φ	Mark
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6	13/20
Total	65/90

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University of Jordan

Electrical Eng. Dept

EE 0933481 Power Systems (1) **2nd Exam.**

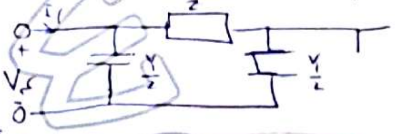
13-12-2015

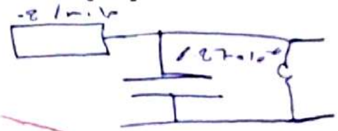
الاسم: [redacted] رقم التفقد(47) الرقم الجامعي: [redacted]

Q1) The shunt admittance of a 300 mile transmission line is ($j6.87*10^{-6}$) S/mile. Its series reactance is 0.8 Ω/ mile. Determine the ABCD constants of the compensation network which should be connected at the receiving end at light loads with 60 % compensation. **[10]**

7/10

~~$Y = 2.061 * 10^{-3}$~~





$Y_{tot} = (6.87*10^{-6} * 300)\, J = 2.061*10^{-3} J$

$\frac{Y}{2} = 1.0305*10^{-3} J$

خلص الورقة

وين الـ ABCD

60 .6 compensation $= \left(\frac{B_C}{B_L}\right) \Rightarrow \frac{B_{compensation}}{1.0305*10^{-3} J} = .6$

$B_{compensation} = 6.183*10^{-4} \Rightarrow \boxed{Y_C = 6.183*10^{-4}}$

12/20

Q2) A 200 mile, 100 kV transmission line has the following parameters at 60 Hz: $z= 0.8\angle 75^0$ Ω/mile and $y= j5.4*10^{-6}$ S/mile.

a- Evaluate the incident voltage at the sending end when the line is open-circuited and the receiving voltage is maintained at a line voltage of 100 kV. **[10]**

$(334.115\angle .165$ kV$)$

2/10

$V(x) = \underbrace{\frac{\frac{V_R}{Z_C} + I_R}{2} e^{\gamma x}}_{incident} + \frac{\frac{V_R}{Z_C} - I_R}{2} e^{-\gamma x}$

$I_R = 0 \Rightarrow$

$V_R = 100k/\sqrt{3}$

$\frac{\frac{V_R}{Z_C} + I_R}{2} e^{\gamma x}$; $x = 200$ mile

$V_R = (100/\sqrt{3})$ kV

$Z = 160\angle 75$

$Y = 1.08*10^{-3}$

$\frac{\frac{100/\sqrt{3}}{160}}{(1.08*10^{-3})}$

$.9 e^{200\gamma}$

$Z_{SIL} = 373.666$

b- Evaluate SIL the line. **[10]**

10/10

$Z_c = \sqrt{L/C} = \sqrt{\frac{400m}{2.8648*10^{-6}}}$

$.207 + .772745$

~~373.6~~

$\angle L = \frac{.77274}{2\pi*60}$

$= 2$ mH

$= 400$ mH

$P = \cancel{\sqrt{3} \cdot V \cdot I} = \frac{V^2}{\sqrt{L/C}} = \frac{100^2}{Z_{SIL}} = 26.762$ MWatt

$1.08*10^{-3} J = Y \Rightarrow wC = 1.08*10^{-3}$

$C = 2.8648*10^{-6}$

$SIL = \sqrt{}$

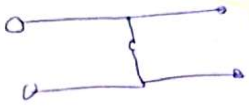
Q1) $.6 = \frac{B_{comp}}{B_L} \Rightarrow .6 \cdot \left(\frac{Y}{2}\right) = B_{comp}$

$\boxed{-jB}$

$B_{comp} = \cancel{.6183} \quad 61.83 \cdot 10^{-3}$ ℧

$$\boxed{Y_{comp} = -61.83 \cdot 10^{-3} j \, ℧}$$

$V_S = V_R + 0$



$I_S = V_R(Y) - I_R$

$Y_c = -jB_c$

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ -61.83 \cdot 10^{-3} & 1 \end{bmatrix}$$

14/14

Q3) The Third Column in the Z_{bus} matrix of a 4-bus system in pu is as follows:

j 0.04	Z_{13}
j 0.06	Z_{23}
j 0.13	Z_{33}
j 0.05	Z_{43}

For a balanced 3-ph fault on Bus 3:

8/8

a- Evaluate subtransient current in the line between buses 2 and 4 if it has pu impedance of j2. [8]

$V_F = 1\angle 0$

$$I_{2-4} = \frac{V_2 - V_4}{2j}$$

$$V_2 = V_F - \frac{V_F}{Z_{33}} \cdot Z_{23}$$

$$= 1\angle 0 - \frac{1\angle 0}{.13j} \cdot .06j = .53846 \,\text{v}$$

$$\frac{.53846 - .61538}{2j} = .03846\angle 90 \quad \text{From } 2 \to 4$$

$$V_4 = 1 - \frac{1}{.13j} \cdot .05j = .61538 \,\text{v}$$

OR

$.03846\angle -90$ From $4 \to 2$

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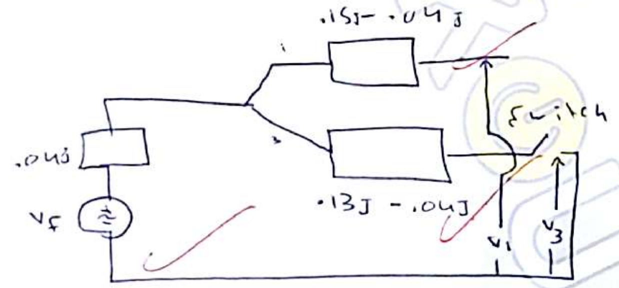
b- If the element Z_{11} of the Z_{bus} matrix is j0.15, draw the thevenin equivalent circuit between buses 1 and 3. [6]



$I_a^{(0)} = 0$

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Q4) The pu 3-ph complex power supplied to Y-connected load is $1.03\angle 0^0$.
Given that : $V_{an}^{(1)} = 0.99\angle 44^0$, $V_{an}^{(2)} = 0.23\angle 250^0$, $I_a^{(1)} = 0.99\angle 44^0$
By using the concept of symmetrical components, evaluate the other sequence currents. [14]

$I_a^{(0)} = 0$

$I_a^{(1)} = .99\angle 44$

$V_{an}^{(1)} = .99\angle 44$

$V_{an}^{(2)} = .23\angle 250$

$$\boxed{\text{So } [I_{a_{012}}] = \begin{bmatrix} 0 \\ .99\angle 44 \\ 2.7685\angle 70 \end{bmatrix}}$$

$$S_{tot} = 3\left(V_{an}^{(0)} I_a^{(0)*} + V_{an}^{(1)} I_a^{(1)*} + V_{an}^{(2)} I_a^{(2)*}\right)$$

$$1.03 = 3\left(.99\angle 44 \cdot .99\angle -44 + .23\angle 250 \cdot I_a^{(2)*}\right)$$

$$.34333 = .9801 + .23\angle 250 \cdot I_a^{(2)*} \Rightarrow I_a^{(2)} = (2.7685\angle -70)^*$$

$Z_s + 2Z_m$

$Z_{aa} -$ Z_{ab}

11/12

Q5) Evaluate the followings

a- Z_2 of a 3-ph generator having at 50 Hz:
R= 2 Ω, L_s = 2.8 mH, M_s = 1.4 mH **[5]**

$Z_2 = R + j\omega(L_s - M_s)$

4/5

$2 + (100\pi)(1.4m)j$

$= 2.0478 \angle 12.4026\ \Omega$

b- Z_0 of a 3-ph transmission line having at 50 Hz:
For each phase conductor: R= 40 Ω, L = 0.5 H
For neutral conductor: R= 20 Ω, L = 0.2 H
Mutual inductance between two phase conductors= 0.3 H
Mutual inductance between phase conductor and neutral= 0.1 H **[7]**

~~40 + 15.50j~~

$\boxed{Z_s + 2Z_m}$

7/7

$Z_{aa} = 40 + .5 \cdot (2\pi 50) j = 162.1 \angle 75.7134$

$Z_{nn} = 20 + .2 \cdot 50 \cdot 2\pi j = 65.94 \angle 72.3432$

$Z_{ab} = .3 \cdot 2\pi \cdot 50 j = 94.247j$

$Z_{an} = 31.4159j$

$Z_0 = Z_s + 2Z_m \Rightarrow (Z_{aa} + 2Z_{ab} + Z_{an}) + 2(Z_{ab}$

خلف الورقة

$(Z_{aa} + 2Z_{ab} + Z_{an}) + 2(Z_{an} + 2Z_{ab}$

13/20

Q6) A generator is rated at 100 MVA, 20 kV, X_1 =20 % and X_0 =5 %.
Its neutral is grounded through a reactor of 0.32 Ω. The generator is operating at rated voltage without load when a single-line-to-ground fault occurs at its terminals.

