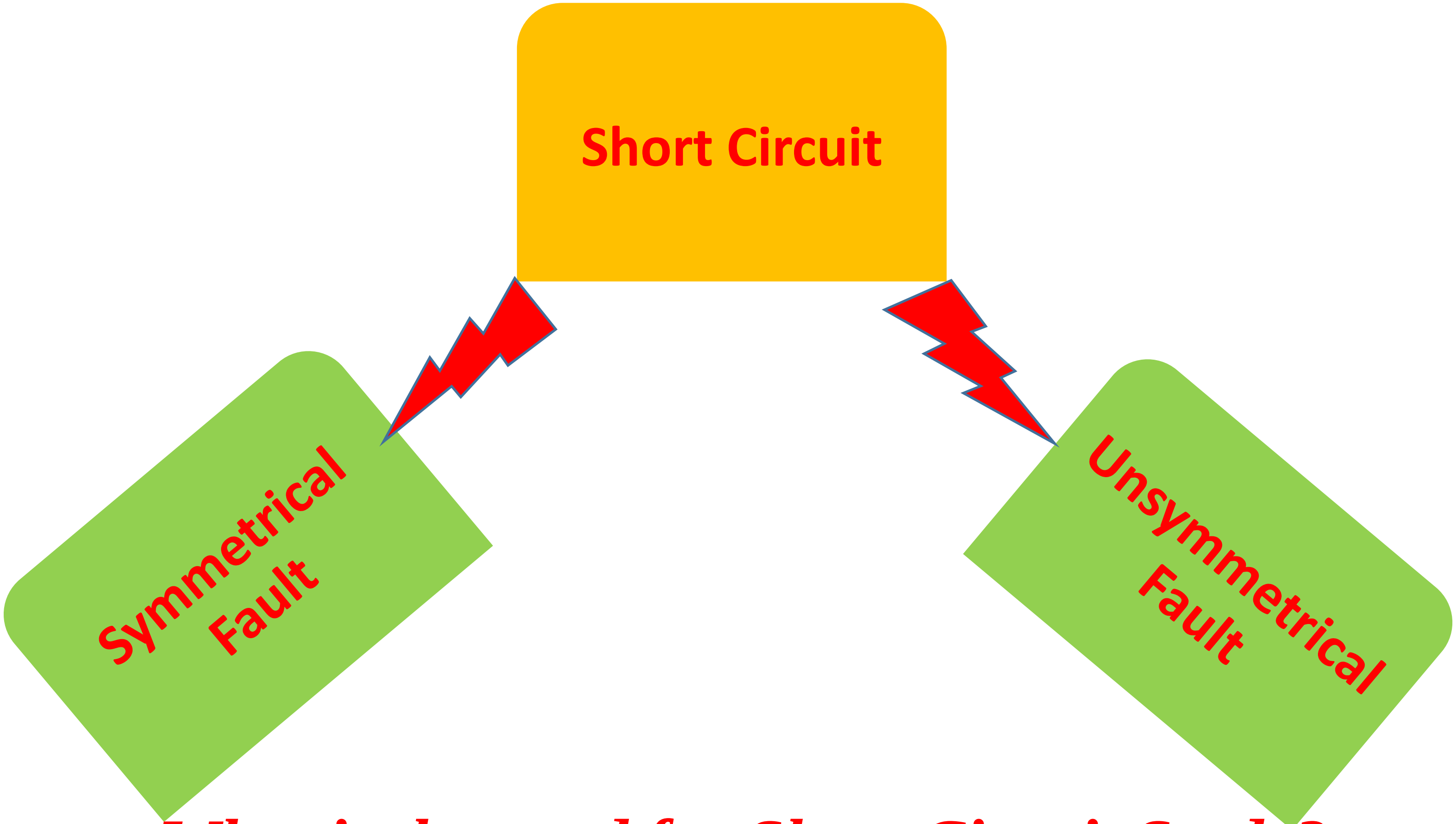
Lecture 7: Short Circuit Analysis-----Unsymmetrical Fault



What is the need for Short Circuit Study?

