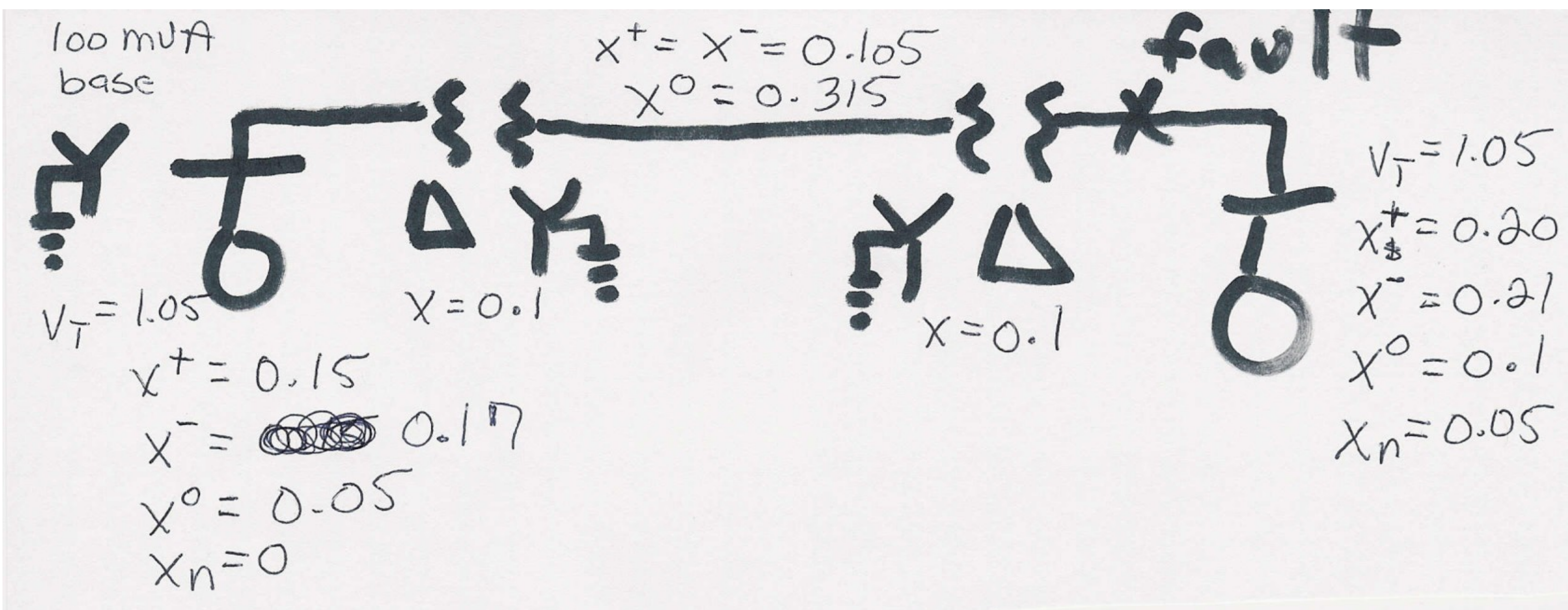
EEE- 601
POWER SYSTEM ANALYSIS
Unit-1

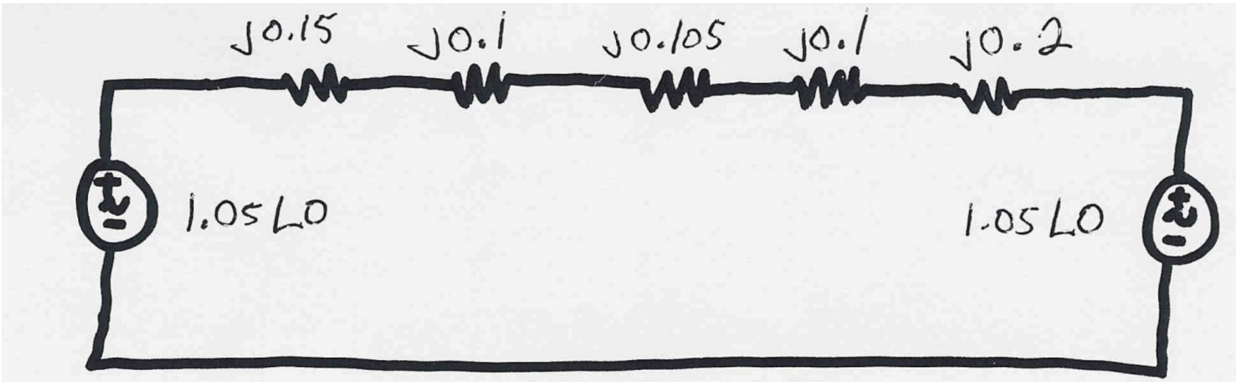
Unbalanced Fault Analysis

- The first step in the analysis of unbalanced faults is to assemble the three sequence networks. For example, for the earlier single generator, single motor example let's develop the sequence networks

