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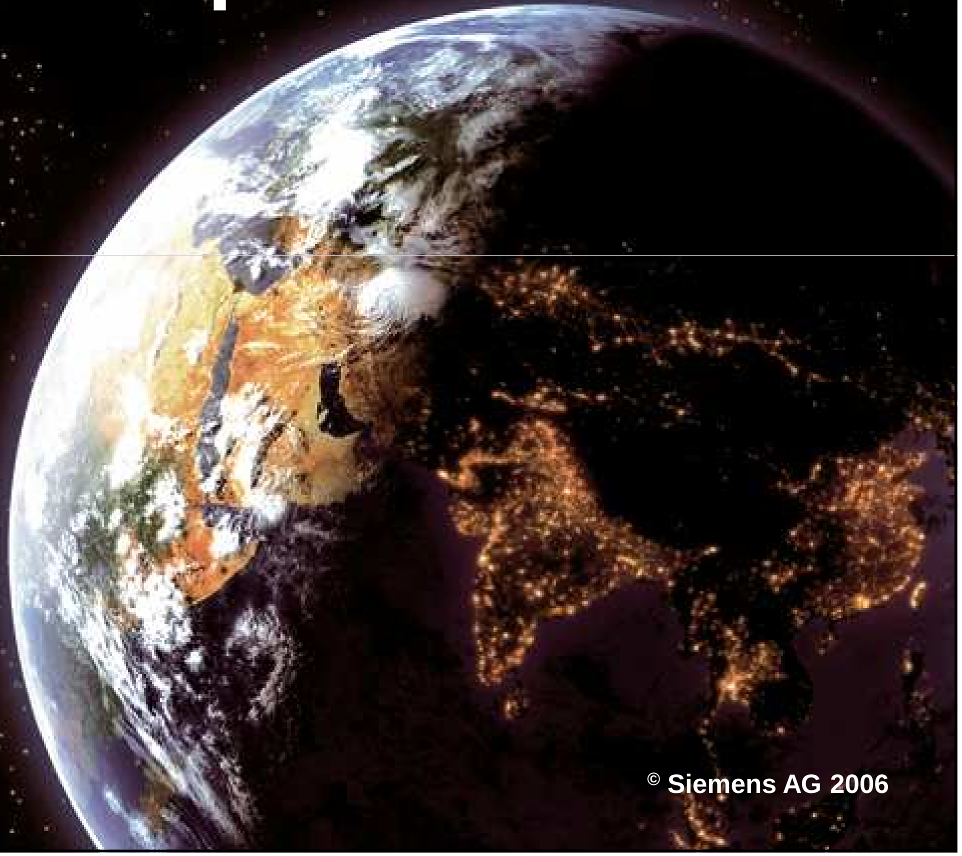
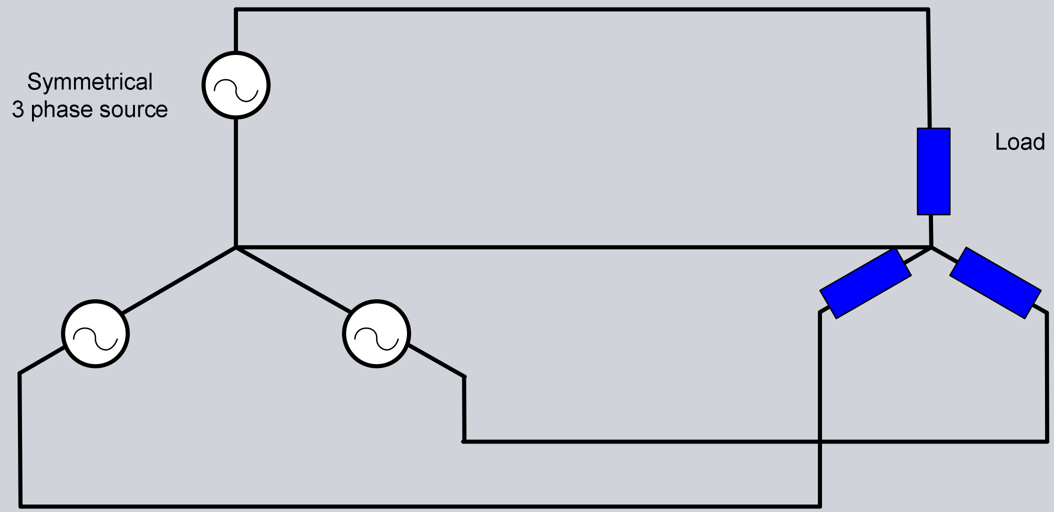
Symmetrical Components

Power Transmission
and Distribution



Symmetrical 3phase system



In a balanced 3 phase system it is possible to treat each phase as an independant single phase. The other phases follow with fixed 120° phase displacement.

