$\frac{56}{60} = \frac{28}{30}$

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2) 5/5
3) 13/15
4) 13/15

University of Jordan

Electrical Eng. Dept

EE 0933481 Power Systems (1)

2nd Exam.

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الاسم: بتول سليمان محمد الدردبيسي / بتول الدردبيسي

رقم التفقد(38 **)**

الرقم الجامعي: 0129244

25/25

Q1) a-A 25 MVA, 13.8 kV 3-ph generator with X" =15 % is connected through a 3-ph transformer rated at 25 MVA, 13.8/6.9 kV, X=10 % to a busbar which supplies two identical 3-ph motors, where each motor is rated at 5 MVA, 6.9 kV and X" =20 % .The motors are drawing rated power at 0.8 pf lagging when a balanced 3-ph fault occur at the busbar of the motors. By using thevenin's Theorem evaluate the contribution of the generator and motors (taking into account the load) to fault current and using Base Quantities of 25 MVA and 13.8 kV. **[15]**

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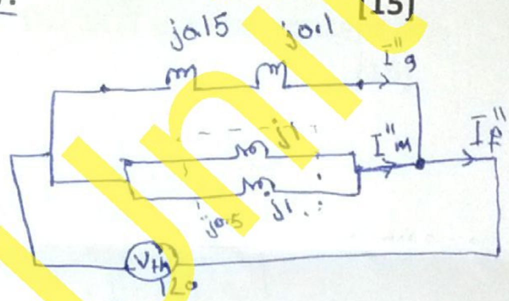
$G: \; 0.15 \times \frac{25}{25} \times \frac{(13.8)^2}{(13.8)^2} = 0.15$

$T: x = 0.1 \quad M: x = 0.2 \times \frac{25}{5} = j1$



$Z_{th} = j \frac{0.25 \times 0.5}{0.25 + 0.5} = j0.167$

$I''_f = \frac{V_{th}}{Z_{th}} = \frac{1\angle 0}{j0.167} = -j6 \text{ p.u}$

$I''_g = -j6 \times \frac{j0.5}{j0.5 + j0.25} = -j4 \text{ p.u}$

$I''_m = -j6 \times \frac{j0.25}{j0.5 + j0.25} = -j2 \text{ p.u}$

$I_L = I_{m1} + I_{m2}$ ~~$\angle -36.87$~~

$= \frac{10}{\sqrt{3}\, 6.9} / \frac{25}{\sqrt{3}\, 6.9} = 0.4\angle -36.87 \text{ p.u}$

$\frac{25}{\sqrt{3}\, 13.8}$

$\therefore I''_g = -j4 + 0.4\angle -36.87 = 4.25\angle -85.7 \text{ p.u} = \boxed{4.445\angle -85.7 \text{ KA}}$

$I''_m = -j2 - 0.4\angle -36.87 = 1.79\angle -100.3 \text{ p.u} = \boxed{3.741\angle -100.3 \text{ KA}}$

b-When a balanced 3-ph fault occur on busbar number 2 of a 4-bus system, the fault current and the bus voltages during the fault were as follows: I''_f = -j4.357, V_1=0.156, V_3=0.349, V_4 =0.344 .

$\frac{25}{\sqrt{3}\, 6.9}$

Evaluate the corresponding column of the Z_{bus} matrix. **[10]**

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$V_f = 1\angle 0$

$I''_f = \frac{V_f}{Z_{22}}$

$-j4.357 = \frac{1\angle 0}{Z_{22}}$

$\Rightarrow \boxed{Z_{22} = j0.2295} \text{ p.u}$

$V_1 = 1\angle 0 - I''_f Z_{12}$

$0.156 = 1 - (-j4.357) Z_{12}$

$\boxed{Z_{12} = j0.1937} \text{ p.u}$

$V_3 = 1\angle 0 - (-j4.357) Z_{32} = 0.349$

$\boxed{Z_{32} = j0.1494} \text{ p.u}$

$V_4 = 1\angle 0 - (-j4.357) Z_{42} = 0.344$

$\boxed{Z_{42} = j0.1506} \text{ p.u}$

$\therefore Z = \begin{bmatrix} \cdot & j0.1937 & \cdot & \cdot \\ \cdot & j0.2295 & & \\ & j0.1494 & & \\ & j0.1506 & & \end{bmatrix}$

