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16/ENG04/021
Electrical/Electronics Engineering

Assignment Solutions

a. Base = 2mVA , Vbase = 11 KV

$x = 10\% = 10/100 = 0.1\Omega$, $x_s = 20\% = 20/100 = 0.2\Omega$

$x_m = 25\% = 25/100 = 0.25\Omega$

T_b, Vbase $= \frac{11 \times 121}{10.8} = 123.2kV$

b. Motor

Voltage base $= \frac{11.2 \times 10.8}{11} = 11kV$

The transformer line and Motor reactance are converted to Pu Values

c. Transformer reactance (x_T).

$x_T = 0.1 \times \frac{25}{30}\left(\frac{10.8}{11}\right)^2 = 0.0803pu$

d. line reactance (x_L)

$x_L = \frac{100 \times 25}{(123.2)^2} = 0.164pu$

e. Motor reactance $x = 0.25$

$x_{m_1} = 0.25 \times \frac{25}{15}\left(\frac{10}{11}\right)^2$

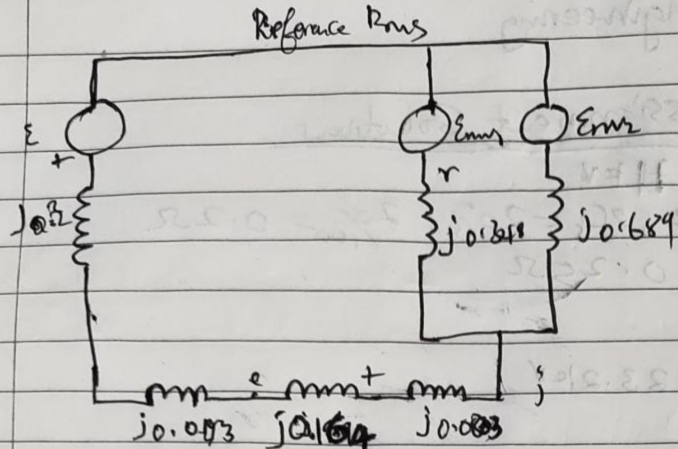
$= 0.347pu$

$x_{m2} = 0.25 \times \frac{25}{7.5}\left(\frac{10}{11}\right)^2 = 0.689pu$

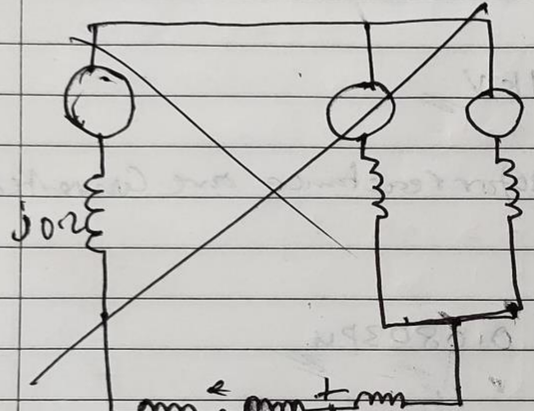
f. Zero sequence reactance of the transmission line (x_{zst})

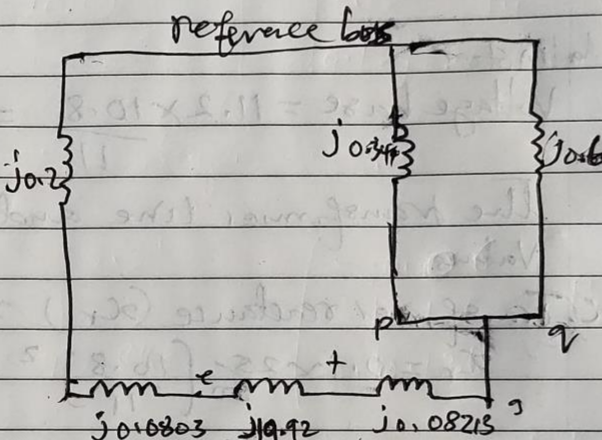
$x_{zst} = \frac{300 \times 25}{(123.2)^2}$

