ETIM PATRICK INI-OBONG
16/ENG04/018
Electrical / Electronics
EEE 553 ASSIGNMENT

Solution

[A]

Base = 25MVA, $x = 10\% = \frac{10}{100} = j0.1\Omega$, $V_{base} = 11kV$

$X_m = 25\% = \frac{25}{100} = j0.25\Omega$, $X_s = 20\% = \frac{20}{100} = j0.2\Omega$

Transmission line Voltage base $= 11 \times \frac{121}{10.8} = 123.2kV$

Motor Voltage base $= 123.2 \times \frac{10.8}{121} = 11kV$

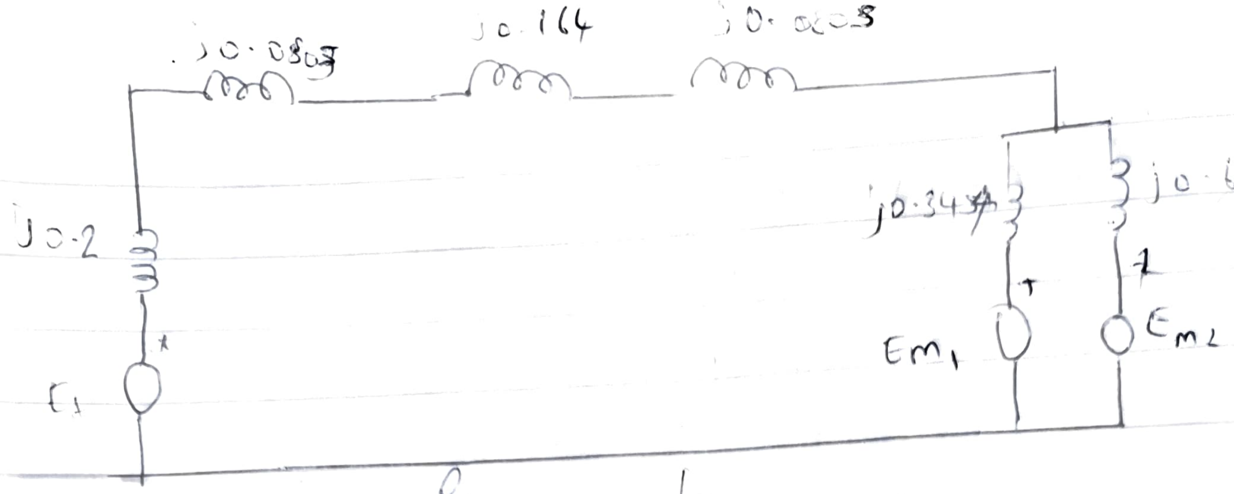
The transformer line and motor reactances are connected to pu values on appropriate bases as follows

Transformer reactance $X_T = 0.1 \times \frac{25}{30} \times \left(\frac{10.8}{11}\right)^2 = 0.0805pu$