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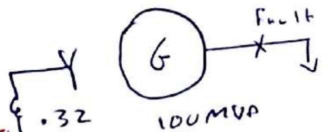
a-Evaluate the fault current in pu. **[11]**

b-Evaluate the corresponding sequence voltages. **[9]**

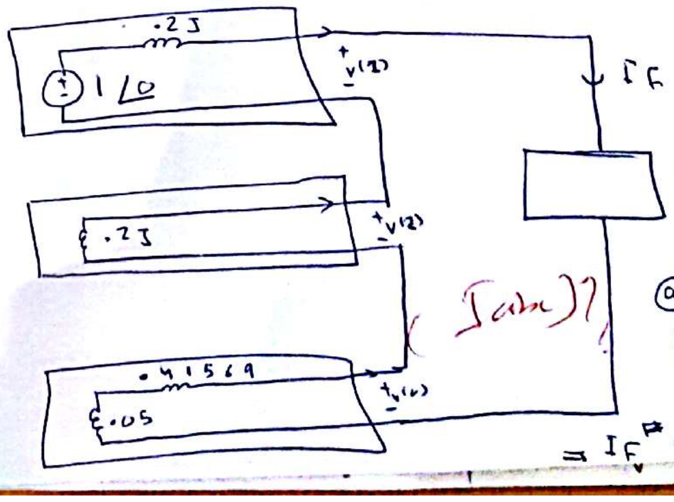
خلف الورقة



9/9

100MVA
20kV
$X_1 = X_2 = .2$
$X_0 = .05$

pu
$.32 \Rightarrow .13856$



$3Z_F = 3 \cdot 0 = 0$

(a)

$I_F'' = \frac{1\angle 0}{j(.2 + .05 + .2 + .41569)}$

$\Rightarrow I_F'' = 1.1551 \angle -90$

part (B) / Q.6

$$I_f = \frac{1\angle 0}{.2 + .2 + .05 + .41569} = 1.155\angle -90$$

$$V^{(0)} = -I_f \cdot (.05 + .41569) j \Rightarrow -.53794 \, v$$

$$V^{(1)} = 1 - (.2j) \cdot I_F \Rightarrow .769 \, v$$

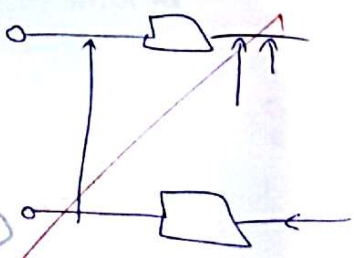
$$V^{(2)} = -I_f \cdot .2j \Rightarrow -.231 \, v$$

$$\begin{bmatrix} -.53794 \, v \\ .769 \, v \\ -.231 \, v \end{bmatrix}_{pu} \Longrightarrow \begin{bmatrix} -10758.8 \, v \\ 15380 \, v \\ -4620 \, v \end{bmatrix}$$

part (B) / Q.5

$$\cancel{V_{aa'} = I_a(Z_{aa} - Z_{an}) + (I_b + I_c)(2 Z_{ab} -}$$

$$V_{aa'} = I_a Z_{aa} + (I_b + I_c) Z_{ab} + I_n (Z_{an})$$



$$- \cancel{I_n (Z_{nn} +}$$

$$(I_n Z_{nn} + I_a Z_{an} + (I_b + I_c) Z_{an})$$

$$I_a (Z_{aa} - Z_{an}) + (I_b + I_c)(Z_{ab} - Z_{an}) + I_n (Z_{an} - Z_{nn})$$

$$I_n = -I_a - (I_b + I_c)$$

$$I_a \underbrace{(Z_{aa} - 2Z_{an} + Z_{nn})}_{Z_s} + (I_b + I_c) \underbrace{(Z_{ab} - 2Z_{an} + Z_{nn})}_{Z_m}$$

$$\boxed{Z_0 = Z_s + 2Z_m} \Rightarrow Z_{aa} - 6Z_{an} + 3Z_{nn} + 2Z_{ab}$$

$$\Rightarrow Z_0 = 354.76454 \angle 73.861$$