Three Phase System

Lecture_2

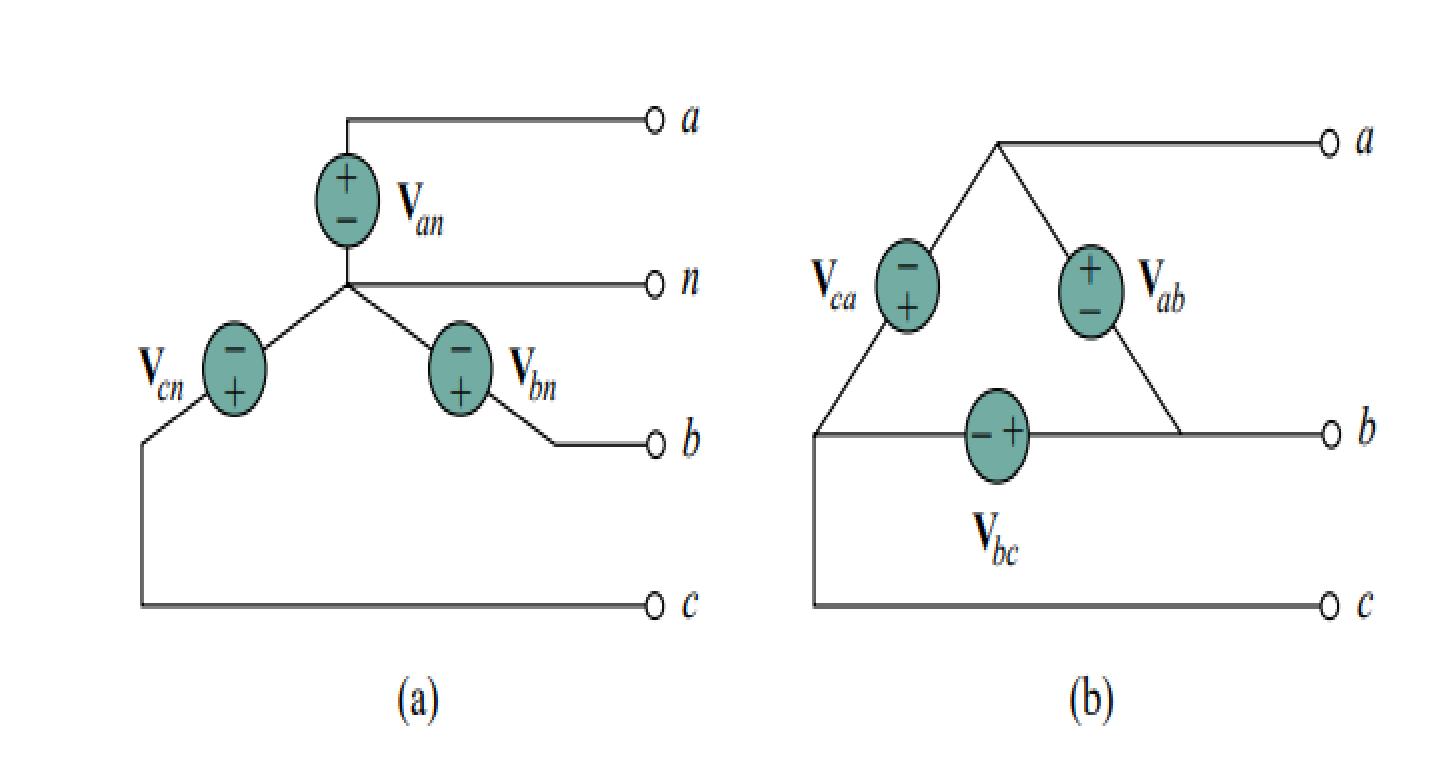
Topics to Be Covered

- ***Balanced*** and ***Unbalanced*** load and Source
- Possible ***Configurations***
- Relation between ***Line*** and ***Phase Voltage***
- Relation between ***Line*** and ***Phase Current***
- Mathematical Approach


Perfectly balanced.
As all things should be.

Balanced and Unbalanced Sources

- Balanced phase voltages are equal in magnitude and are out of phase with each other by 120◦.



