Short Circuit Problem 1

The positive-sequence one-line diagram for a network is shown below. The ground ties at busses 1 and 4 represent the subtransient impedances of machines. Prefault voltages are all 1.0pu.

\[ z_{jk} = \frac{\Delta V_j}{\Delta I_k} \]

\[ \Delta I_m = 0 \quad m \neq k \]

a. Use the definition \( z_{jk} = \frac{\partial V_j}{\partial I_k} = \left. \frac{V_j}{I_k} \right|_{I_m=0, m \neq k} \) to fill in column 1 of the Z matrix.

Now, a solidly-grounded three-phase fault occurs at bus 1.

b. Compute the fault current

c. Use the fault current and Z matrix terms to compute the voltages at busses 2 and 3.

d. Find the magnitude of the current flowing in the line connecting busses 2 and 3.

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \Sigma y )'s connected to #1</td>
<td>( -\Sigma y )'s connected between 1&amp;2</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0.05</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>0.1</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>0.3</td>
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Short Circuit Problem 3

A one-line diagram for a two-machine system is shown below.

Machines 1 and 2:  
100 MVA  
20 kV  
$X_0 = 0.04$  
$X_1 = X_2 = 0.2$  
$X_b = 0.05$

Transformers $T_1$ and $T_2$:  
100 MVA  
20Δ/345Y kV  
$X_1 = X_2 = X_0 = 0.08$

The transmission line between busses 2 and 3 has $X_1 = X_2 = 0.12\text{pu}$, $X_0 = 0.40\text{pu}$ on a 100MVA, 345kV base.

Using a base of 100MVA, 345kV in the transmission line, draw one line diagrams in per unit for positive, negative, and zero-sequences.

Then,

a. Compute the phase a fault current (in pu) for a three-phase bolted fault at bus 2.

b. Compute the phase a fault current (in pu) for a line-to-ground fault at bus 2, phase a.
Short Ckt Analysis

Single-Phase or Balanced 3P - one-line diagram

Case 1 - Ground Tie to \( \pm 3 \)

\[ F = 3 \]
\[ I_B = \begin{cases} F & V_3 = 0 \\ F & \end{cases} \]
\[ I_3^F = I_{3,51} + I_{3,52} \]
\[ F \]

From the left:
\[ I = \frac{V_{31}}{3s_1 + 3s_2} \]
\[ F \]

From the right:
\[ I = \frac{V_{52}}{3s_2 + 3s_1 + 3s_3} \]
\[ F \]

Case 2, Ground Tie to \( \pm 5 \)

\[ V_{5}^F = 0 \] Node Eq

\[ \frac{V_3 - V_{31}}{3s_1 + 3s_3} + \frac{V_2 - V_{32}}{3s_3 + 3s_2} + \frac{V_3}{3s_5} = 0 \]

Solve for \( V_3 \):
\[ I_5 = \frac{V_3}{3s_5} \]

So, write Eq for case, solve Fault Contributions?
Thevenin Approach

\[ \Delta V = Z \Delta I \]

\[ \Delta V_1 = Z_{11} \Delta I_1 + \cdots + Z_{1N} \Delta I_N \]

\[ \Delta V_2 = Z_{21} \Delta I_1 + \cdots + Z_{2N} \Delta I_N \]

\[ \Delta V_N = Z_{N1} \Delta I_1 + \cdots + Z_{NN} \Delta I_N \]

\[ \Delta V_5 = Z_{51} \Delta I_1 + Z_{52} \Delta I_2 + Z_{53} \Delta I_3 + Z_{54} \Delta I_4 + Z_{55} \Delta I_5 \]

IF \( V_5^F = 0 \), then \( \Delta V_5 = V_5 - V_5^F = -V_5 \)
\[ I_5 = \frac{-V_5^{\text{pre}}}{255} = I_5^{\text{pre}} - I_5^{\text{pre}} = I_5 \text{ (in)} \]

Usually define fault I going out

so \[ I_5^{\text{F}} = \frac{V_5^{\text{pre}}}{255} \]

Thevenin

Currents in segments

\[ I_{13}^{\text{pre}} = \frac{V_{13}^{\text{pre}}}{Z_{13}} \]

\[ \Delta I_{13} = (I_{13}^{\text{F}} - I_{13}^{\text{pre}}) \]

\[ I_{13}^{\text{F}} = \frac{V_{13}^{\text{F}} - V_{13}^{\text{pre}}}{Z_{13}} = \left( \frac{V_{13}^{\text{F}} - V_{13}^{\text{pre}}}{Z_{13}^{\text{F}}} \right) \]

\[ V_1^{\text{F}}, V_3^{\text{F}} \]

\[ \Delta V_1 = Z_{11} \Delta I_1 + \ldots + Z_{13} \Delta I_3 = Z_{15} \Delta I_5 \text{ (in)} \]

\[ \Delta V_1 = (V_1^{\text{F}} - V_1^{\text{pre}}) = Z_{15} \Delta I_5 \text{ (in)} \]

\[ \Delta V_2 = (V_3^{\text{F}} - V_3^{\text{pre}}) = Z_{35} \Delta I_5 \]

So, get \( \Delta I_5 \), then \( \Delta V_1 \) & \( \Delta V_3 \), then \( \Delta I_{13} \) etc.

Fault contrib
What About Fault impedance?

\[ V_5^F \neq 0, \quad V_5^F = -I_5^F \cdot Z_F \]

\[ I_5^F = Z_F \cdot (10 \text{ J}, \text{ example}) \]

\[ 0 = Z_{SS} \cdot I_5 \]

\[ (V_5^F - V_5^{\text{pre}}) = Z_{SS} \left( I_5^F - I_5^{\text{pre}} \right) \]

\[ (-I_5^F \cdot Z_F - V_5^{\text{pre}}) = Z_{SS} \left( I_5^F - I_5^{\text{pre}} \right) \]

\[ I_5^F (Z_F + Z_{SS}) = V_5^{\text{pre}} - Z_{SS} \cdot I_5^{\text{pre}} \]

\[ I_5^F = \frac{-V_5^{\text{pre}}}{Z_F + Z_{SS}} \quad \Rightarrow \quad \text{Then } V_1^F, V_3^F \]

**Summary**

\[ I_K^F = \frac{V_5^{\text{pre}}}{Z_{KK} + Z_F} \]

\[ V_5^F = V_5^{\text{pre}} - \frac{Z_{KK} \cdot I_K^F}{Z_F + Z_{KK}} \]

\[ \Delta I_{LM} = \frac{(V_L^F - V_M^F)}{Z_{LM}} - \frac{(V_L^{\text{pre}} - V_M^{\text{pre}})}{Z_{LM}} \]

Usually assumed 100% everywhere so no fault pre-fault current.