$= 0.494 pu$

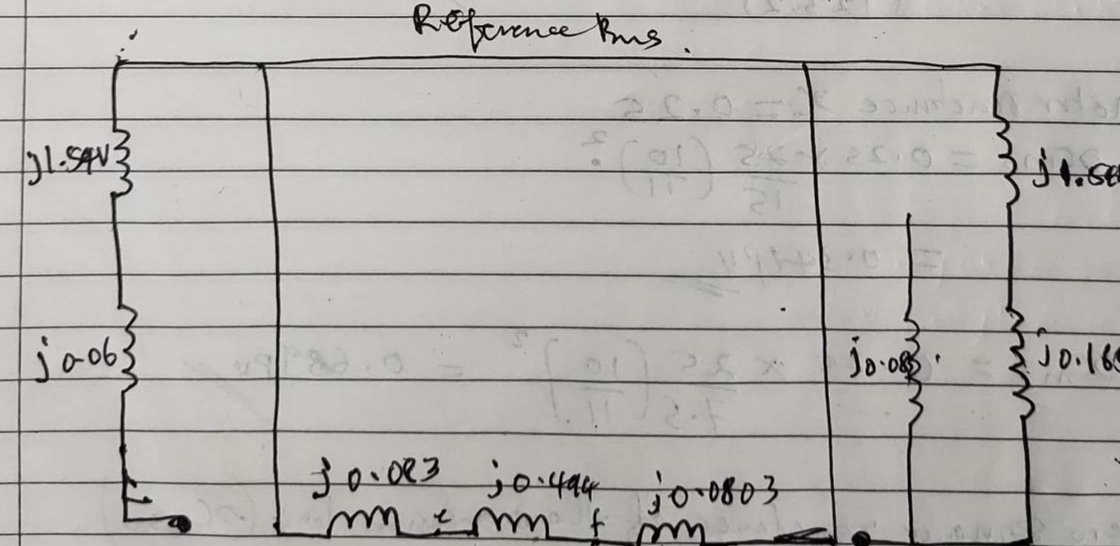


Possitive sequence network





Negative sequence network



Zero Sequence Network

i. Reactance of Current limiting reactor network $= \frac{2.5 \times 25}{(11)^2} = 0.516 pu$

ii. Reactance of current limiting reactor included in the zero sequence network $= 3\times0.516 = 1.548\,pu$

Zero sequence reactance of motor.

a. Motor 1.

$X_{z0 Rm1} = 0.06\times\left(\frac{25}{15}\right)\times\left(\frac{10}{11}\right)^2 = 0.0828\,Pu$

b. Motor 2

$X_{z0Rm2} = 0.06\times\left(\frac{25}{7.5}\right)\left(\frac{10}{11}\right)^2 = 0.165\,Pu$

B. Calculate the fault and the current in all parts of the system

- Neglecting prefault currents.

$E_g'' = E_{m1}'' = E_{m2}'' = V_f$ (V_f prefault voltage at g $= \frac{10}{11}$

$= 0.909\,pu$

$Z_2 = Z_1 = j0.16\,Pu$.

from the sequence network

$$I_{a0} = \frac{V_f}{Z_1+Z_2+Z_0}$$

$$= \frac{0.909}{j2.032} = -j0.447\,Pu.$$

$I_{a2} = I_{a0} = I_{a1} = -j0.447\,Pu$

fault current $= 3I_{a0} = 3\times(-j0.447)$

$= -j1.341\,Pu$

I_{a1} = Component flowing to g from the generator

$$-j0.447\times\frac{j0.23}{j0.755}$$

$= -j0.136\,Pu$

I_{a_1} Component flowing to g from the motor.

$$-j0.447 \times \frac{j0.128}{j0.755}$$

$$= -j0.311 \text{ pu}$$

For flow to g.

fault currents from the generator towards g.