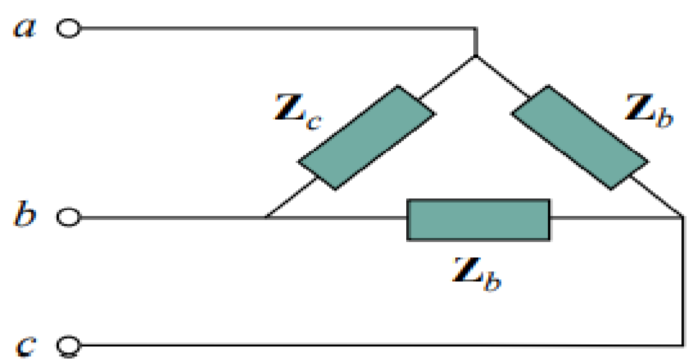
em

Problem_1

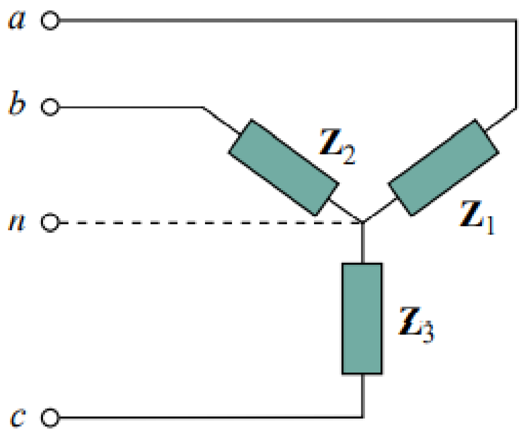
Prove that, the summation of balance three phase voltages is zero.

Balance Load

- A balanced load is one in which the phase impedances are equal in magnitude and in phase.



(b)



(a)

For a *balanced* wye-connected load,

$$\mathbf{Z}_1 = \mathbf{Z}_2 = \mathbf{Z}_3 = \mathbf{Z}_Y \qquad (12.6)$$

where $\mathbf{Z}_Y$ is the load impedance per phase. For a *balanced* delta-connected load,

$$\mathbf{Z}_a = \mathbf{Z}_b = \mathbf{Z}_c = \mathbf{Z}_\Delta \qquad (12.7)$$

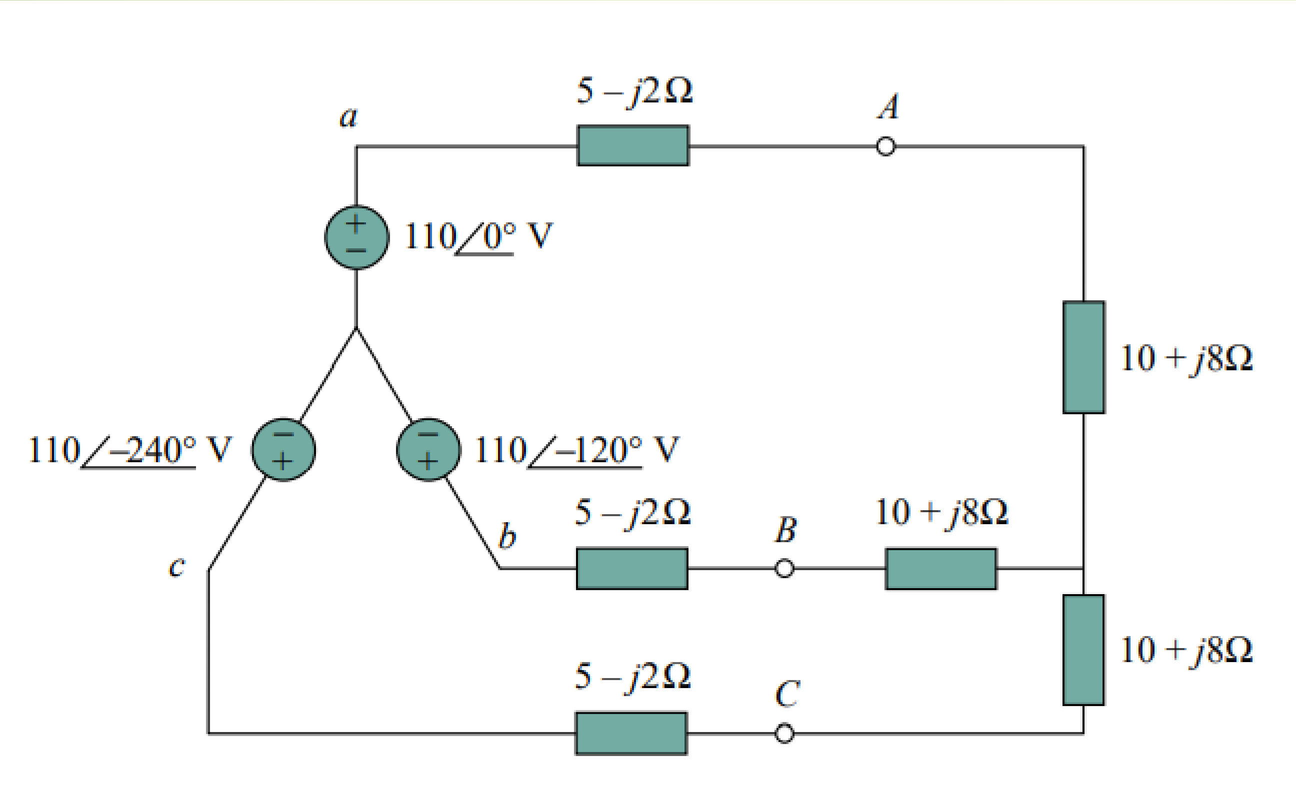
where $\mathbf{Z}_\Delta$ is the load impedance per phase in this case. We recall from Eq. (9.69) that

