NAME: ABBEY FLOURISH OBARI-AKASE

16/ENG04/001

ELECT/ELECT

EEE553 ASSIGNMENT

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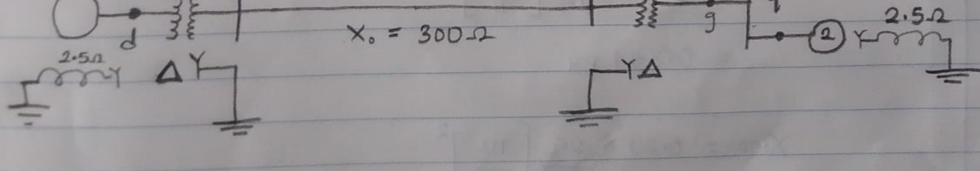
ASSIGNMENT

A 25 MVA, 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% subtransient reactance. The three-phase transformers are both rated 30MVA, 10.8/11KV, connection Δ-Y with leakage reactance of 10% each. The series reactance of the line is 100 ohms

a. Draw the positive, negative and the zero sequence networks of the system with reactances marked in per unit.

b. If the motors are loaded to draw 15 and 7.5 MW 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 subtransient current in all parts of the system.

NB Assume that the negative sequence reactance of each machine is equal to the subtransient reactance. Omit resistances. Select generator rating as base in the generator circuit.



SOLUTION

Base = 25MVA

V_{Base} = 11KV

$X = 10\% = \frac{10}{100} = 0.1Ω$

$X_s = 20\% = 20/100 = 0.2Ω$

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

A

a. $T_1, V_{base} = 11 \times \frac{121}{10.8}$

$= 123.2KV$

b. Motor,

Voltage base $= 11.2 \times \frac{10.8}{121}$

$= ~~10.5_{KV}~~ = 11_{KV}$

$~~\approx 11_{KV}~~$

The transformers, line and motor reactances are converted to pu values;

c. Transformer reactance,

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

$$= 0.0803\ pu$$

d. Line reactance,

$$~~X_L = \frac{100 \times 25}{(121)^2}~~ \quad X_L = \frac{100 \times 25}{(123.2)^2}$$

$$~~= 0.164pu~~ \quad = 0.164pu$$

$$~~= 19.929_{pu}~~$$

e. Motor reactance; $X = 25\% = 25/100 = 0.25$

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

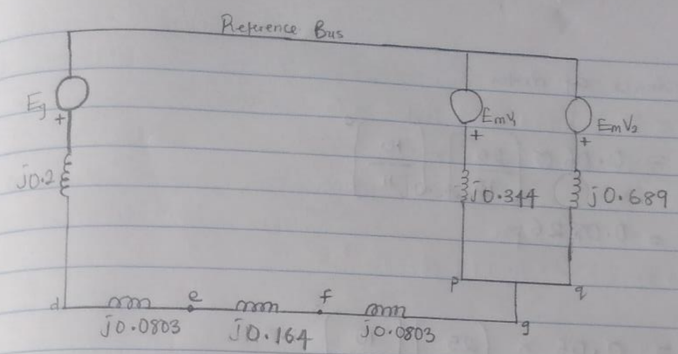
$$= 0.344\ pu$$

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

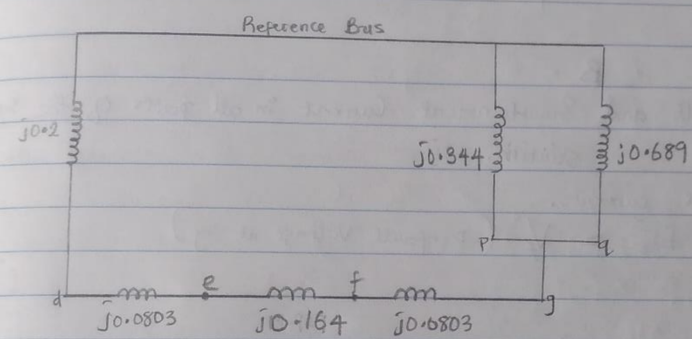
$$= 0.689_{pu}$$

f. Zero Sequence reactance of the transmission line,

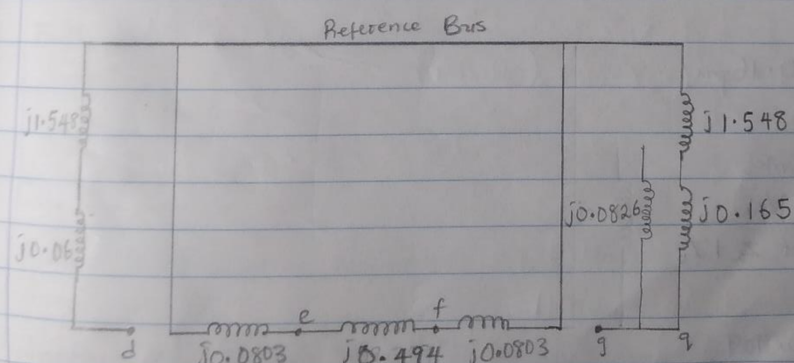
$$~~X_{zsTL} = \frac{300 \times 25}{(121)^2} = 59.789_{pu}~~ \quad X_{zsTL} = \frac{300 \times 25}{(123.2)^2} = 0.494pu$$



Positive Sequence network



Negative Sequence Network



Zero Sequence Network

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

- Reactance of current limiting reactor included in the Zero Sequence network

$= 3 \times 0.516$

$= 1.548pu$

i. Zero Sequence reactance of motor

a. Motor 1

$$X_{zSRM1} = 0.06 \times \left[\frac{25}{15}\right] \times \left[\frac{10}{11}\right]^2$$

$$= 0.0826 pu$$

b. Motor 2

$$X_{zSRM2} = 0.06 \times \left[\frac{25}{7.5}\right]\left[\frac{10}{11}\right]^2$$

$$= 0.165 pu$$

B

Calculate the fault and Subtransient Current in all parts of the System.

