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16/ENG04/056
ELECT / ELECT ENGR

ASSIGNMENT SOLUTION

Base = 25MVA $\quad X = 10\% = \frac{10}{100} = 0.1\Omega \quad X_m = 25\% = \frac{25}{100} = 0.25$

$V_{base} = 11kV \quad X_o = 20\% = \frac{20}{100} = 0.2\Omega$

a) $I_L = V_{base} = 11 \times \frac{121}{10.8} = 123.2kV$

b) Motor

$V_{base} = 11.2 \times \frac{10.8}{121} = 11kV$

The transformer's line & motor reactances are converted to pu values.

c) Transformer reactance

$X_T = 0.1 \times \frac{25}{30}\left[\frac{10.8}{11}\right]^2$

$= 0.0803pu$

d) Line reactance;

$X_L = \frac{100 \times 25}{[123.2]^2}$

$= 0.164pu$

e) Motor reactance;

$X = 25\% = \frac{25}{100} = 0.25$

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

$= 0.344pu$

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

$= 0.689pu$

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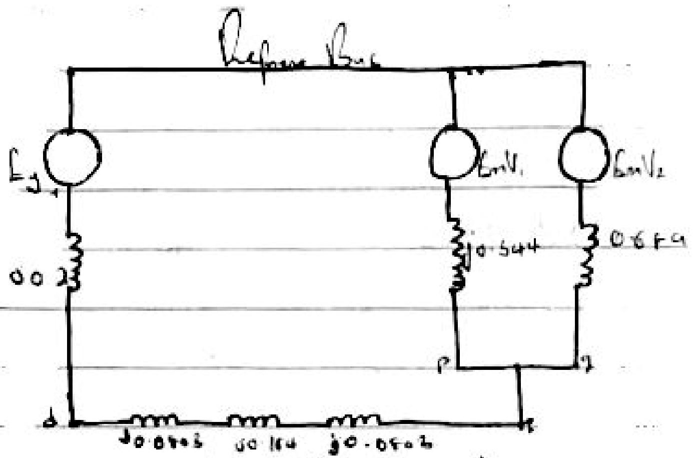
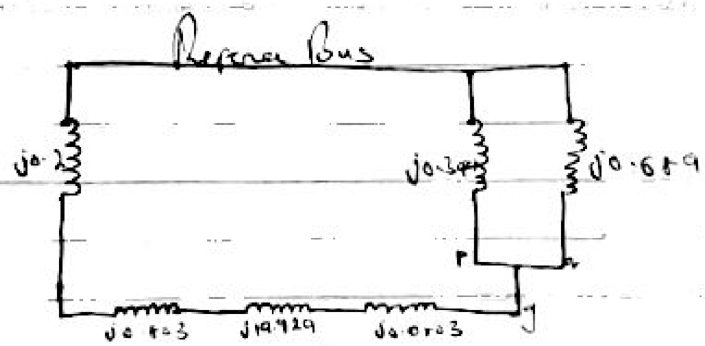
Zero Sequence reactance of the transmission line

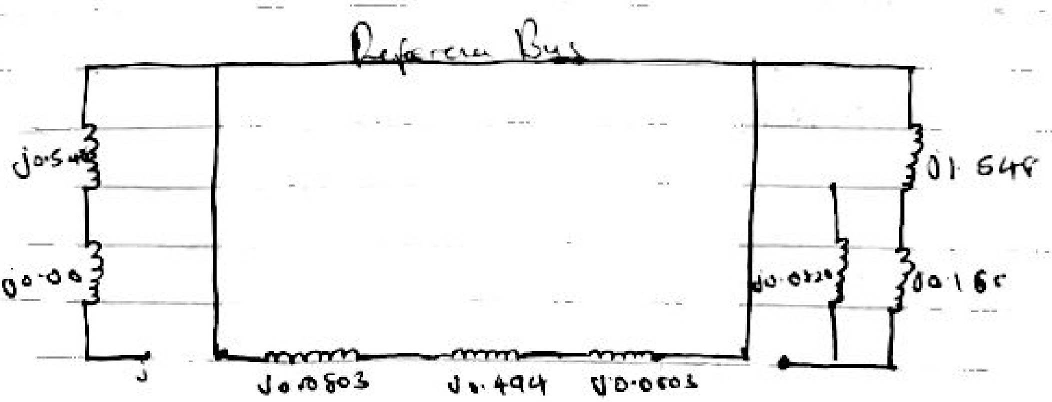
$$X_{esTL} = \frac{300 \times 25}{(123.2)^2} = 0.494\ pu$$



positive Sequence network



Negative Sequence Network



Zero Sequence Network

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

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Reactance of Current limiting reactor included in the zero Sequence network

$= 3 \times 0.516$

$= 1.548 pu$

i] Zero Sequence reactance of motor

a] Motor I

$$X_{2SRm1} = 0.06 \times \left[\frac{25}{15}\right] \times \left[\frac{10}{11}\right]^2$$

$$= 0.0826 pu$$

b] Motor 2

$$X_{2SRm2} = 0.06 \times \left[\frac{25}{7.5}\right] \times \left[\frac{10}{11}\right]^2$$

$$= 0.1625 pu$$

B

Neglecting prefault currents

$E_g = E_{m1} = E_{m2} = V_f$ [prefault voltage at g]

$$= \frac{10}{11}$$

$$= 0.909 pu$$

$Z_2 = Z_1 = j0.16 pu$

from the Sequence network,

$$I_{a1} = \frac{V_f}{Z_1 + Z_2 + Z_0}$$

$$= \frac{0.909}{j2.032}$$

$$= -j0.447 pu$$

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

Fault Current $= 3I_{a0} = 3 \times [j0.447]$
$= -j1.341 \text{ pu}$

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

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

I_{a1} Component flowing to g from the motor,

$$-j0.447 \times \frac{j0.525}{j0.755}$$
$$= -j0.311 \text{ pu}$$

I_{a0} 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 current from the motor towards g,

$$\begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ \alpha^2 & \alpha & 1 \\ \alpha & \alpha^2 & 1 \end{bmatrix} \begin{bmatrix} -j0.311 \\ -j0.311 \\ -j0.447 \end{bmatrix} = \begin{bmatrix} -j1.06 \\ -j0.136 \\ -j0.136 \end{bmatrix} \text{pu}$$