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[***C:\Users\dell\Pictures\unsymmetrical fault.PNG***](C:\Users\dell\Pictures\unsymmetrical fault.PNG)

Assumptions

1. The power system operates under balanced steady-state conditions before the fault occurs. Thus the zero-, positive-, and negative sequence networks are uncoupled before the fault occurs. During unsymmetrical faults they are interconnected only at the fault location.

2. Pre-fault load current is neglected. Because of this, the positive sequence internal voltages of all machines are equal to the pre-fault voltage VF. Therefore, the pre-fault voltage at each bus in the positive-sequence network equals VF.

3. Transformer winding resistances and shunt admittances are neglected.

Assumptions (2)

4. Transmission-line series resistances and shunt admittances are neglected.

5. Synchronous machine armature resistance, saliency, and saturation are neglected.

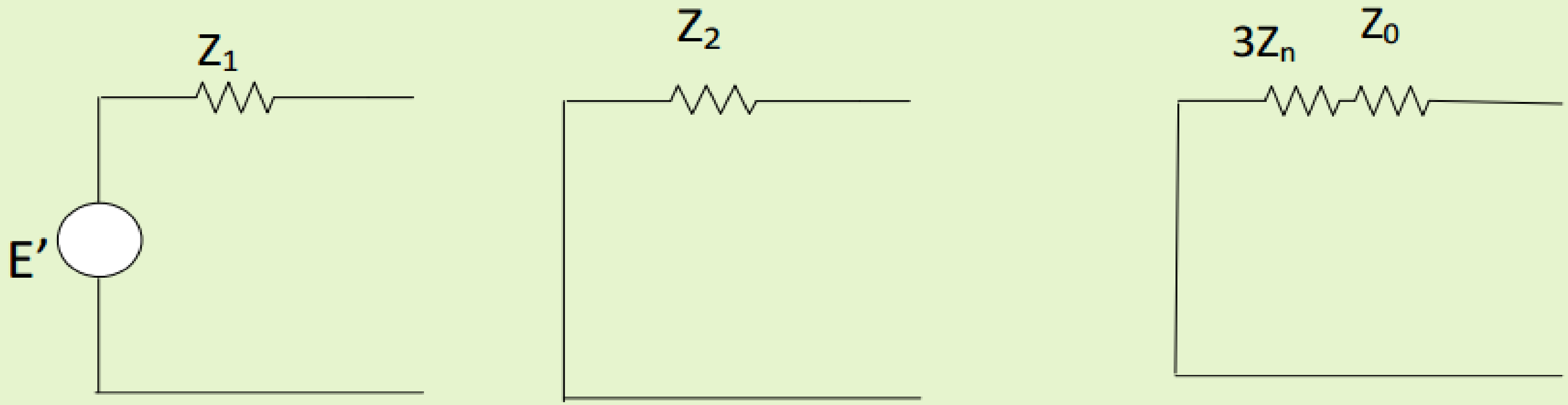
6. All nonrotating impedance loads are neglected.

7. Induction motors are either neglected (especially for motors rated 50 hp or less) or represented in the same manner as synchronous machines.

Note: these assumptions are made for simplicity in this text, and in practice should not be made for all cases.

Sequence Diagrams of Generators

- Key point: generators only produce positive sequence voltages; therefore only the positive sequence has a voltage source