Solution.

Neglecting Prefault currents.

$$E_g'' = E_{M1}'' = E_{M2}'' = V_f^{\circ} \text{ (Prefault Voltage at g)}$$

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

$$= 0.909 pu$$

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

from the Sequence network;

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

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

$$= -j0.447 pu$$

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

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_{a1} Component flowing to g from the motor;

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

$= -j0.311$ pu

I_{a0} flow to g.

Fault currents from the generator towards g;

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

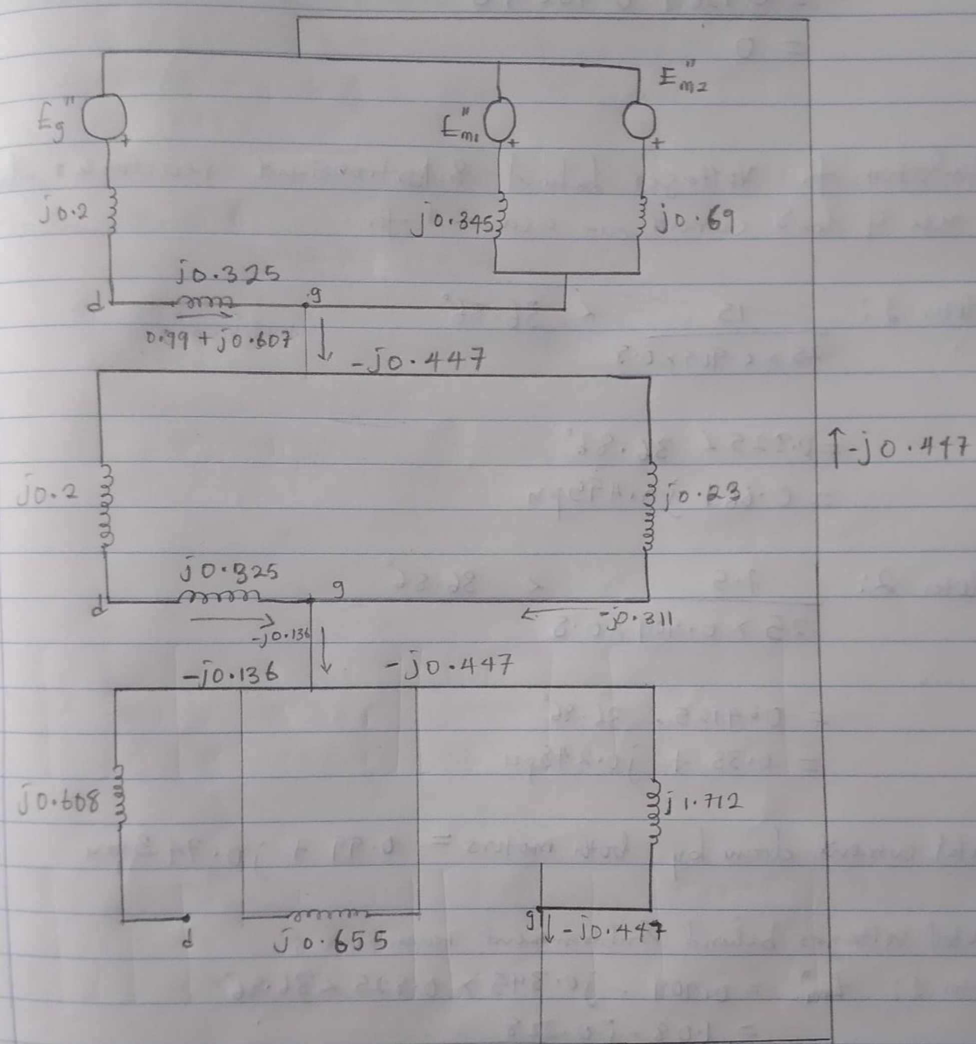
Fault currents from the motor towards g;

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

Positive (+ve) Sequence component of the transmission line current has phase shift -90°

Negative (-ve) Sequence Component of the transmission line current is Shift to $+90^\circ$

Positive Sequence current $= j \times (-j0.136) = -0.136$ pu
Negative Sequence current $= j \times (-j0.136) = 0.136$ pu
Zero Sequence current $= 0$



Connection of the Sequence networks

Line a current on the transmission line.

$= -0.136 + 0.136 + 0$

$= 0$

calculation for voltages behind subtransient reactances to be use if load current are accounted for.

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

$= 0.825 \angle 36.86^\circ$

$= 0.66 + j0.495 pu$

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

$= 0.4125 \angle 36.86^\circ$

$= 0.33 + j0.248 pu$

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

Total voltages behind subtransient reactances;

Motor 1; $E_{m_1}'' = 0.909 - j0.345 \times 0.825 \angle 36.86^\circ$

$= 1.08 - j0.228$

$= 1.104 \angle -11.92 pu$

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

$= 1.08 - j0.228$

$= 1.104 \angle -11.92 pu$

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

$= 0.52 + j0.52$

$= 0.735 \angle 45^\circ pu$

Therefore, the actual value of positive 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

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

$= -0.99 - j1.054$