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

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

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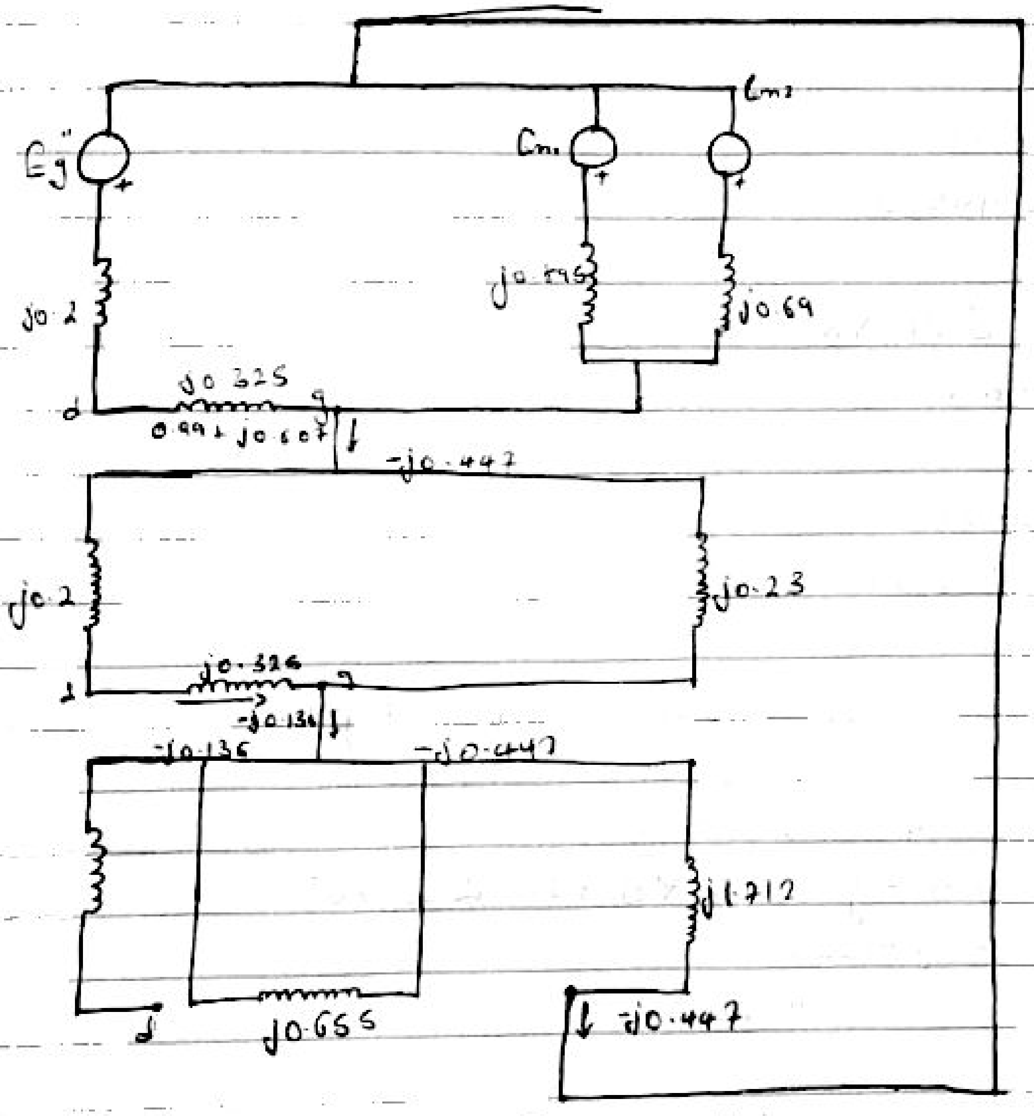
Positive Sequence Current = j × [-j0.136] = -0.136 pu
Negative Sequence Current = j × [-j0.136] = 0.136 pu
Zero Sequence Current = 0



Connection of the Sequence Network

Line a current on the transmission line
= -0.136 + 0.136 + 0
= 0

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Calculation for Voltages behind Subtransient reactances to be used, if load current are accounted for.

Motor 1: $\frac{15}{25 \times 0.909 \times 0.8} \angle 36.86°$

$= 0.825 \angle 36.86°$
$= 0.66 + j0.495 pu$

Motor 2: $\frac{7.5}{25 \times 0.909 \times 0.8} \angle 36.86$

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

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

Total voltages behind Subtransient reactances

Motor 1, $E_{m1}'' = 0.909 - j0.345 \times 0.825 \angle 36.86°$
$= 1.08 - j0.228$
$= 1.104 \angle -11.92 pu$

Motor 2, $E_{m2}'' = 0.909 - j0.69 \times 0.4125 \angle 36.86$
$= 1.08 - j0.228$
$= 1.104 \angle -11.92 pu$

Generator: $E_g'' = 0.909 + j0.525 \times 1.2375 \angle 36.86$
$= 0.52 + j0.52$
$= 0.735 \angle 45° pu$

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Therefore, the actual value of +ve sequence current from the generator towards the fault is

$0.99 + [-j0.73] - j0.136$

$= 0.99 - j1.054$

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

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

$= 0.99 - j1.054$

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