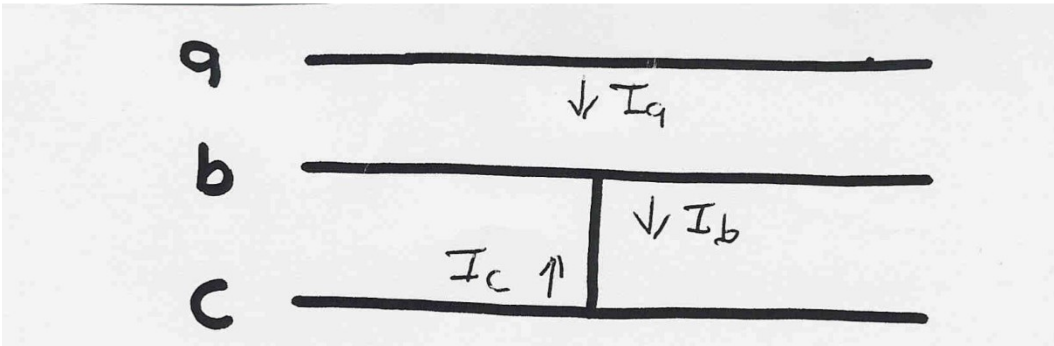
EEE- 601
POWER SYSTEM ANALYSIS
Unit-2

Line-to-Line (LL) Faults

- The second most common fault is line-to-line, which occurs when two of the conductors come in contact with each other. With out loss of generality we'll assume phases b and c.



Current Relationships: $I_a^f = 0, \quad I_b^f = -I_c^f, \quad I_f^0 = 0$

Voltage Relationships: $\mathrm{V}_{\mathrm{bg}} = V_{cg}$

LL Faults, cont'd

Using the current relationships we get

$$\begin{bmatrix} I_f^0 \\ I_f^+ \\ I_f^- \end{bmatrix} = \frac{1}{3}\begin{bmatrix} 1 & 1 & 1 \\ 1 & \alpha & \alpha^2 \\ 1 & \alpha^2 & \alpha \end{bmatrix}\begin{bmatrix} 0 \\ I_b^f \\ -I_b^f \end{bmatrix} \rightarrow$$

$$I_f^0 = 0$$

$$I_f^+ = \frac{1}{3} I_b^f \left(\alpha - \alpha^2\right) \qquad I_f^- = \frac{1}{3} I_b^f \left(\alpha^2 - \alpha\right)$$

Hence $I_f^+ = -I_f^-$

LL Faults, con'td

Using the voltage relationships we get

$$\begin{bmatrix} V_f^0 \\ V_f^+ \\ V_f^- \end{bmatrix} = \frac{1}{3}\begin{bmatrix} 1 & 1 & 1 \\ 1 & \alpha & \alpha^2 \\ 1 & \alpha^2 & \alpha \end{bmatrix}\begin{bmatrix} V_{ag}^f \\ V_{bg}^f \\ V_{cg}^f \end{bmatrix} \rightarrow$$

Hence

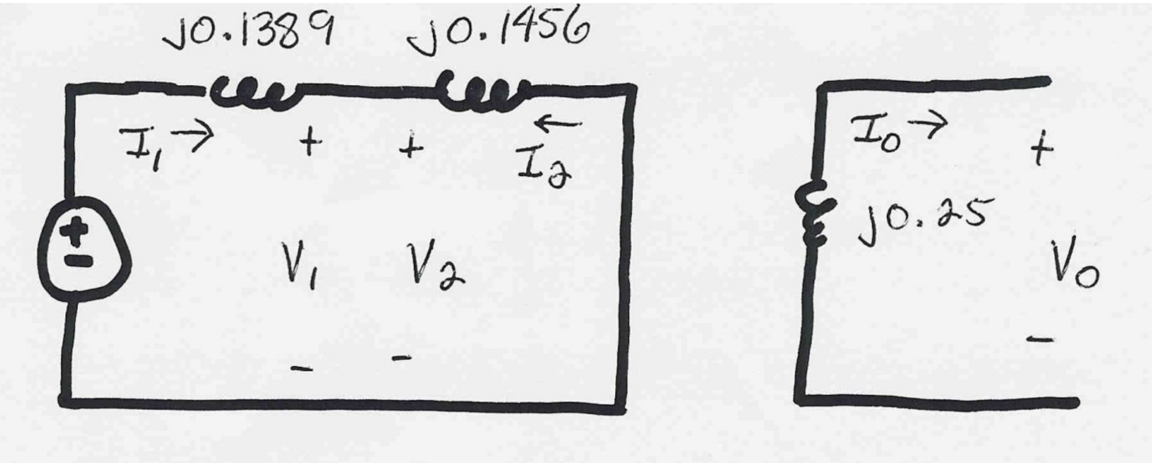
$$V_f^+ = \frac{1}{3}\left[V_{ag}^f + \left(\alpha + \alpha^2\right)V_{bg}^f\right]$$