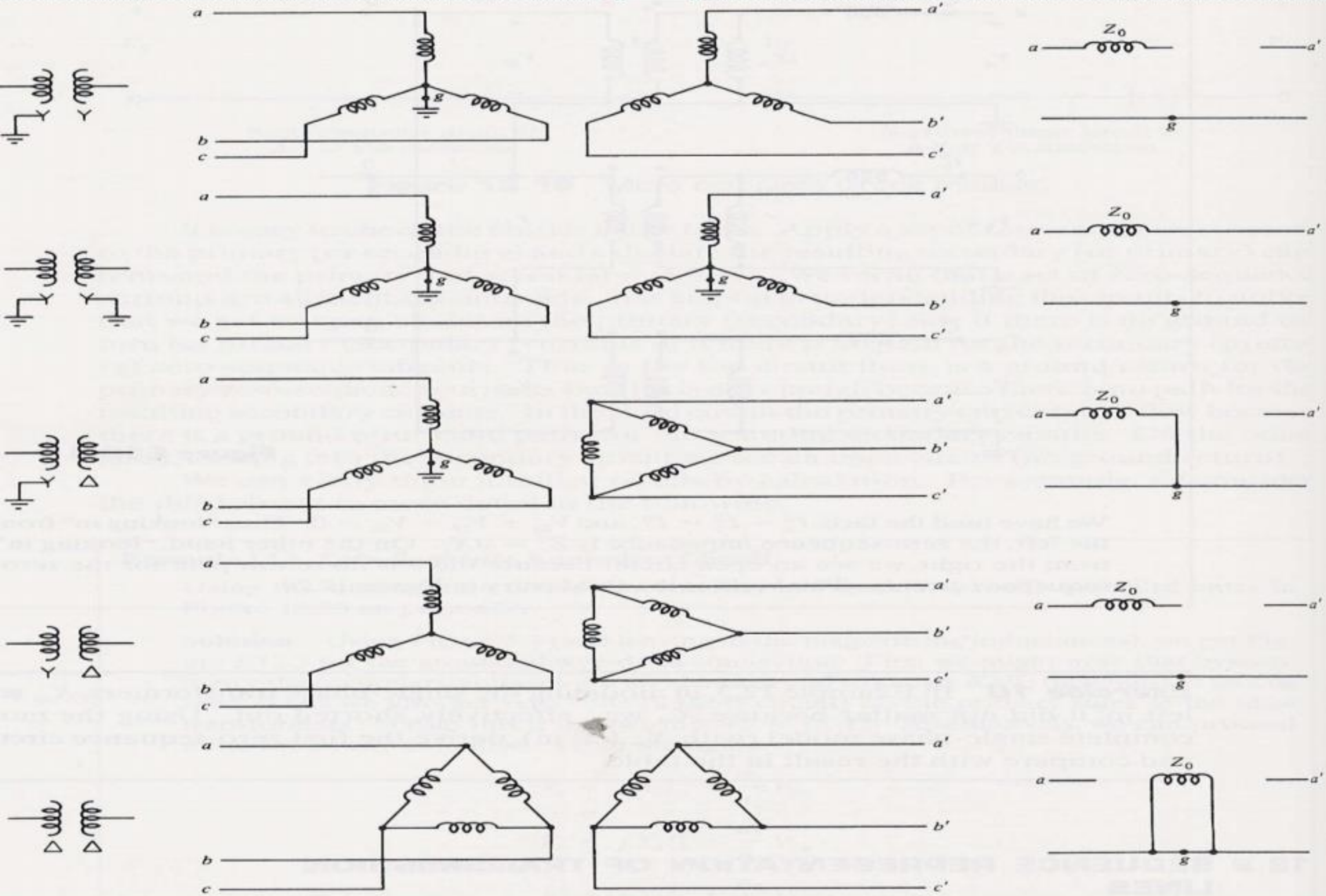
During a fault $Z^1 \approx Z^2 \approx X_d$". The zero sequence impedance is usually substantially smaller. The value of Z_n depends on whether the generator is grounded

Transformer Sequence Diagram

- The positive and negative sequence diagrams for transformers are similar to those for transmission lines.

- The zero sequence network depends upon both how the transformer is grounded and its type of connection.