Q2) If a circuit breaker has a rated S/C MVA of 2386 at a voltage of 73 kV and K factor equal to 1.2, evaluate the maximum current which the breaker can interrupt and its corresponding voltage. [5]

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$2386M = \sqrt{3} \times 73K \times I_{sc} \times 10^{-3}$

$I_{sc} = 18.87\ KA$

$I_{interrupt\ max.} = 1.2 \times 18.87K = \boxed{22.644\ KA}$

$K = 1.2 = \frac{V_{rated\ max}}{V_{lower\ limit}} \Rightarrow V_{lower\ limit} = \frac{73KV}{1.2} = \boxed{60.83\ KV}$

Q3) The line currents flowing to the Y-side of 10 MVA, 66 Y/13.2 Δ kV transformer are: $I_a=100\angle 0^0$, $I_b=141.4\angle 225^0$, $I_c=100\angle 90^0$.
By using the concept of symmetrical components in pu, evaluate the currents flowing in the lines from the Δ-side. DO NOT use the concept of turns ratio. [15]

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$I_{base} = \frac{10M}{\sqrt{3} \times 66K} = 87.48\ A$

Y: $I_A = 100\angle 0\ A$
$= 1.143\angle 0\ p.u$

$I_B = 1.616\angle 225°$

$I_C = 1.143\angle 90°$

$$\begin{bmatrix} I_A^{(0)} \\ I_A^{(1)} \\ I_A^{(2)} \end{bmatrix} = \frac{1}{3}\begin{bmatrix} 1 & 1 & 1 \\ 1 & a & a^2 \\ 1 & a^2 & a \end{bmatrix}\begin{bmatrix} 1.143\angle 0 \\ 1.616\angle 225 \\ 1.143\angle 90° \end{bmatrix}$$

$\therefore I_A^{(0)} = 0,\ I_A^{(0)} = \frac{1}{3}(\underbrace{I_A + I_B + I_C}_{=0})$ for Y

$I_A^{(1)} = 1.275\angle -15\ p.u$

$I_A^{(2)} = 0.3414\angle 105\ p.u$

Δ: $I_a^{(0)} = 0$

$I_a^{(1)} = 1.275\angle -15° - 30°$
$= 1.275\angle -45°\ p.u = 111.537\ A$ $\angle -45$

$I_a^{(2)} = 0.3414\angle 105 + 30$
$= 0.3414\angle 135°\ p.u = 29.87\ A$ $\angle 135$

$I_{base} = \frac{10 \times 10^6}{\sqrt{3} \times 13.2}$

$$\begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & a^2 & a \\ 1 & a & a^2 \end{bmatrix}\begin{bmatrix} 0 \\ 111.537\angle -45 \\ 29.87\angle 135 \end{bmatrix}$$

$\boxed{I_a = 81.667\angle -45\ A}$

$\boxed{I_b = 129\angle -153.4\ A}$ $129\angle -153.4\ A$

$\boxed{I_c = 129\angle 63.4\ A}$

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Q4)a-Draw the zero sequence network of the system shown in Fig. 1. [5]
Given the following zero sequence and earthing impedance values in pu for the elements on the same base:

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Parameter	G_1	G_2	A	T_1	$T.L_{BC}$	T_2	G_3	B
Z_0	x_a	x_b	z_y	x_c	x_d	x_e	x_f	z_y
Z_n	z_a	z_b	direct	–	–	–	z_c	isolated