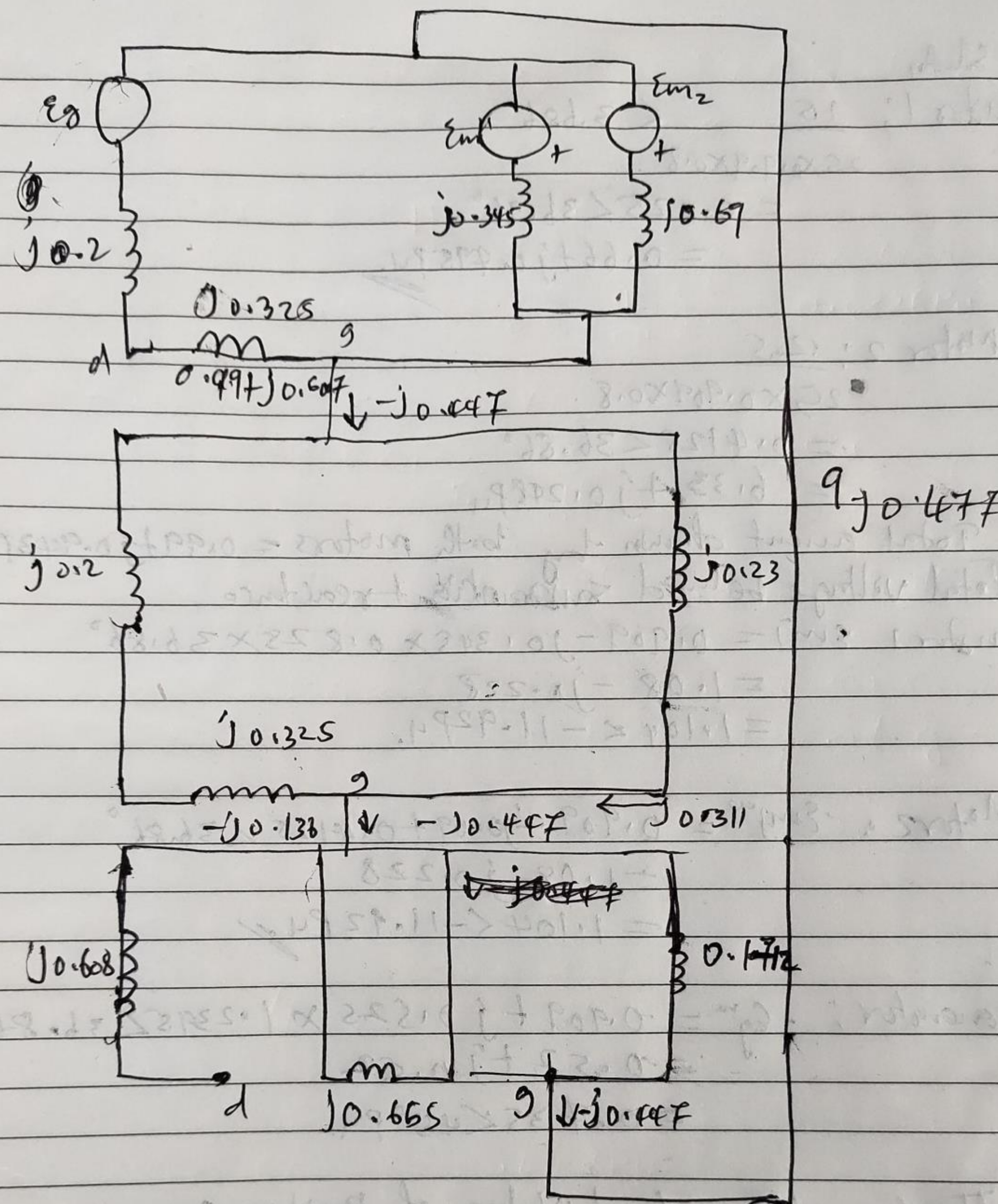
$$\begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ \alpha^2 & \alpha & 1 \\ \alpha & \alpha^2 & 1 \end{bmatrix} \begin{bmatrix} -j0.136 \\ -j0.136 \\ 0 \end{bmatrix} = \begin{bmatrix} -j0.272 \\ -j0.136 \\ j0.136 \end{bmatrix} \text{pu}$$

fault currents from the motor towards g.

$$\begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ \alpha^2 & \alpha & 1 \\ \alpha & \alpha^2 & 1 \end{bmatrix} \begin{bmatrix} -j0.311 \\ -j0.311 \\ -j0.447 \end{bmatrix} = \begin{bmatrix} -j0.206 \\ -j0.136 \\ -j0.136 \end{bmatrix} \text{pu}$$

Positive sequence component of the transmission line current has phase shift -90°

Negative sequence component of the transmission line current is shift $+90^\circ$



Connection of the sequence networks.

line current in the transmission line $= -0.138 + 0.136 + 0$

$= 0$

Calculate Voltage behind subtransient reactance to be used if load current are accounted for

PTO

Solution

Motor 1; $\frac{15}{25 \times 0.909 \times 0.8} < 3.686^\circ$

$= 0.825 \angle 36.96^\circ$

$= 0.66 + j0.495 pu$

Motor 2; $\frac{2.5}{25 \times 0.909 \times 0.8}$

$= 0.4125 \angle 36.86^\circ$

$= 0.33 + j0.248 pu$

Total current drawn by both motors $= 0.99 + j0.743 pu$

Total voltage behind subtransient reactance

motor 1 $Em1 = 0.909 - j0.345 \times 0.825 \times 36.86^\circ$

$= 1.08 - j0.228$

$= 1.104 < -11.92 pu.$

Motor 2: $Em_2'' = 0.909 - j0.09 + 0.4125 \angle 36.86^\circ$

$= 1.08 - j0.228$

$= 1.104 < -11.92 pu$

Generator; $-Eg'' = -0.909 + j0.525 \times 1.2395 \angle 36.86^\circ$

$= -0.52 + j0.52$

$= 0.735 \angle 45^\circ pu$

Therefore the actual value of Positive sequence current from the motor to the name is $-0.99 - j0.743 - j0.311$

$= -0.99 - j1.054$