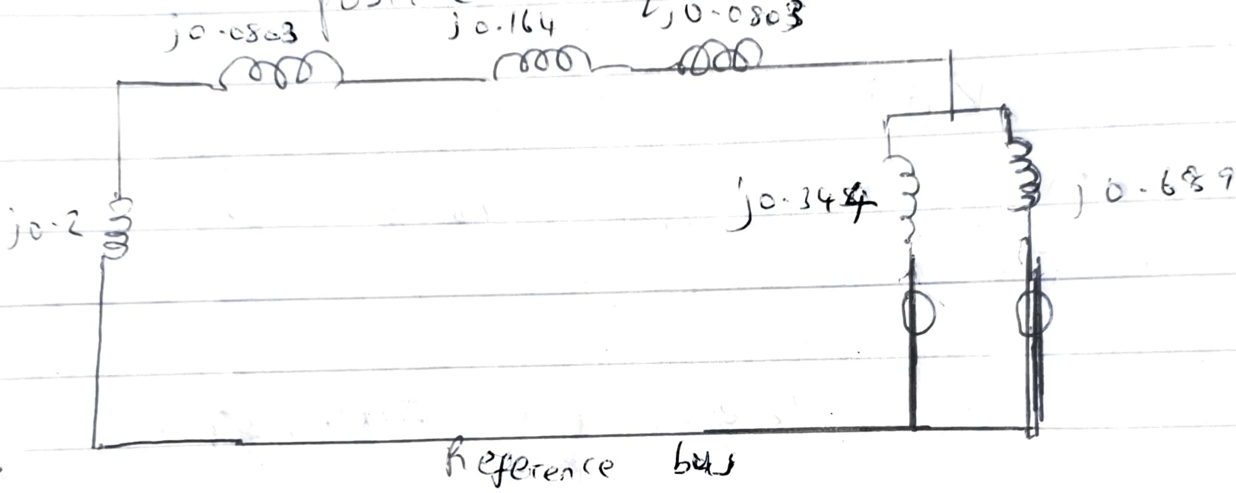
line reactance $X_L = \frac{100 \times 25}{(123.2)^2} = 0.164pu$

Motor reactance $X_{m1} = 0.25 \times \frac{25}{15}\left[\frac{10}{11}\right]^2 = 0.344pu$

$X_{m2} = 0.25 \times \frac{25}{7.5}\left[\frac{10}{11}\right]^2 = 0.689pu$



positive sequence network



Negative Sequence network

Zero Sequence

Zero sequence reactance of the transmission line

$$X_{0TL} = \frac{300 \times 25}{(123.2)^2} = j0.494 pu$$

Zero seqance reactance of motor 1

$$X_{0RM1} = 0.06 \times \left(\frac{25}{15}\right) \times \left(\frac{10}{11}\right)^2$$

$$= 0.0826 pu$$

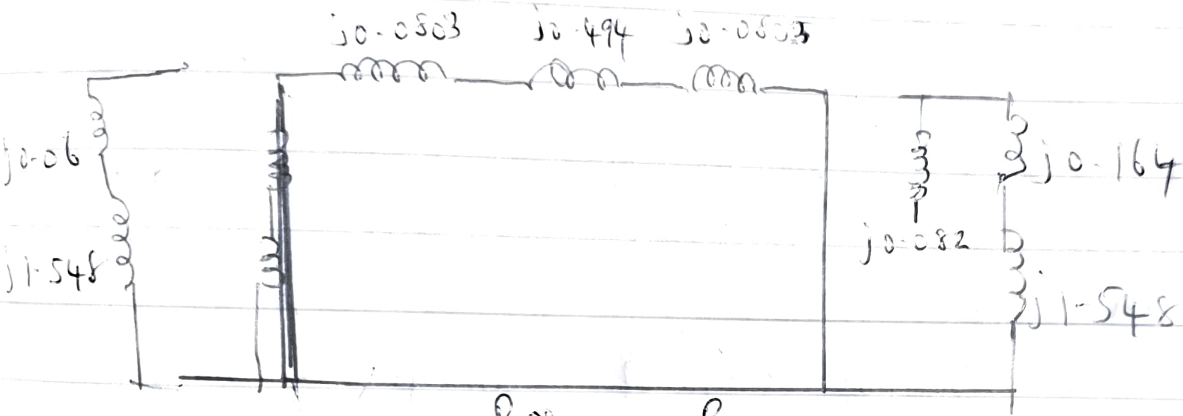
~~Motor 2~~ " " " " motor 2

$$X_{0RM2} = 0.06 \times \frac{25}{7.5} \times \left[\frac{10}{11}\right]^2 = j0.164 pu$$

Reactance of Current limiting reactor:

$$\frac{2.5 \times 2.5}{11^2} = j0.516 \, pu$$

Reactance of Current limiting reactor included in zero negative network = j 3 × 0.516 = j 1.548 pu



