36.87 + 30 - 30$

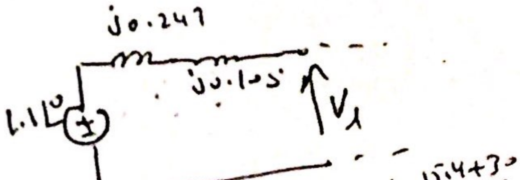
$= \boxed{\cancel{0.9\angle 0}}$

$= 0.9\angle -36.87$

$I_G = \frac{300 \times 10^6}{\sqrt{3} \times 20 \times 10^3} \angle 36.87 = 8660.3 \text{ A}$

$I_b = \frac{300 \times 10^6}{\sqrt{3} \times 18 \times 10^3} = 9622.5 \text{ A}$

$\therefore I_G = 8660.3/9622.5 \angle 36.87 = \boxed{0.9\angle 36.87}$



$\therefore V_l = 0.94\angle -15.4 + 30$
$= 0.94\angle 14.6$

(3). $V1 = 1.1\angle 0 - 0.9\angle 36.87 \times j.352 = 1.1\angle 0 - .317\angle 53.13 = 0.91 - j0.25$
$= 0.94\angle -15.4$ Assuming no-phase shift

2BGT **Q2) A 150 km, 50 Hz transmission line has the following parameters:**

$A = 0.936\angle 0.98^{0}$ $B = 142\angle 76.4^{0}\ \Omega$

i) Evaluate the capacitance of this line. **[12]**

ii) If a reactive compensation is to be installed at the receiving end of the line with a series compensation factor of 0.8, evaluate the 1st row of the matrix of the equivalent [A,B,C,D] parameters after compensation. **[20]**

i) This is a medium Line with:

4 . $A = 1 + Z\frac{Y}{2}$, $B = Z$

$\therefore \frac{Y}{2} = (A-1)/Z = (0.936\angle 0.98 - 1)/142\angle 76.4 = (-0.064 + j0.016)/142\angle 76.$

$= 0.066\angle 165.9 / 142\angle 76.4 = 4.65\times10^{-4}\angle 89.5 \simeq 90$

4 . $\therefore Y = 9.36\times10^{-4}\angle 90$

$\therefore |Y| = \omega C = 9.36\times10^{-4}$

4 . $\therefore C = \frac{9.36\times10^{-4}}{\omega} = \frac{9.36\times10^{-4}}{2\pi\times50} = 0.029\times10^{-4} = \boxed{2.9}\ \mu F$

ii) The matrix of the Line is $M_1 = \begin{bmatrix} 0.936\angle 0.98 & 142\angle 76.4 \\ C & D \end{bmatrix}$

6 The matrix of the compensation is $M_2 = \begin{bmatrix} 1 & X_c \\ 0 & 1 \end{bmatrix}$

$|X_c| / |X_L| = 0.8$, $\therefore X_c = 0.8 X_L$

Now $Z = B = 142\angle 76.4$

3 $\therefore |X_L| = 142 \sin 76.4 = 138.02\ \Omega$

3 $\therefore |X_c| = 0.8 \times 138.02 = \boxed{110.42}\ \Omega$

$\therefore X_c = -j110.42$

8 $\therefore$ The equivalent Matrix $= \begin{bmatrix} 0.936\angle 0.98 & 142\angle 76.4 \\ C & D \end{bmatrix}\begin{bmatrix} 1 & -j110.42 \\ 0 & 1 \end{bmatrix}$

$\therefore$ 1st row $= \begin{bmatrix} 0.936\angle 0.98 & 0.936\angle 0.98 \times 110.42\angle -90 + 142\angle 76.4 \end{bmatrix}$

$= \begin{bmatrix} 0.936\angle 0.98 & 103.35\angle -89.02 + 142\angle 76.4 = 33.41 + j34.65 \end{bmatrix}$

