SOLUTION QUESTION 1

The base impedance for line is

$$Z_B = \frac{(400)^2}{100} = 1{,}600\Omega$$

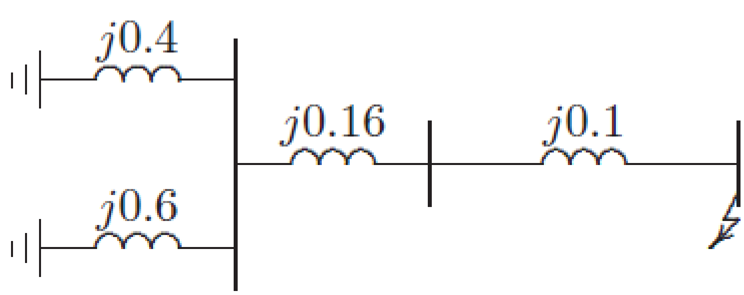
and the base current is

$$I_B = \frac{100{,}000}{\sqrt{3}(400)} = 144.3375 \text{ A}$$

The reactances on a common 100 MVA base are

$$\begin{aligned} X'_{dg1} &= \frac{100}{60}(0.24) = 0.4\text{pu} \\ X'_{dg2} &= \frac{100}{40}(0.24) = 0.6\text{pu} \\ X_t &= \frac{100}{100}(0.16) = 0.16\text{pu} \\ X_{\text{line}} &= \frac{160}{1600} = 0.1\text{pu} \end{aligned}$$

The impedance diagram is as shown in figure below:.



Impedance to the point of fault is

$$X = j\frac{(0.4)(0.6)}{0.4+0.6} + j0.16 + j0.1 = j0.5\text{pu}$$

The fault current is

$$\begin{aligned} I_f &= \frac{1}{j0.5} = 2\angle -90°\text{pu} \\ &= (144.3375)(2\angle -90°) = 288.675\angle -90° \text{ A} \end{aligned}$$

The Short-circuit MVA is

$$\text{SCMVA} = \sqrt{3}(400)(288.675)(10^{-3}) = 200\text{MVA}$$

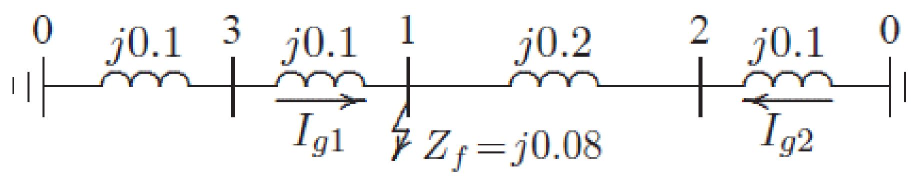
SOLUTION QUESTION 2.

The impedance diagram is as shown in Figure 70.
(a) Impedance to the point of fault is

$$X = j\frac{(0.2)(0.3)}{0.2 + 0.3} = j0.12\text{pu}$$

The fault current is

$$I_f = \frac{1}{j0.12 + j0.08} = 5\angle - 90°\text{pu}$$



(b)

$$\begin{aligned}
V_1 &= (j0.08)(-j5) = 0.4\text{pu} \\
I_{g1} &= \frac{j0.3}{j0.5}(5)\angle - 90° = 3\angle - 90°\text{pu} \\
I_{g2} &= \frac{j0.2}{j0.5}(5)\angle - 90° = 2\angle - 90°\text{pu} \\
V_2 &= 0.4 + (j0.2)(-j2) = 0.8\text{pu} \\
V_3 &= 0.4 + (j0.1)(-j3) = 0.7\text{pu}
\end{aligned}$$

SOLUTION QUESTION 3.

See lecture notes "ER66-W9-The Symmetrical Components (Fortescue Method)", from slide 47 to slide 50.

SOLUTION QUESTION 4. QUIZ

Q1 - Answer: C,D

Q2 - Answer: A,B,C,D

Q3 - Answer: C

Q4 - Answer: A

Q5 - Answer: C

Q6 - Answer: B

SOLUTION QUESTION 5

1 Subtransient Short-Circuit Current at Generator Terminals

Given data:

- $X_d^{''} = 0.15pu$
- Stator voltage $= 20\text{kV} \times 1.05 = 21\text{kV}$
- Base impedance (not necessary):

$$Z_{\text{base}} = \frac{V_{\text{base}}^2}{S_{\text{base}}} = \frac{(20\text{kV})^2}{500MVA} = 0.8\Omega$$

1 Subtransient short-circuit current (in kA):

$$I_{\text{kA}}^{''} = I_{\text{pu}}^{''} \times I_{\text{base}}$$

where:

$$I_{\text{base}} = \frac{S_{\text{base}}}{\sqrt{3} \cdot V_{\text{base}}}$$

2 **Substituting values:**

- $I_{\text{pu}}^{''} = 7pu$
- $I_{\text{base}} = \frac{500}{\sqrt{3} \cdot 20} = 14.43kA$

$$I_{\text{kA}}^{''} = 7 \times 14.43 = 101.01kA$$

3 **Total Subtransient Short-Circuit Current**

- Total reactance considering the subtransient time frame :

  We do consider in this way the transformer, load and line impedance are in parallel with $X_d^{''}$ as the fault occurs in the generator terminals.

$$X_{\text{total}} = X_d^{''} // X_m^{''} + X_{\text{L}} = 1/0.15 + 1/(0.20 + 0.305) = 0.1156\text{pu}$$

- Total short-circuit current (per unit):

$$I_{\text{pu, total with load}}^{''} = \frac{1.05}{X_{\text{total}}} += \frac{1.05}{0.1156} = 9.079$$

- Total short-circuit current (kA):

$$I_{\text{kA, total}}^{''} = I_{\text{pu, total}}^{''} \times I_{\text{base}}$$

Substituting values:

$$I_{\text{kA, total}}^{''} = 9.079 \times 14.43 = 131kA$$