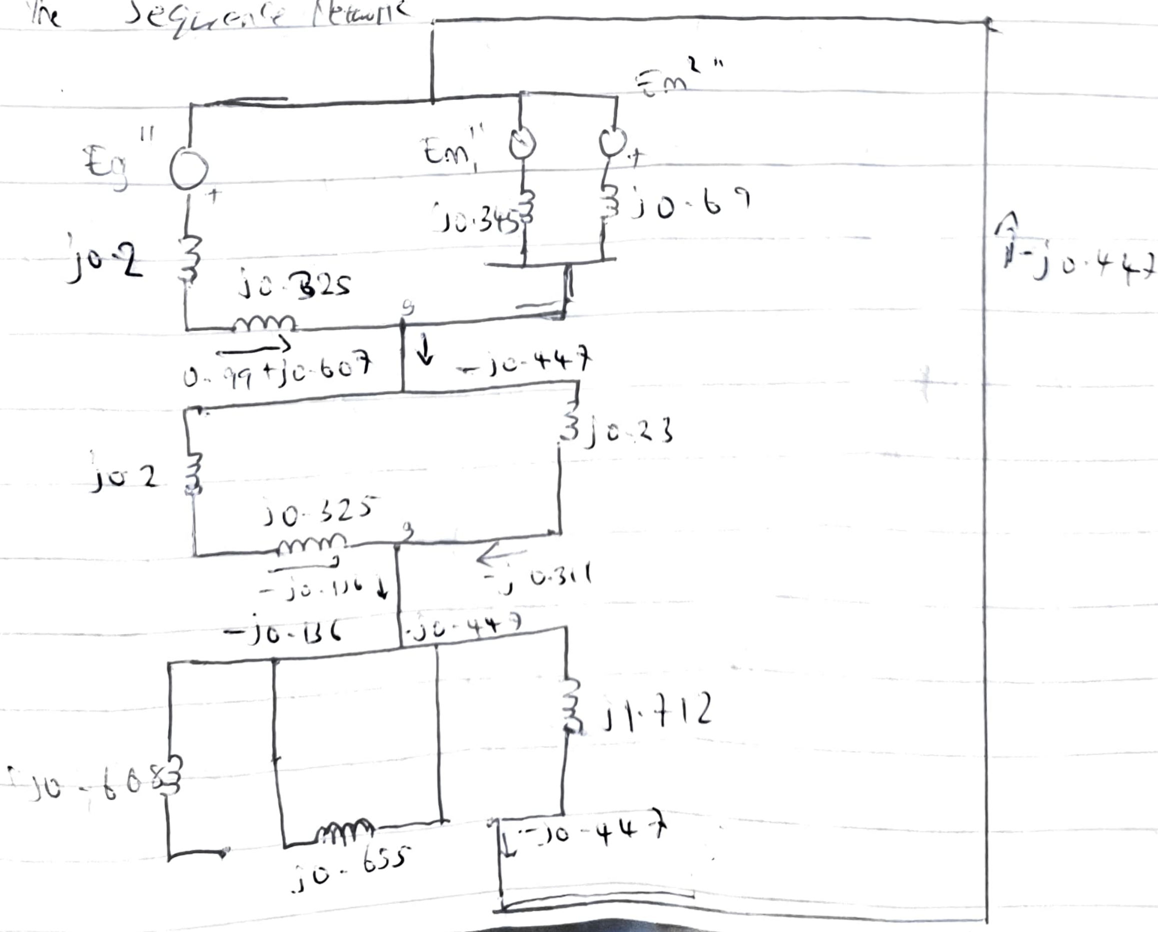
Reference Bus

[B] Solution

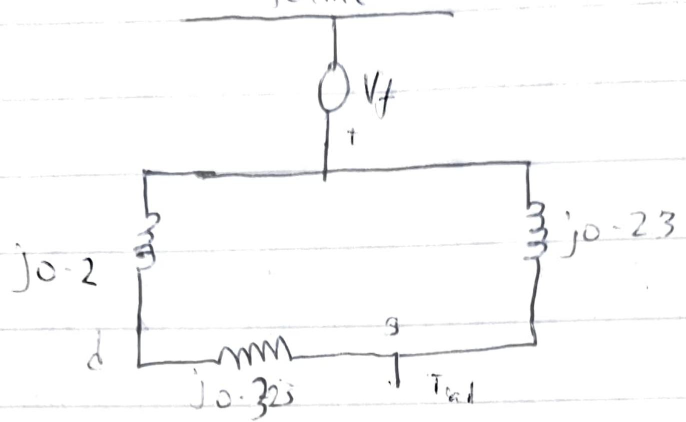
If pre fault current are neglected

$$E_g = E_{m_1}'' = E_{m_2}'' = V_f'' = \frac{10}{11} = 0.909 \, pu$$

Connection of the Sequence Network



The positive sequence network can be easily replaced by its Thevenin equivalent solution below



Now calculating Z_1

$$Z_1 = \frac{j0.525 \times j0.23}{j0.755} = j0.16 pu$$

$$Z_2 = Z_1 = j0.16 pu$$

From the sequence network connection

$$I_{a1} = \frac{V_f^0}{Z_1 + Z_2 + Z_0} = \frac{0.909}{j2.032} = -j0.447 pu$$

$$I_{a2} = I_{a0} = I_{a1} = -j0.447 pu$$

$$\text{fault current} = 3I_{a0} = 3 \times (-j0.447) = -j1.341 pu$$

The component of the I_{a1} flowing towards g from the generator side.

$$-j0.447 \times \frac{j0.23}{j0.755} = -j0.136 pu$$

and its component flowing towards g from the motor side

$$-j0.447 \times \frac{j0.525}{0.755} = j0.311 pu$$

Fault Current from the generator towards g am

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

and to g from motors side

$$\begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ \alpha^2 & \alpha & 1 \\ \alpha & \alpha^2 & 1 \end{bmatrix} \begin{bmatrix} -j0.311 \\ -j0.311 \\ +j0.447 \end{bmatrix} = \begin{bmatrix} -j0.069 \\ -j0.136 \\ +j0.136 \end{bmatrix} pu$$

Positive Sequence Component of the transmission line Current has phase shift $-90°$

