EEE- 601
POWER SYSTEM ANALYSIS
Unit-1

FUNDAMENTALS OF SYMMETRICAL COMPONENTS

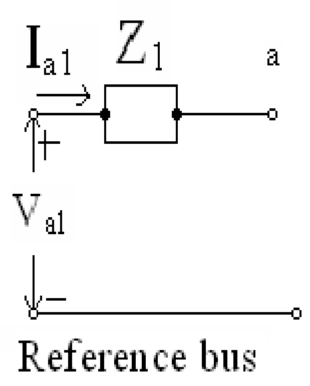
- Symmetrical components can be used to transform three phase unbalanced voltages and currents to balanced voltages and currents
- Three phase unbalanced phasors can be resolved into following three sequences

  1.Positive sequence components

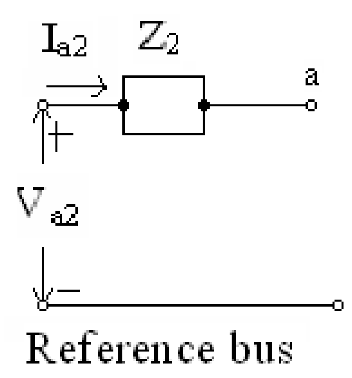
  2. Negative sequence components

  3. Zero sequence components

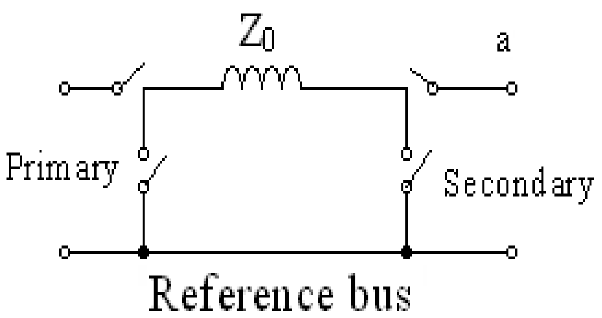
SEQUENCE NETWORK FOR TRANSFORMER



positive sequence network



negative sequence network



Zero sequence network

Analysis of Unsymmetrical Systems

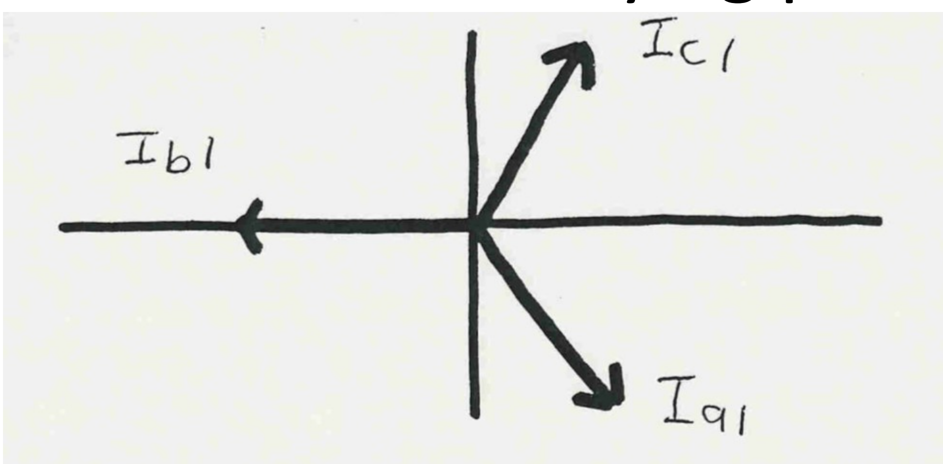
- Except for the balanced three-phase fault, faults result in an unbalanced system.
- The most common types of faults are single line-ground (SLG) and line-line (LL). Other types are double line-ground (DLG), open conductor, and balanced three phase.
- System is only unbalanced at point of fault!
- The easiest method to analyze unbalanced system operation due to faults is through the use of symmetrical components

Symmetric Components

- The key idea of symmetrical component analysis is to decompose the system into three sequence networks. The networks are then coupled only at the point of the unbalance (i.e., the fault)
- The three sequence networks are known as the
  - positive sequence (this is the one we've been using)
  - negative sequence
  - zero sequence