Symmetrical Components
History

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• Due to **Charles LeGeyt Fortescue** (1918):

"a set of n unbalanced phasors in an n-phase system can be resolved into n sets of balanced phasors by a linear transformation"

The n sets of balanced phasors are called symmetrical components

In the 3 phase system n = 3

Symmetrical Components
Example: Non-symmetrical 3 phase voltage

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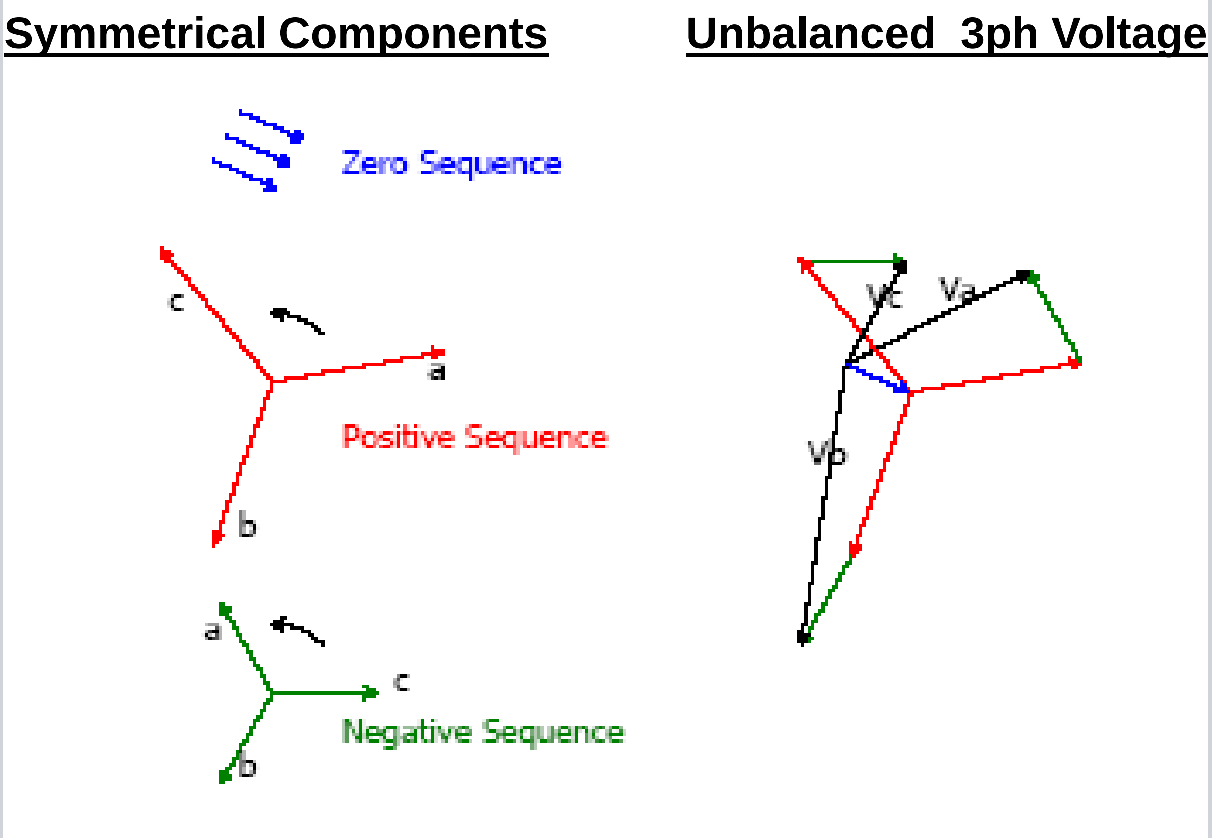