Cont'd…

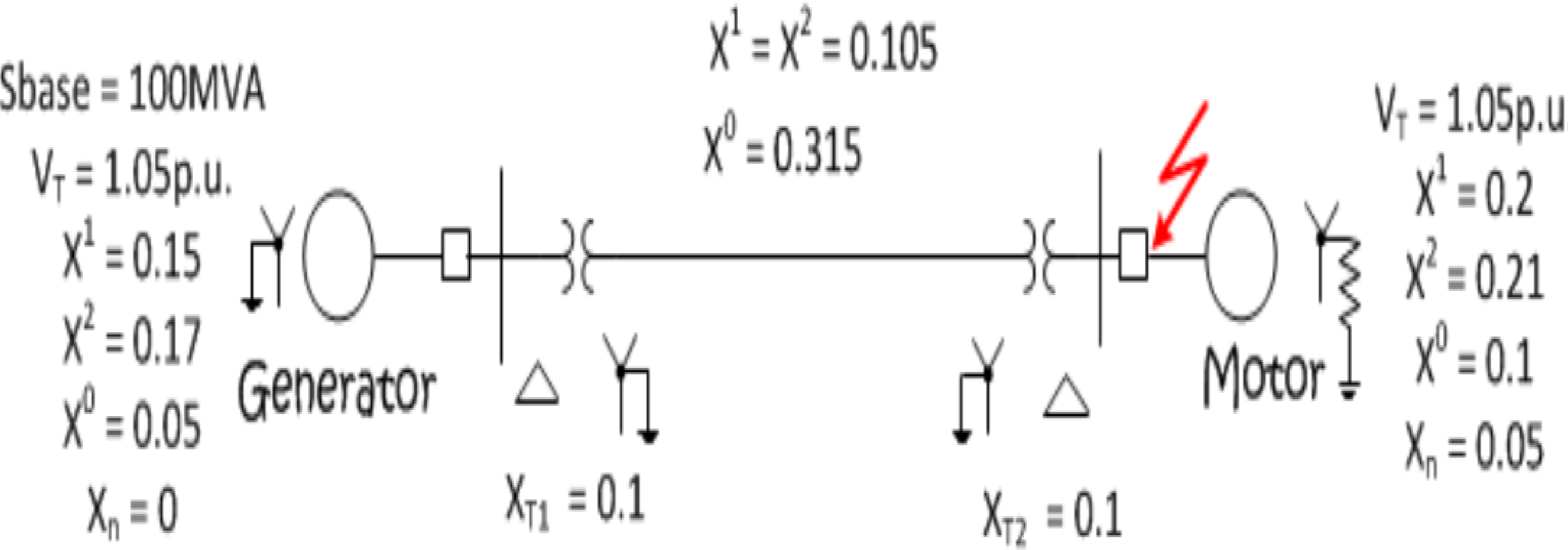


Example

a) Draw the per-unit zero-, positive-, and negative sequence networks?

b) Reduce the sequence networks to their Thevenin equivalents as referred to the fault point?

c) Find fault current and voltages if the faults are LG, LL and DLG?