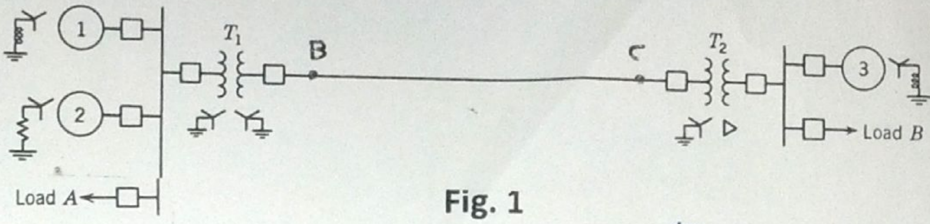
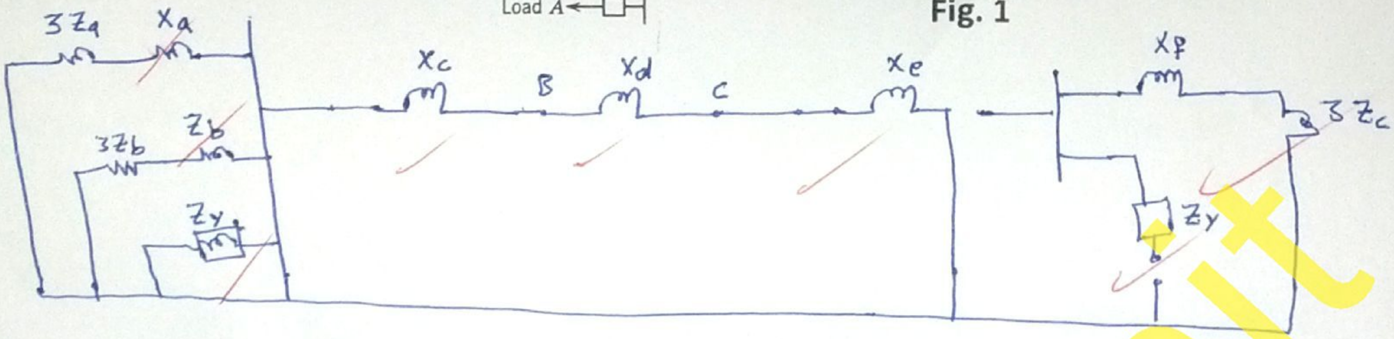


Fig. 1



b-A single-line-to ground fault occur at a point Q in a given power system. The fault current I_F = -j2.42. If the corresponding equivalent sequence impedances in pu were as follows: Z_1=j0.5, Z_2=j0.5, Z_0=J0.24, evaluate phase voltages at point Q. [10]

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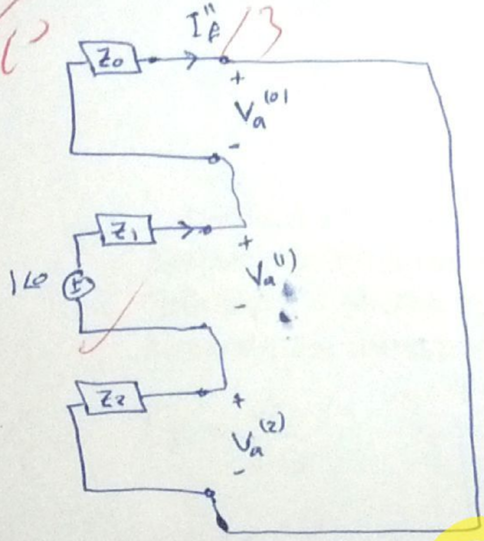

$V_a^{(0)} = -(-j2.42)(j0.24)$

$= -0.5808$

$V_a^{(1)} = 1\angle 0 - (-j2.42)(j0.5)$

$= -0.21$

$V_a^{(2)} = -(-j2.42)(j0.5)$

$= -1.21$

$$\begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & a^2 & a \\ 1 & a & a^2 \end{bmatrix} \begin{bmatrix} -0.5808 \\ -0.21 \\ -1.21 \end{bmatrix}$$

$V_a = -2$

$V_b = 0.876\angle -81.5$

$V_c = 0.876\angle +81.5$