$= \begin{bmatrix} 0.936\angle 0.98 & 48.16\angle 46.07 \end{bmatrix}$

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Q3) A 320 km transmission line has the following data at 60 Hz:

z=(0.13 + j 0.49) Ω/km

y= j 3.39*10 $^{-6}$ S/km

If the line is open-circuited at the receiving end and the receiving end Phase voltage is 57.4 kV, evaluate:

i) The incident and reflected voltages. [15]

ii)The SIL. [9]

i) $V_s = \frac{V_R + I_R Z_c}{2} e^{\gamma l} + \frac{V_R - I_R Z_c}{2} e^{-\gamma l}$

o/c at receiving end, means $I_R = 0$

$\therefore$ Incident voltage, $V_{in} = \frac{1}{2} V_R e^{\gamma l}$

Reflected voltage, $V_{Ref} = \frac{1}{2} V_R e^{-\gamma l}$

$V_R = 57.4$ kV

$\therefore \gamma l = \sqrt{Zl \cdot yl} = \sqrt{Zy}\, l = \sqrt{(0.13 + j0.49) * 3.39*10^{-6} \angle 90} * 320$

$= \sqrt{0.51 \angle 75.14 * 3.39*10^{-6} \angle 90} * 320 = 1.31*10^{-3} \angle 82.57 * 320$

$= \boxed{0.42 \angle 82.57} = 0.05 + j0.42$

$\therefore e^{\gamma l} = e^{0.05} e^{j0.42} = \boxed{1.05 \angle 24.08}$

$e^{-\gamma l} = \frac{1}{1.05 \angle 24.08} = \boxed{0.95 \angle -24.08}$

$\therefore V_{in} = \frac{1}{2} 57.4 \angle 0 * 1.05 \angle 24.08 = \boxed{60.27 \angle 24.08} * \frac{1}{2}$ kV $= \boxed{30.135 \angle 24.08}$

$V_{ref} = \frac{1}{2} 57.4 \angle 0 * 0.95 \angle -24.08 = \boxed{54.53 \angle -24.08 \text{ kV}} * \frac{1}{2} = \boxed{27.265 \angle -24}$

ii) $SIL = |V_L|^2 / \sqrt{L/C}$

$L = 0.49/\omega$

$C = \frac{3.39*10^{-6}}{\omega}$

$SIL = |V_L|^2 / \sqrt{\frac{0.49}{3.39*10^{-6}}} = \frac{(\sqrt{3} * 57.4 * 10^3)^2}{0.38 * 10^3} = \boxed{26.01 \text{ MW}}$

Q4) A 400 km, 50 Hz transmission line has the following data:

$\cosh\gamma l = 0.9\angle 1.3^0$, $\sinh\gamma l = 0.5\angle 85^0$, $Z_c = 406\angle -6^0\ \Omega$

If the load on the line is 125 MVA at 215 kV and unity pf, evaluate the Radius of the power circle diagram. [12]

$$\text{Radius} = \frac{|V_s||V_R|}{|B|}$$

2. $|V_R| = \boxed{\frac{215}{\sqrt{3}}\ kV} \Rightarrow$

3. $B = Z_c \sinh\gamma l = 406\angle -6 * 0.5\angle 85 = 203\angle 79$

$\therefore |B| = |Z_c||\sinh\gamma l| = \boxed{203}$

$A = \cosh\gamma l$

4. $V_s = A V_R + B I_R$

$I_R = \frac{125 * 10^6}{\sqrt{3} * 215 * 10^3}\angle 0 = \boxed{335.7\angle 0\ A}$

$\therefore V_s = 0.9\angle 1.3 * \frac{215}{\sqrt{3}} * 10^3\angle 0 + 203\angle 79 * 335.7\angle 0$

$= 111.7 * 10^3\angle 1.3 + 68.15 * 10^3\angle 79$

$= (124.67 + j\,69.43) * 10^3$

$\therefore |V_s| = \boxed{142.7\ kV}$

3. $\therefore \text{Radius} = 142.7 * 10^3 * \frac{215}{\sqrt{3}} * 10^3 * \frac{1}{203} = \boxed{87.26}\ MVA.$