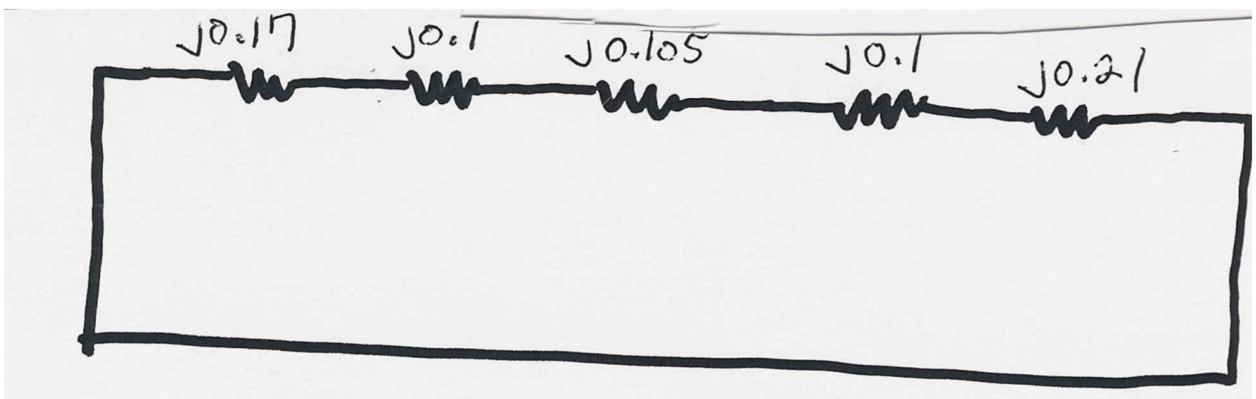


Sequence Diagrams for Example

Positive Sequence Network

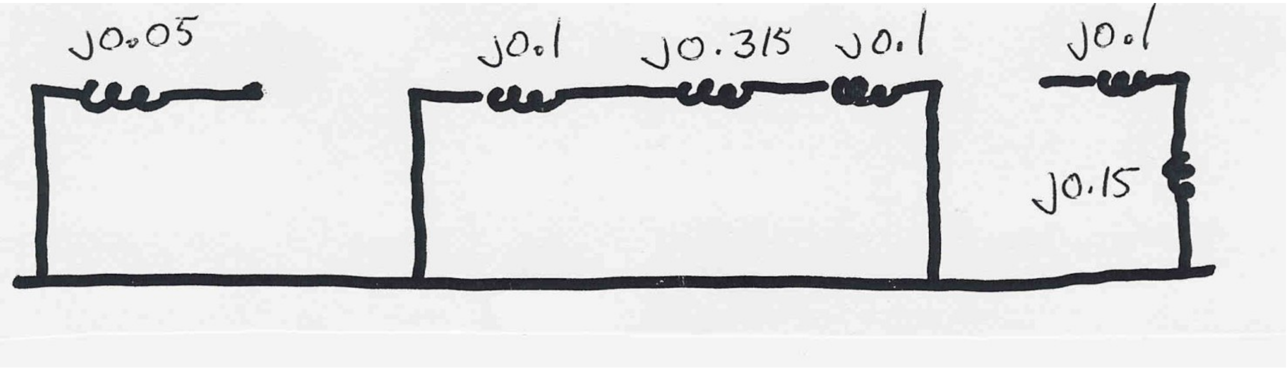


Negative Sequence Network



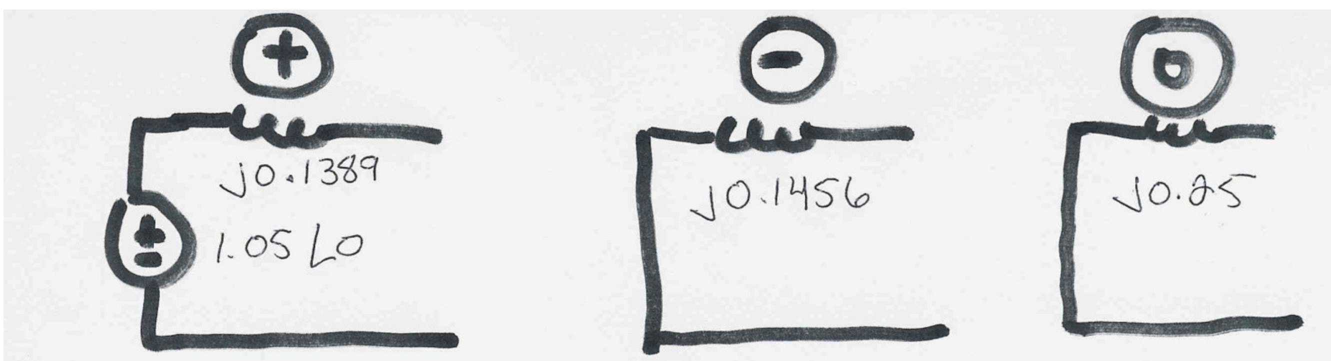
Sequence Diagrams for Example

Zero Sequence Network



Create Thevenin Equivalents

- To do further analysis we first need to calculate the thevenin equivalents as seen from the fault location. In this example the fault is at the terminal of the right machine so the thevenin equivalents are:



$$Z_{th}^{+} = j0.2 \text{ in parallel with j0.455}$$