Positive Sequence Sets

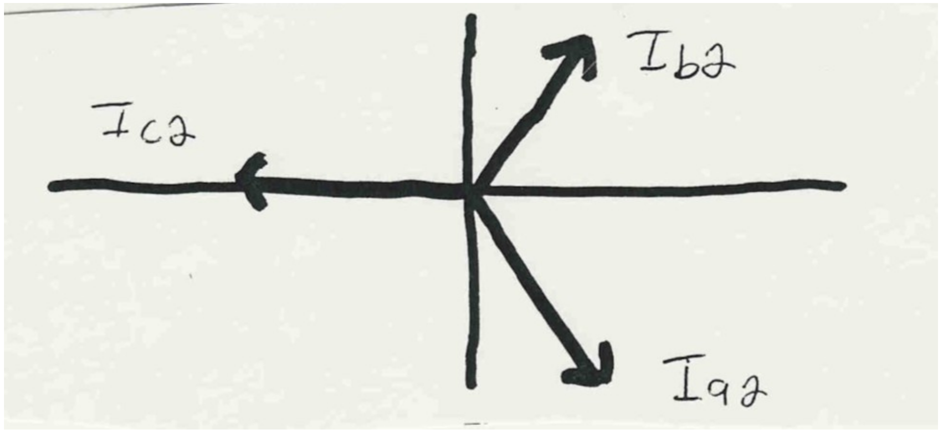
- The positive sequence sets have three phase currents/voltages with equal magnitude, with phase b lagging phase a by 120°, and phase c lagging phase b by 120°.
- We've been studying positive sequence sets



Positive sequence sets have zero neutral current

Negative Sequence Sets

- The negative sequence sets have three phase currents/voltages with equal magnitude, with phase b leading phase a by 120°, and phase c leading phase b by 120°.
- Negative sequence sets are similar to positive sequence, except the phase order is reversed



Negative sequence sets have zero neutral current

Zero Sequence Sets

- Zero sequence sets have three values with equal magnitude and angle.
- Zero sequence sets have neutral current

Sequence Set Representation

- **Any** arbitrary set of three phasors, say I_a, I_b, I_c can be represented as a sum of the three sequence sets

$$
\begin{aligned}
I_a &= I_a^0 + I_a^+ + I_a^- \\
I_b &= I_b^0 + I_b^+ + I_b^- \\
I_c &= I_c^0 + I_c^+ + I_c^-
\end{aligned}
$$

where

I_a^0, I_b^0, I_c^0 is the zero sequence set

I_a^+, I_b^+, I_c^+ is the positive sequence set

I_a^-, I_b^-, I_c^- is the negative sequence set

Conversion from Sequence to Phase

Only three of the sequence values are unique,

$\mathrm{I}_\mathrm{a}^0, I_a^+, I_a^-$; the others are determined as follows:

α □ $\qquad \alpha + \alpha^2 + \alpha^3 = 0 \qquad \alpha^3 = 1$

$\mathrm{I}_\mathrm{a}^0 = \mathrm{I}_\mathrm{b}^0 = \mathrm{I}_\mathrm{c}^0$ (since by definition they are all equal)

$I_b^+ = \alpha^2 I_a^+ \qquad I_c^+ = \alpha I_a^+ \qquad I_b^- = \alpha I_a^- \qquad I_c^- = \alpha^2 I_a^-$

$$\begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix} = \mathrm{I}_\mathrm{a}^0 \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} + \mathrm{I}_\mathrm{a}^+ \begin{bmatrix} 1 \\ \alpha^2 \\ \alpha \end{bmatrix} + I_a^- \begin{bmatrix} 1 \\ \alpha \\ \alpha^2 \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & \alpha^2 & \alpha \\ 1 & \alpha & \alpha^2 \end{bmatrix} \begin{bmatrix} I_a^0 \\ I_a^+ \\ I_a^- \end{bmatrix}$$

Conversion Sequence to Phase

Define the symmetrical components transformation matrix

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

Then $$\mathbf{I} = \begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix} = \mathbf{A} \begin{bmatrix} I_a^0 \\ I_a^+ \\ I_a^- \end{bmatrix} = \mathbf{A} \begin{bmatrix} I^0 \\ I^+ \\ I^- \end{bmatrix} = \mathbf{A}\,\mathbf{I}_s$$

Conversion Phase to Sequence

By taking the inverse we can convert from the phase values to the sequence values

$$\mathbf{I}_s = \mathbf{A}^{-1}\mathbf{I}$$

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

Sequence sets can be used with voltages as well as with currents

Thank you