Negative Sequence Component of the transmission line Current is shift $+90°$

Positive Sequence Current $= j \times (-j0.136) = -0.136$ pu

Negative Sequence Current $= j \times j0.136 = 0.136$ pu

Zero Sequence Current $= 0$

Line a Current in the transmission line

$I_a = -0.136 + 0.136 + 0 = 0$

Calculating the voltages behind the subtransient reactances to be used if the load changes are accumulated for

$$\text{Motor} \; \frac{15}{25 \times 0.909 \times 0.8} \times 36.86° = 0.825 \angle 36.86°$$

$$= 0.66 + j0.495 \text{ pu}$$

Motor 2 : $\frac{7.5}{25 \times 0.909 \times 0.8}$ $\angle 36.82$

$= 0.4125 \angle 36.86 = 0.33 + j0.248$ pu

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

Total Voltages behind Subtransient Reactances

motor : $E_{m_1}'' = 0.909 - j0.245 \times 0.825 \angle 36.86$

$= 1.08 - j0.228 = 1.104 \angle -11.92$ pu

Motor 2 $E_{m_2}'' = 0.909 - j0.69 \times 0.4125 \angle 36.86$

$= 1.08 - j0.228 = 1.104 \angle -11.92$ pu

Generator $E_g'' = 0.909 + j0.325 \times 1.2375 \angle 36.86$

$= 0.52 + j0.52 = 0.735 \angle 45$ pu

Therefore the actual value of positive sequence current from the generator towards the fault is

$0.99 + (-j0.73) - 0.336 = 0.99 - j1.054$

The actual value of positive sequence current from the motor to the fault is

$= -0.99 - j0.743 - j0.311$

$= -0.99 - j1.054$