$$Z_{th}^{-} = j0.21 \text{ in parallel with j0.475}$$

Three phase power in symmetrical components

- $S = V_p^T I_p^* \quad = \quad [A\, V_s]^T [A\, I_s]^*$

  $= V_s^T A^T A^* I_s^* \quad = \quad 3\, V_s^T I_s^*$

  $= 3V_{a0} I_{a0}^* + 3V_{a1} I_{a1}^* + 3V_{a2} I_{a2}^*$

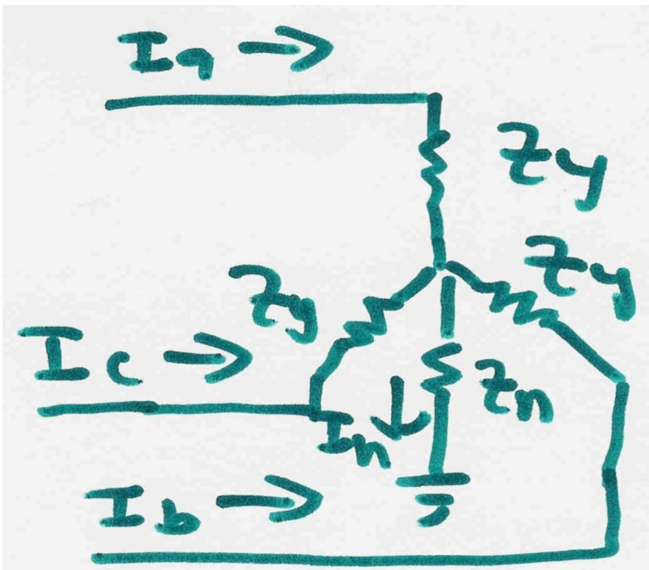
  note that $A^T = A$

$$A^* = \begin{bmatrix} 1 & 1 & 1 \\ 1 & a & a^2 \\ 1 & a^2 & a \end{bmatrix}$$

$$A^T A^* = 3 * \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Use of Symmetrical Components

