DAFE MERCY EBELE 16/ENG04/014 EEE553 ASSIGNMENT

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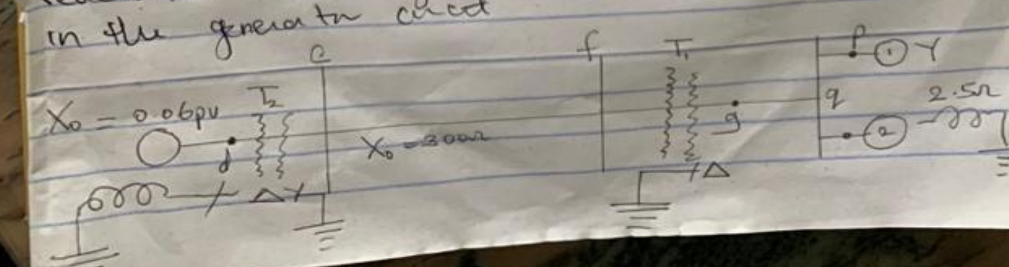
16/ENG04/014
EEE553 Assignment

- A 25MVA, 11kV, three-phase generator has a subtransient reactance of 20%. The generator supplies two motors over a transmission line with transformers at both ends as shown in the one-line diagram. The motors have rated inputs of 15 and 7.5 MVA, both 10kV with 25% substransient reactance. The three phase transformer are both rated 30MVA, 10.8/11kV Connection Δ-Y with leakage reactance of 10% each. The series reactance of the line is 100Ω

- Draw the positive, negative & the zero sequence networks of the system with reactance marked in per unit

- If the motors are loaded to draw 15 and 7.5MW at 10kV, 0.8 leading power factor before the occurence of a solid LG at bus g and the prefault current is neglected, calculate the fault current and substransient current in all parts of the system.

- Assume that the negative occurence reactance of each machine is equal to the substransient reactances. Select generator rating as base in the generator circuit



T Base = 25MVA
T Vbase = 121kV
T X = 10%

$\frac{10}{100} = 0.1\Omega$

$X_s = 20\% = \frac{20}{100} = 0.2\Omega$

$X_m = 25\% = \frac{25}{100} = 0.25\Omega$

T_L, Vbase $= 11 \times \frac{121}{10.8}$

$= 123.24kV$

motor

Voltage base $= 123.24 \times \frac{10.8}{121}$

10.996kV

= 11kV

The reactance for transformer, transmission line and motors connected to pu values with their base respectively

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

$= j0.0805pu$

Transmission line reactance $= \frac{100 \times 0.5}{(123.24)^2}$

$= j0.164pu$

Rectance of motor 1 $= 0.25 \times \frac{25}{15} \times \left(\frac{10}{11}\right)^2 = j0.343\,pu$

Reactance of motor 2 $= 0.25 \times \frac{25}{7.5} \times \left(\frac{10}{11}\right)^2 = j0.69\,pu$

The positive sequence network is shown below

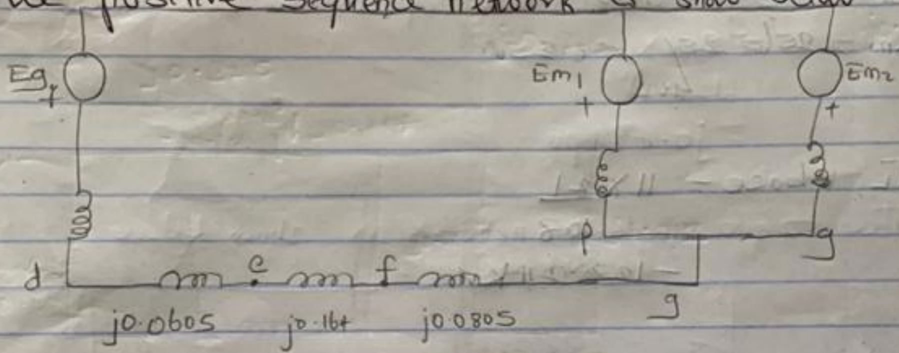


fig1: Positive sequence network

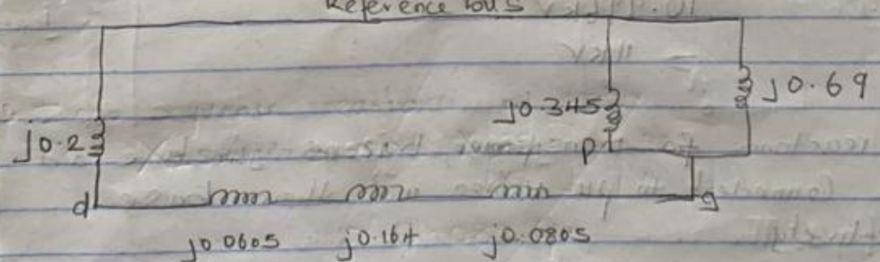


fig2: Negative Sequence Network

Since all the negative sequence reactance of the system are equal to the negative sequence reactances, the negative sequence network is identical to the positive sequence network