Symmetrical Components
Equations (Example voltage)

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Calculation of phase voltage/current from symmetrical components:

$$\underline{V_A} = \underline{V_0} + \underline{V_1} + \underline{V_2}$$

$$\underline{V_B} = \underline{V_0} + a^2\underline{V_1} + a\underline{V_2}$$

$$\underline{V_C} = \underline{V_0} + a\underline{V_1} + a^2\underline{V_2}$$

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

$$V_P = \begin{pmatrix} \underline{V_A} \\ \underline{V_B} \\ \underline{V_C} \end{pmatrix} \qquad V_{Sym} = \begin{pmatrix} \underline{V_0} \\ \underline{V_1} \\ \underline{V_2} \end{pmatrix}$$

$$V_P = A \cdot V_{Sym}$$

Symmetrical Components
Equations (Example voltage)

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Calculation of symmetrical components from phase voltage/current:

$$\underline{V_0} = \frac{\underline{V_A} + \underline{V_B} + \underline{V_C}}{3}$$

$$\underline{V_1} = \frac{\underline{V_A} + a\underline{V_B} + a^2\underline{V_C}}{3}$$

$$\underline{V_2} = \frac{\underline{V_A} + a^2\underline{V_B} + a\underline{V_C}}{3}$$

$$V_{Sym} = A^{-1} \cdot V_P$$

$$A^{-1} = \frac{1}{3}\begin{bmatrix} 1 & 1 & 1 \\ 1 & a & a^2 \\ 1 & a^2 & a \end{bmatrix}$$

$$V_{Sym} = \begin{pmatrix} \underline{V_0} \\ \underline{V_1} \\ \underline{V_2} \end{pmatrix}$$

$$V_P = \begin{pmatrix} \underline{V_A} \\ \underline{V_B} \\ \underline{V_C} \end{pmatrix}$$

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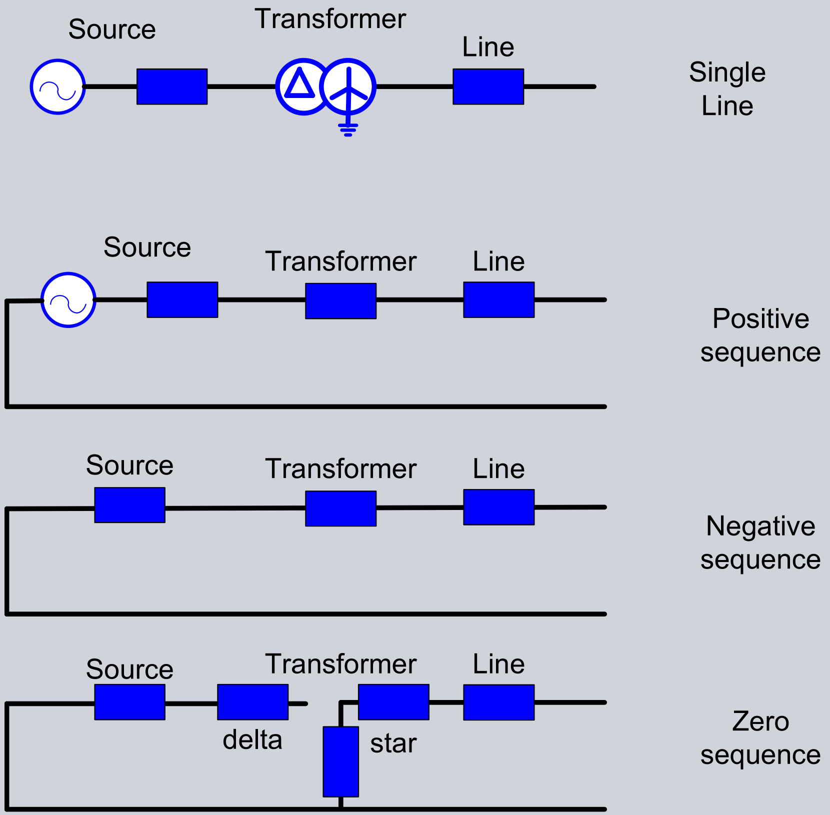
Single line diagram – symmetrical component circuits