- Consider the following wye-connected load:



$$I_n = I_a + I_b + I_c$$

$$V_{ag} = I_a Z_y + I_n Z_n$$

$$V_{ag} = (Z_Y + Z_n) I_a + Z_n I_b + Z_n I_c$$

$$V_{bg} = Z_n I_a + (Z_Y + Z_n) I_b + Z_n I_c$$

$$V_{cg} = Z_n I_a + Z_n I_b + (Z_Y + Z_n) I_c$$

$$\begin{bmatrix} V_{ag} \\ V_{bg} \\ V_{cg} \end{bmatrix} = \begin{bmatrix} Z_y + Z_n & Z_n & Z_n \\ Z_n & Z_y + Z_n & Z_n \\ Z_n & Z_n & Z_y + Z_n \end{bmatrix} \begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix}$$

Use of Symmetrical Components

$$\begin{bmatrix} V_{ag} \\ V_{bg} \\ V_{cg} \end{bmatrix} = \begin{bmatrix} Z_y + Z_n & Z_n & Z_n \\ Z_n & Z_y + Z_n & Z_n \\ Z_n & Z_n & Z_y + Z_n \end{bmatrix} \begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix}$$

$$\mathbf{V} = \mathbf{Z}\,\mathbf{I} \qquad \mathbf{V} = \mathbf{A}\,\mathbf{V}_s \qquad \mathbf{I} = \mathbf{A}\,\mathbf{I}_s$$

$$\mathbf{A}\,\mathbf{V}_s = \mathbf{Z}\,\mathbf{A}\,\mathbf{I}_s \quad \rightarrow \quad \mathbf{V}_s = \mathbf{A}^{-1}\,\mathbf{Z}\,\mathbf{A}\,\mathbf{I}_s$$

$$\mathbf{A}^{-1}\,\mathbf{Z}\,\mathbf{A} = \begin{bmatrix} Z_y + 3Z_n & 0 & 0 \\ 0 & Z_y & 0 \\ 0 & 0 & Z_y \end{bmatrix}$$

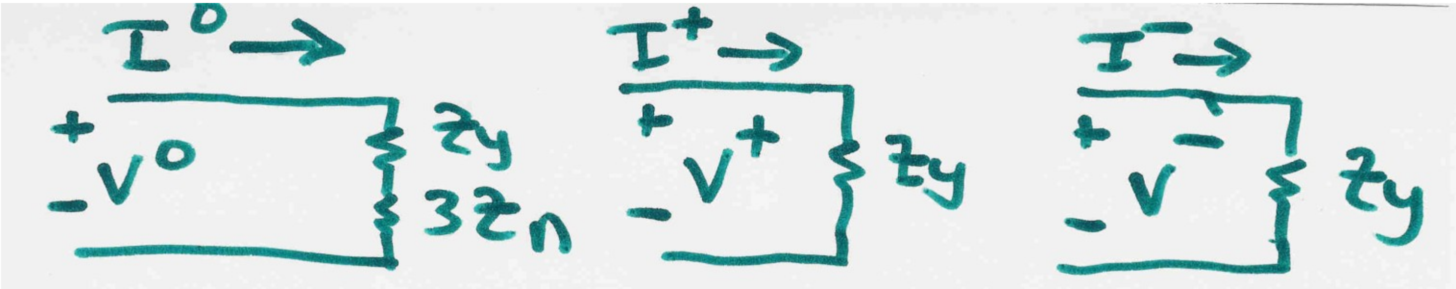
Networks are Now Decoupled

$$\begin{bmatrix} V^0 \\ V^+ \\ V^- \end{bmatrix} = \begin{bmatrix} Z_y + 3Z_n & 0 & 0 \\ 0 & Z_y & 0 \\ 0 & 0 & Z_y \end{bmatrix} \begin{bmatrix} I^0 \\ I^+ \\ I^- \end{bmatrix}$$

Systems are decoupled

$V^0 = (Z_y + 3Z_n)\, I^0 \qquad V^+ = Z_y\, I^+$

$V^- = Z_y\, I^-$



Thank you