Zero sequence reactance of motor 2 $= 0.06 \times \frac{25}{7.5} \times \left(\frac{10}{11}\right)^2$

reactance of current limiting $= \frac{2.5 \times 25}{(11)^2} = j0.516pu$

Rectance of current limiting reactor included in zero sequence network $= 3 \times 0.516 = j1.548pu$

Zero sequence reactance of transmission line

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

$= j0.494pu$

The zero sequence network is shown below

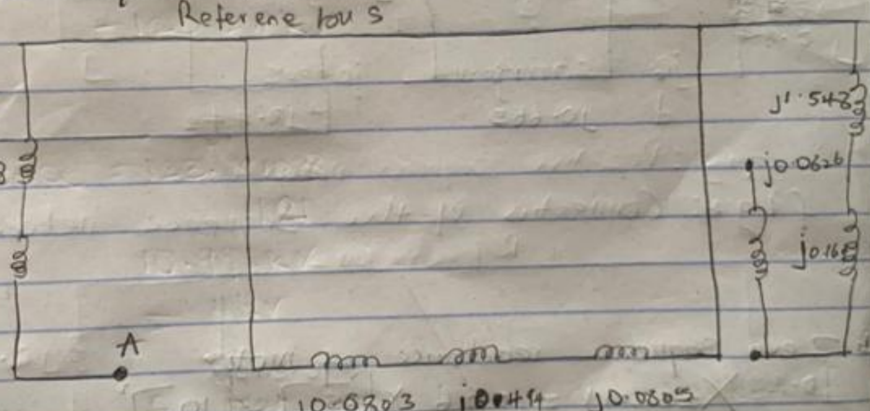


fig 3: The zero Sequence network

If the prefault currents are neglected

$E_g = E^{\circ}m_1 = E^{\circ}m_2 = V_f$ (prefault voltage 4g)