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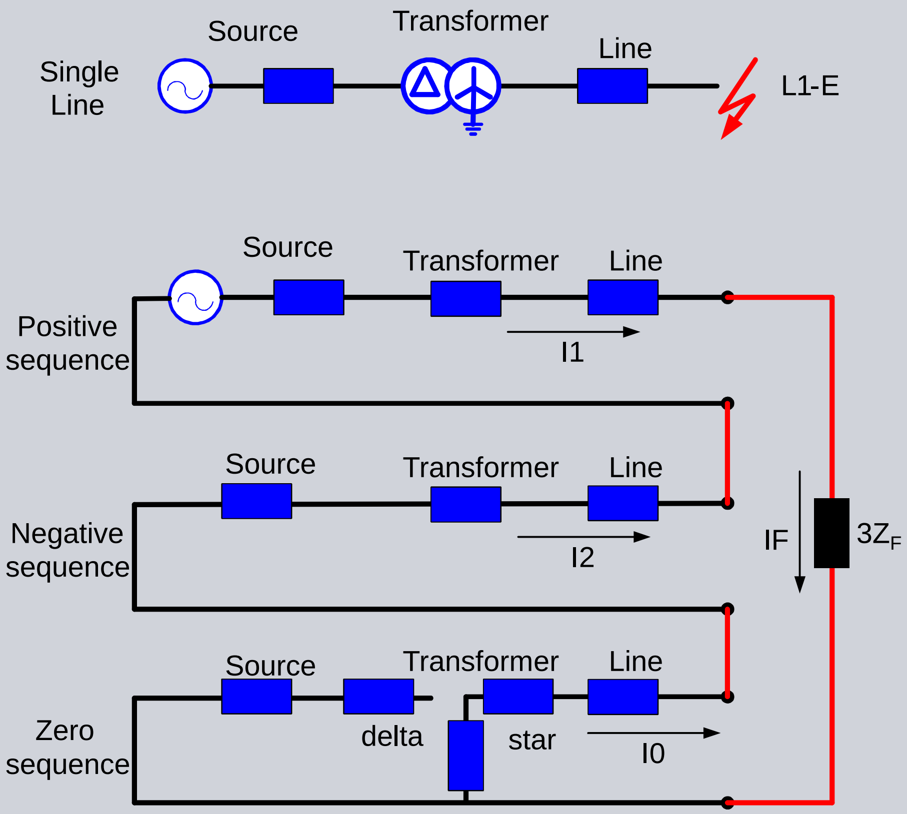
Example: L1-E Fault



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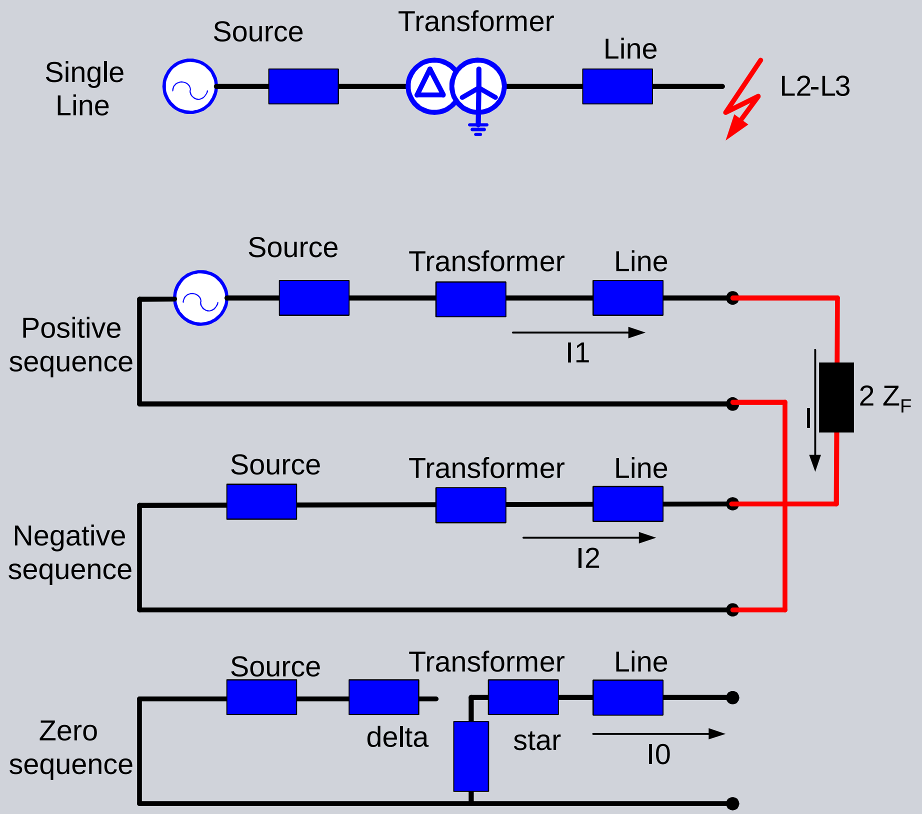
Example: L2-L3 Fault