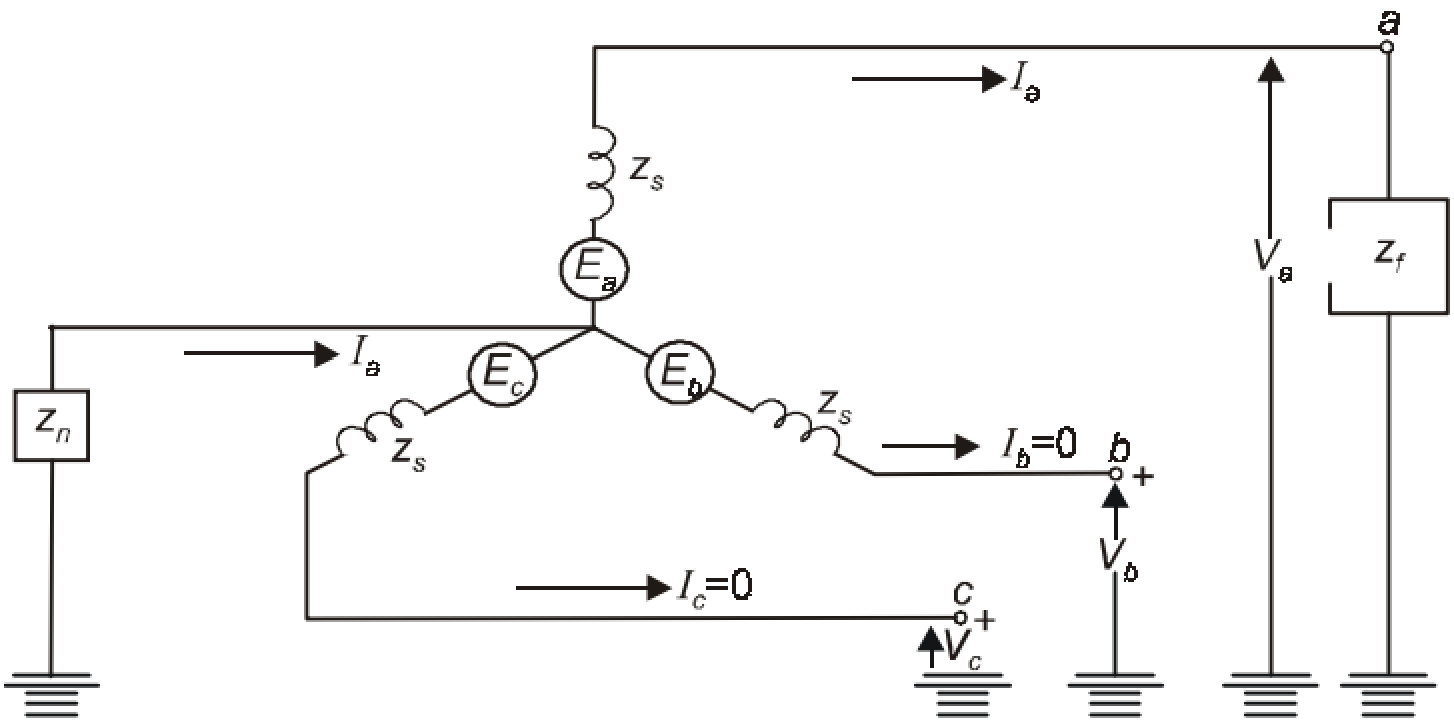
Shunt Faults…….L-G Fault

Assume the fault is occurred at phase ‘a’ through impedance Zf and consider the generator has no load initially.

The neutral is grounded with impedance Zn

$$I_b = 0$$
$$I_c = 0$$
$$V_a = Z_f\, I_a$$

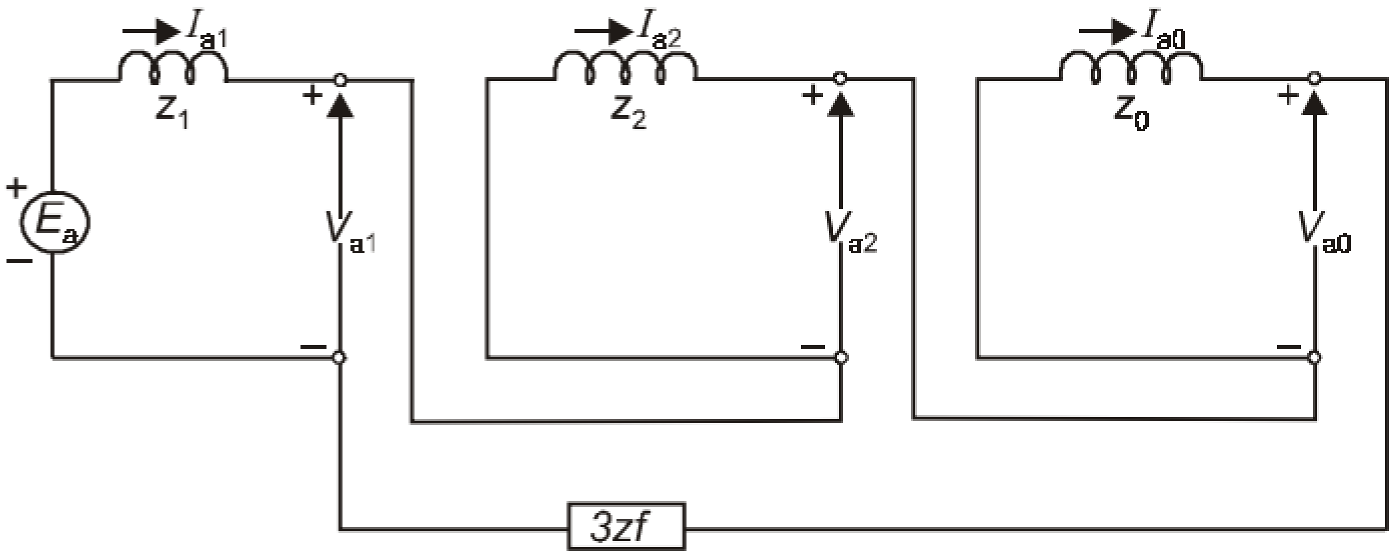
$$\Rightarrow \begin{bmatrix} I_{a1} \\ I_{a2} \\ I_{a0} \end{bmatrix} = \frac{1}{3}\begin{bmatrix} 1 & \beta & \beta^2 \\ 1 & \beta^2 & \beta \\ 1 & 1 & 1 \end{bmatrix}\begin{bmatrix} I_a \\ 0 \\ 0 \end{bmatrix}$$



$$I_{a1} = I_{a2} = I_{a0} = \frac{1}{3} I_a$$

$$V_{a1} + V_{a2} + V_{a0} = Z_f, I_a = 3 Z_f I_{a1}$$

- cascading each sequence ntks to obtain Thevenin eqt.