$\frac{10}{11} = 0.909pu$

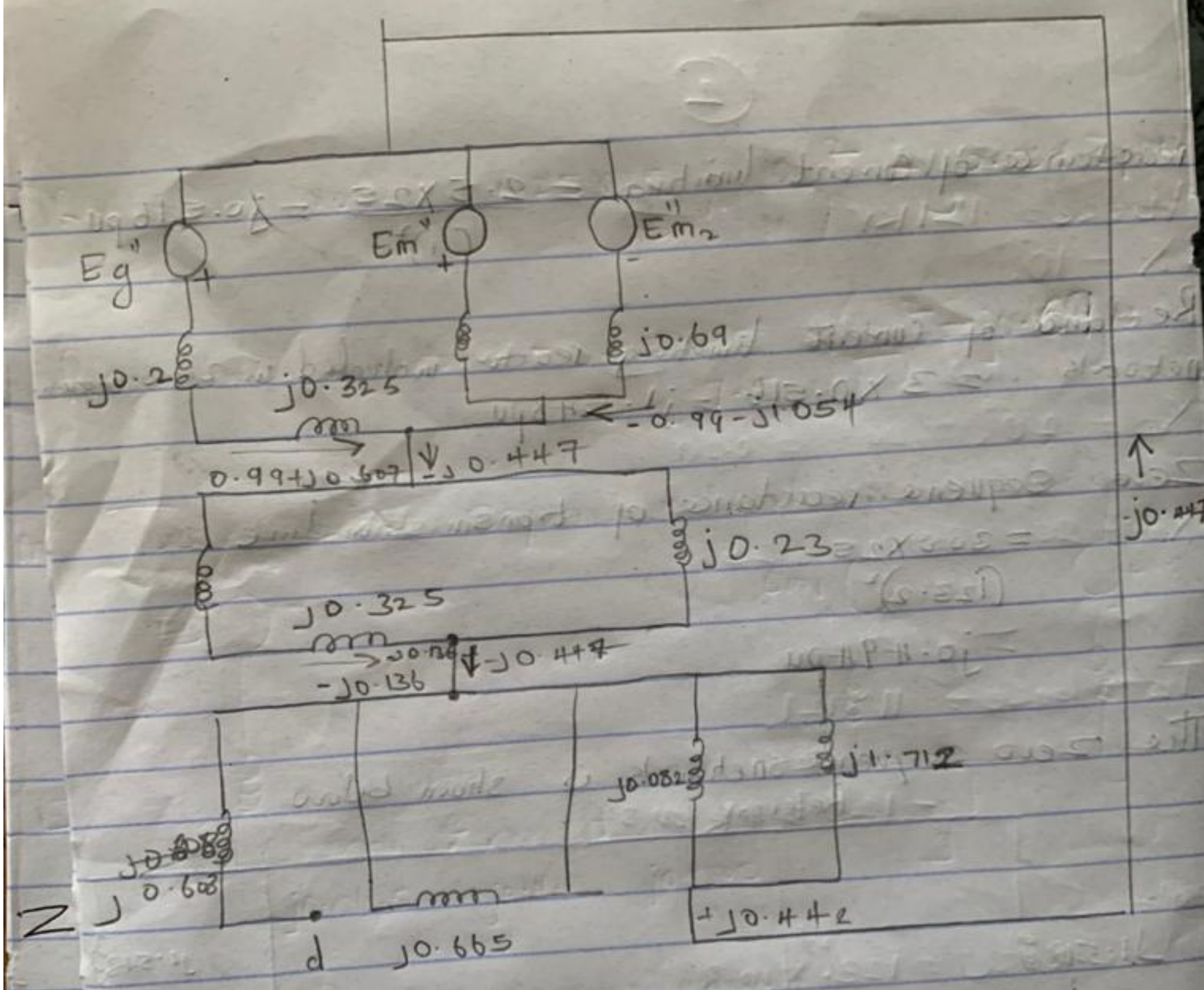


fig 4: Connection of the sequence networks

Zero sequence reactance of motor

$$X_{2SRM1} = 0.06 \times \left[\frac{25}{15}\right] \times \left[\frac{10}{11}\right]^2$$

$$= 0.0826 \text{pu}$$

The positive sequence network can be easily replaced by it's thevenin equivalent shown in fig 5

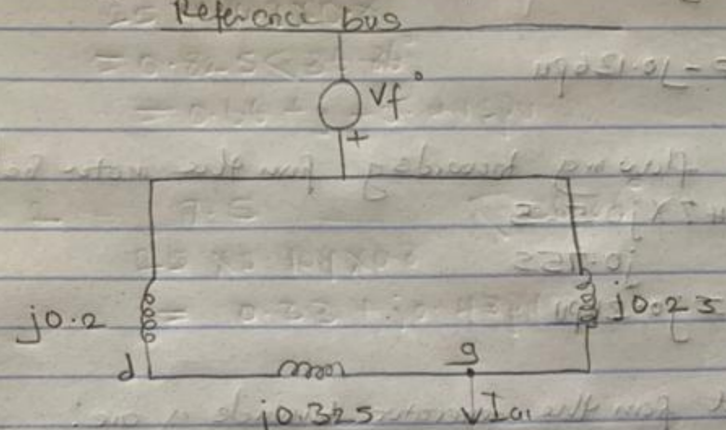


fig 5

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

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

$$I_{a_1} = \frac{V_f^\circ}{Z_1 + Z_2 + Z_0}$$
$$= \frac{0.909}{j2.032}$$
$$= -j0.447pu$$

$$I_{a_2} = I_{a_0} = I_{a_1} = -j0.447pu$$

$$\text{fault current} = 3I_{a_0} = 3 \times (-j0.447)$$
$$= -j1.341pu$$

The Component of I_{a_1} flowing towards g from the generator side

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

$$= -j0.136 pu$$

Component flowing towards g from the motor side

$$\frac{-j0.447 \times j0.525}{j0.755}$$

$$= j0.311 pu$$

fault current from the generator towards g are:

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

fault current from the motor

$$\begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ \alpha^2 & \alpha & 1 \\ \alpha & \alpha^2 & 1 \end{bmatrix} \begin{bmatrix} -j0.311 \\ -j0.311 \\ -j0.447 \end{bmatrix} = \begin{bmatrix} -j1.069 \\ -j0.136 \\ -j0.136 \end{bmatrix} pu$$

positive sequence current $= -j(-j0.136)$

$= -0.136 pu$

Negative sequence current $= j(-j0.136) = 0.136 pu$

Zero sequence current $= 0$

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

I_b & I_c are similarly calculated.

(2)

The per unit motor

$$\text{motor } 1 = \frac{15}{25 \times 0.909 \times 0.8} \angle 36.86^\circ$$

$$= 0.825 \angle 36.86^\circ$$

$$= 0.66 + j + 0.495 pu$$

$$\text{Motor } 2 = \frac{7.5}{25 \times 0.909 \times 0.8} \angle 36.86^\circ$$

$$= 0.33 + j0.48 pu$$

$$E_{m_1}'' = 0.909 - j0.345 \times 0.825 \angle 36.86^\circ$$

$$= 1.104 \angle -11.92^\circ pu$$

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

$$= 1.08 - j0.228$$

$$= 1.1042 \; -11.92 pu$$

$$E_g'' = 0.909 + j0.525 \times 1.2375 \angle 36.86^\circ$$

$$= 0.52 \times j0.52$$

$$= 0.735 \angle 45^\circ pu$$

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

$$(0.99) + (-j0.743) - (j0.136)$$

$$= 0.99 + j0.607$$

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

$$-0.99 - j0.743 - j0.311 = -0.99 - j1.054$$

Since the two sequence reactance are large, load current is comparable with the fault current.