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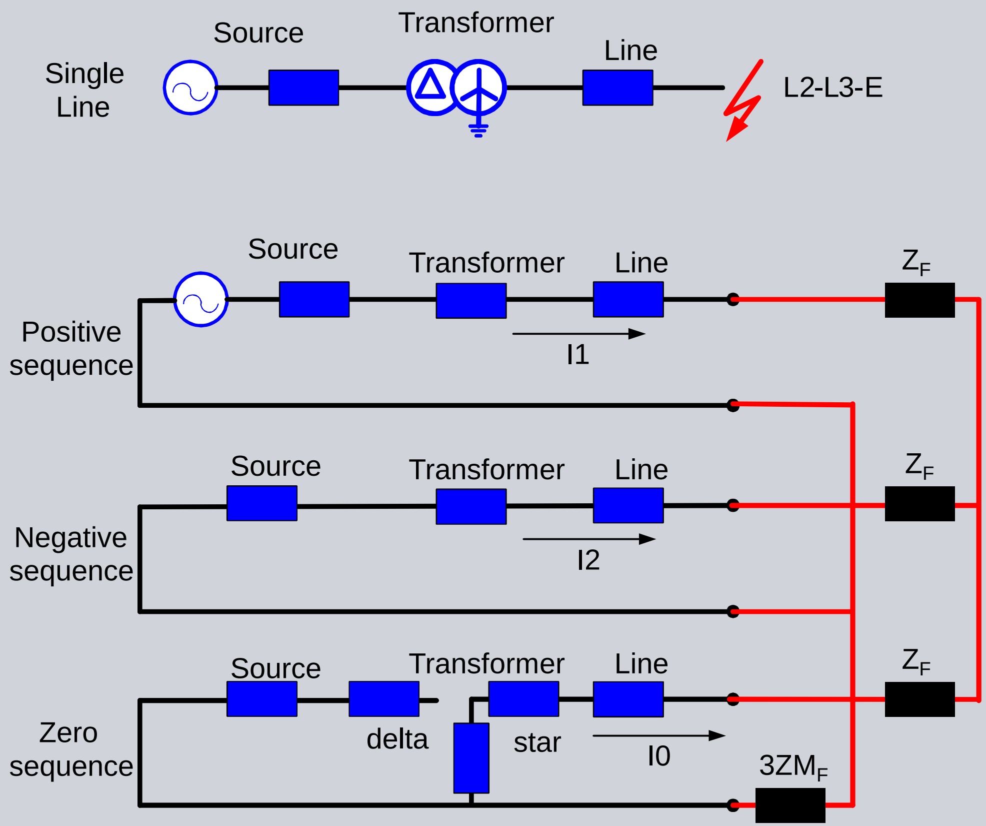
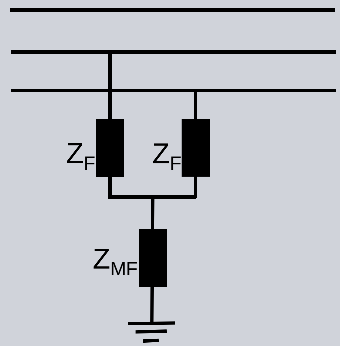
Example: L2-L3-E fault





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Example: Infeed from 2 sides onto L1-E fault