$$I_{a1} = \frac{E_a}{(Z_1 + Z_2 + Z_0) + 3Z_f}$$

Fault currents I_a is then given by

$$I_a = 3I_{a1} = \frac{3E_a}{(Z_1 + Z_2 + Z_0) + 3Z_f}$$

- The voltages at Phase b and c

$$V_b = \beta^2 V_{a1} + \beta V_{a2} + V_{a0}$$

$$V_b = E_a \frac{\left[3\beta^2 Z_f + Z_2(\beta^2 - \beta) + Z_0(\beta^2 - 1)\right]}{(Z_1 + Z_2 + Z_0) + 3Z_f}$$

$$V_c = \beta V_{a1} + \beta^2 V_{a2} + V_{a0}$$

$$V_c = E_a \frac{\left[3\beta Z_f + Z_2(\beta - \beta^2) + Z_0(\beta - 1)\right]}{(Z_1 + Z_2 + Z_0 + 3Z_f)}$$

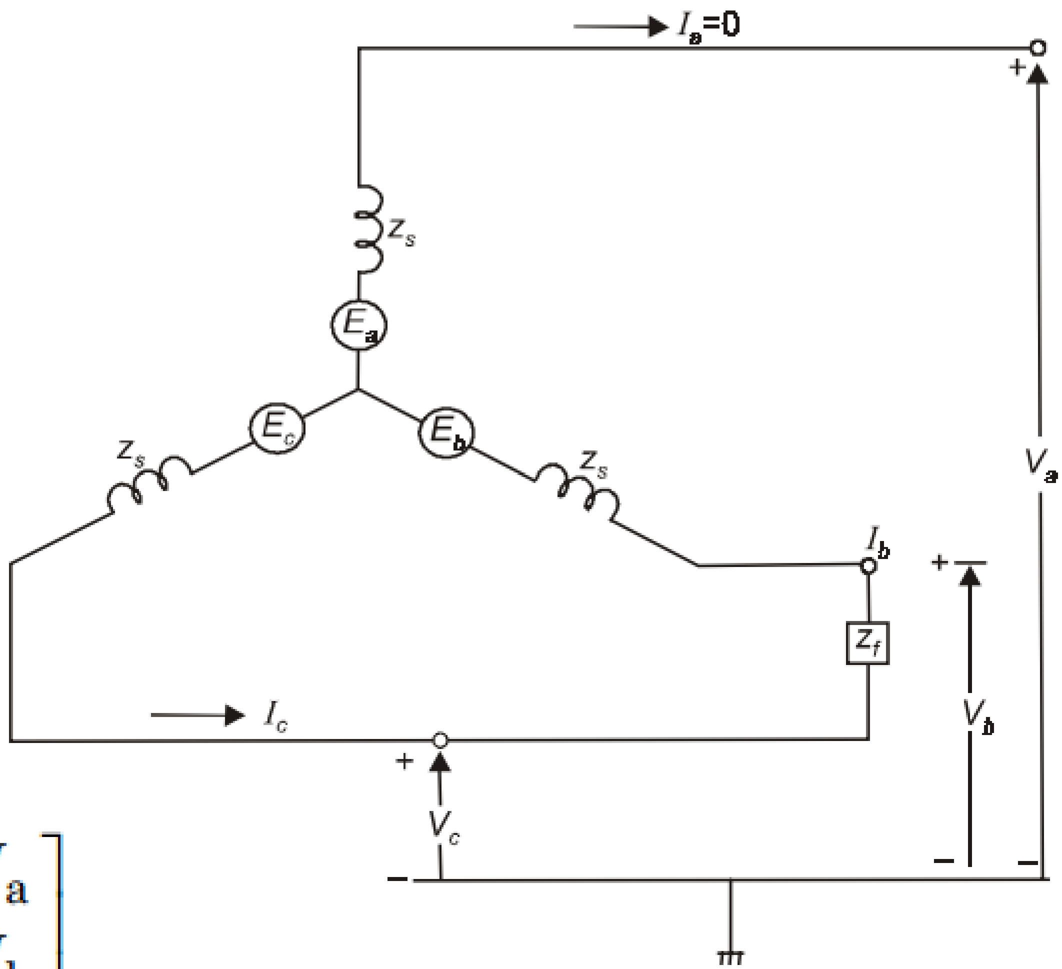
L-L Fault

Assume the generator is at no load condition

$$V_b - V_c = Z_f \cdot I_b$$

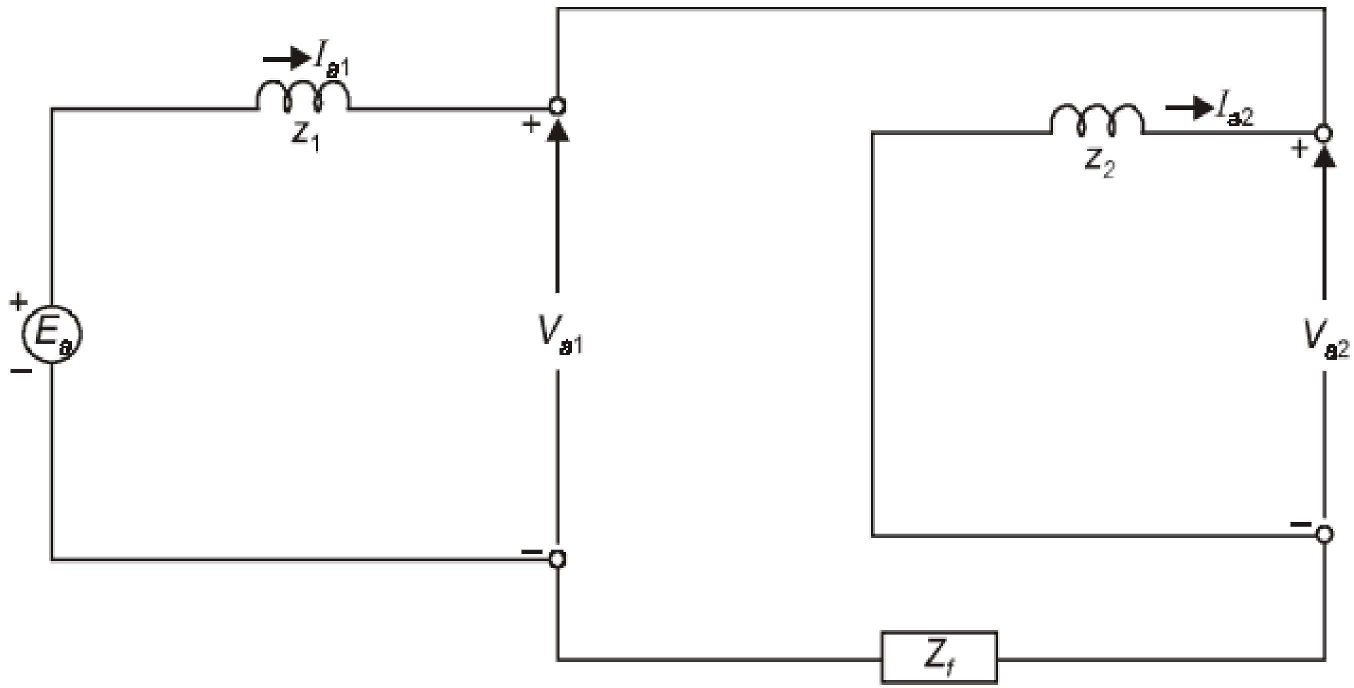
$$I_b + I_c = 0$$

$$I_a = 0$$



$$\begin{bmatrix} I_{a1} \\ I_{a2} \\ I_{a0} \end{bmatrix} = \frac{1}{3} \begin{bmatrix} 1 & \beta & \beta^2 \\ 1 & \beta^2 & \beta \\ 1 & 1 & 1 \end{bmatrix} \begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix}$$