$$V_f^- = \frac{1}{3}\left[V_{ag}^f + \left(\alpha^2 + \alpha\right)V_{bg}^f\right] \quad \rightarrow \quad V_f^+ = V_f^-$$

LL Faults, cont'd

To satisfy $I_f^+ = -I_f^- \quad \& \; V_f^+ = V_f^-$

the positive and negative sequence networks must be connected in parallel



LL Faults, cont'd

Solving the network for the currents we get

$$I_f^+ = \frac{1.05\angle 0^\circ}{j0.1389 + j0.1456} = 3.691\angle -90^\circ$$

$$\begin{bmatrix} I_a^f \\ I_b^f \\ I_c^f \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & \alpha^2 & \alpha \\ 1 & \alpha & \alpha^2 \end{bmatrix} \begin{bmatrix} 0 \\ 3.691\angle -90^\circ \\ 3.691\angle 90^\circ \end{bmatrix} = \begin{bmatrix} 0 \\ -6.39 \\ 6.39 \end{bmatrix}$$

LL Faults, cont'd

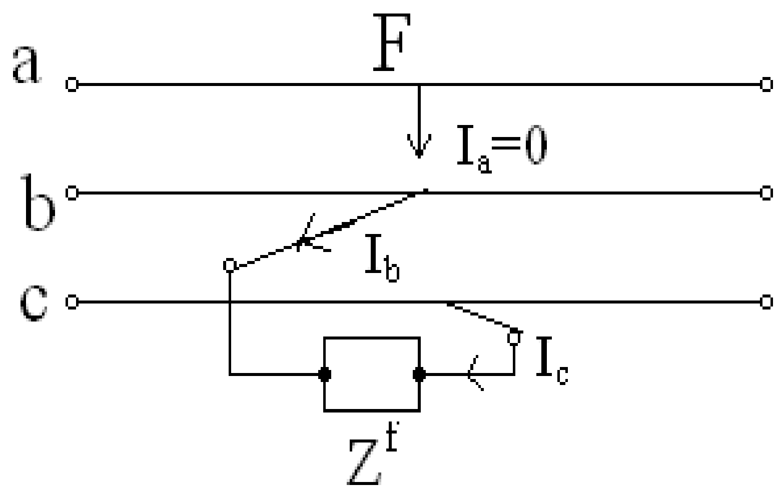
Solving the network for the voltages we get

$$V_f^+ = 1.05\angle 0° - j0.1389 \times 3.691\angle -90° = 0.537\angle 0°$$

$$V_f^- = -j0.1452 \times 3.691\angle 90° = 0.537\angle 0°$$

$$\begin{bmatrix} V_a^f \\ V_b^f \\ V_c^f \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & \alpha^2 & \alpha \\ 1 & \alpha & \alpha^2 \end{bmatrix} \begin{bmatrix} 0 \\ 0.537 \\ 0.537 \end{bmatrix} = \begin{bmatrix} 1.074 \\ -0.537 \\ -0.537 \end{bmatrix}$$

LINE TO LINE (LL) FAULT



$$I_a = 0$$

$$I_c = -I_b$$

$$V_b - V_c = I_b Z^f$$

$$I_{a2} = -I_{a1}$$

$$I_{a0} = 0$$

$$V_{a1} - V_{a2} = Z^f I_{a1}$$

$$I_{a1} = \frac{E_a}{Z_1 + Z_2 + 3Z^f}$$

$$I_b = -I_c = \frac{-jE_a}{Z_1 + Z_2 + 3Z^f}$$

Consider a fault between phase b and c through an impedance z_f

Thank you