Sequence ntk of L-L fault

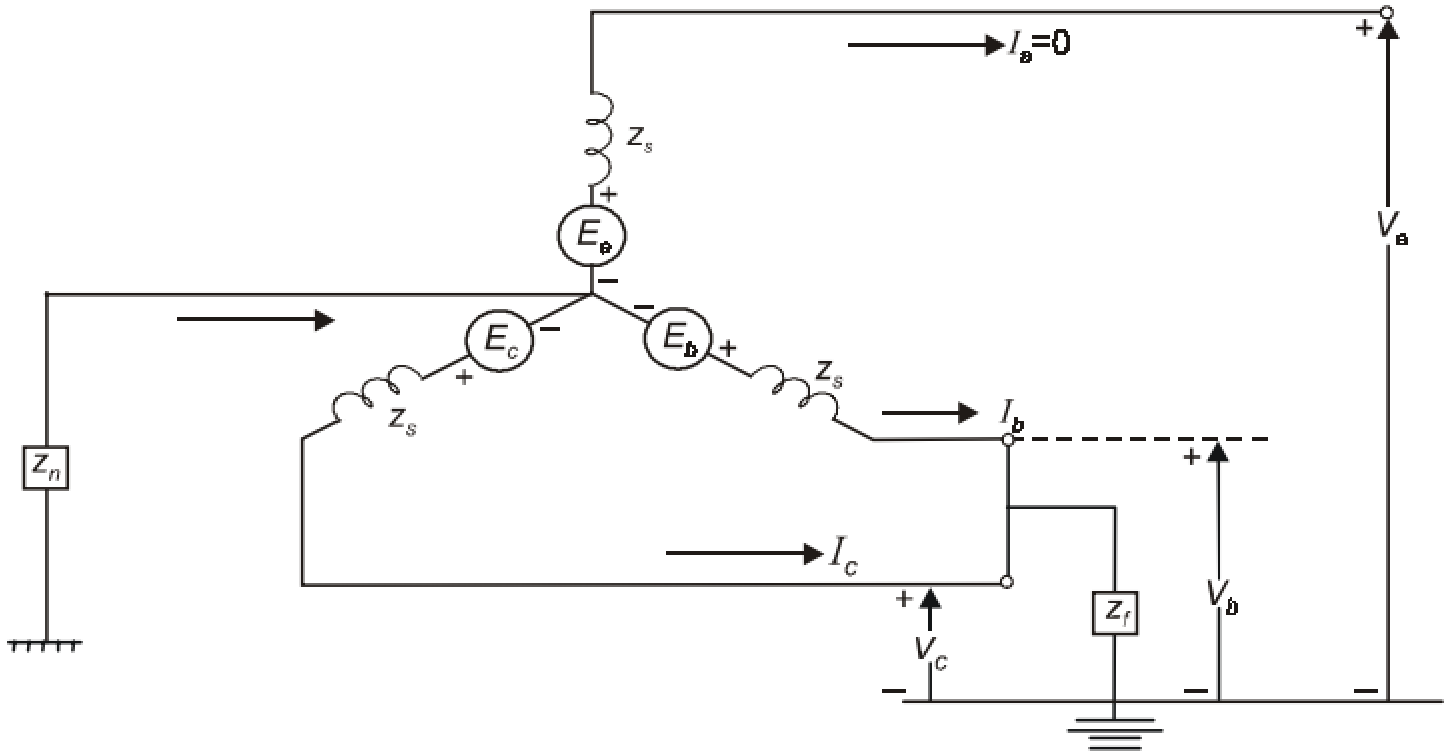


$$I_{a1} = \frac{E_a}{(Z_1 + Z_2 + Z_f)}$$

$$I_b = -I_c = \frac{-j\sqrt{3}\,E_a}{(Z_1 + Z_2 + Z_f)}$$

DLG Fault

Assume the alternator is not loaded



$$I_a = 0$$

$$I_{a1} + I_{a2} + I_{a0} = 0$$

$$V_b = V_c = (I_b + I_c)\, Z_f = 3Z_f\, I_{a0}$$

Thank You!