$$\mathbf{Z}_\Delta = 3\mathbf{Z}_Y \qquad \text{or} \qquad \mathbf{Z}_Y = \frac{1}{3}\mathbf{Z}_\Delta \qquad (12.8)$$

so we know that a wye-connected load can be transformed into a delta-connected load, or vice versa, using Eq. (12.8).

Mathematical Problems

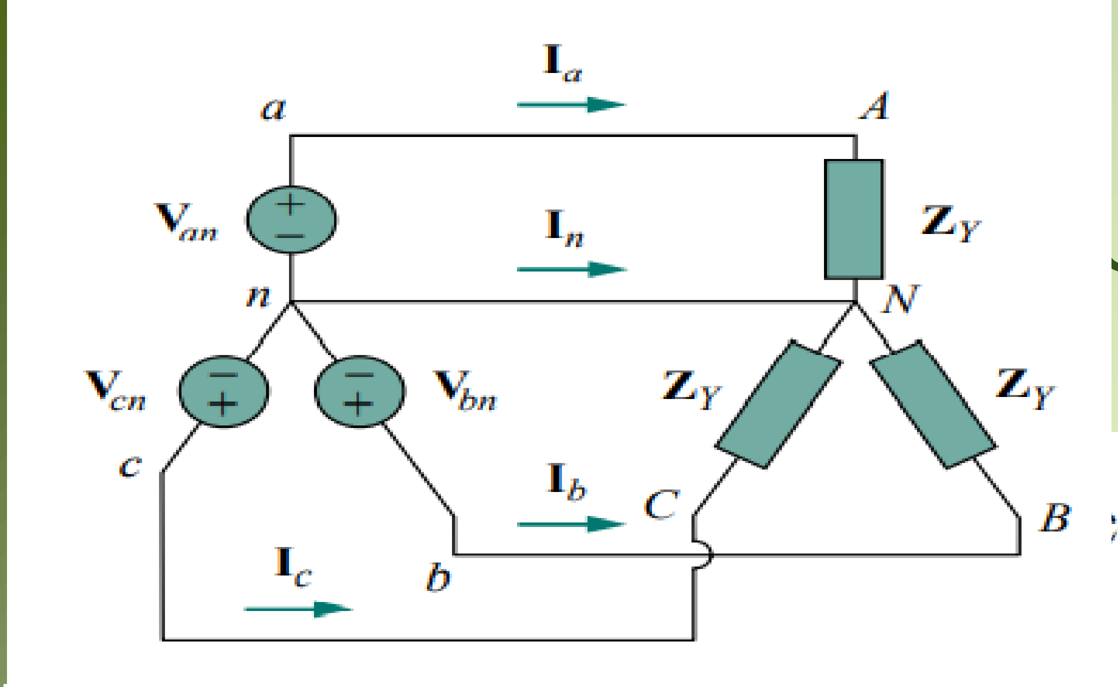
- Convert wye connected load into delta connected load

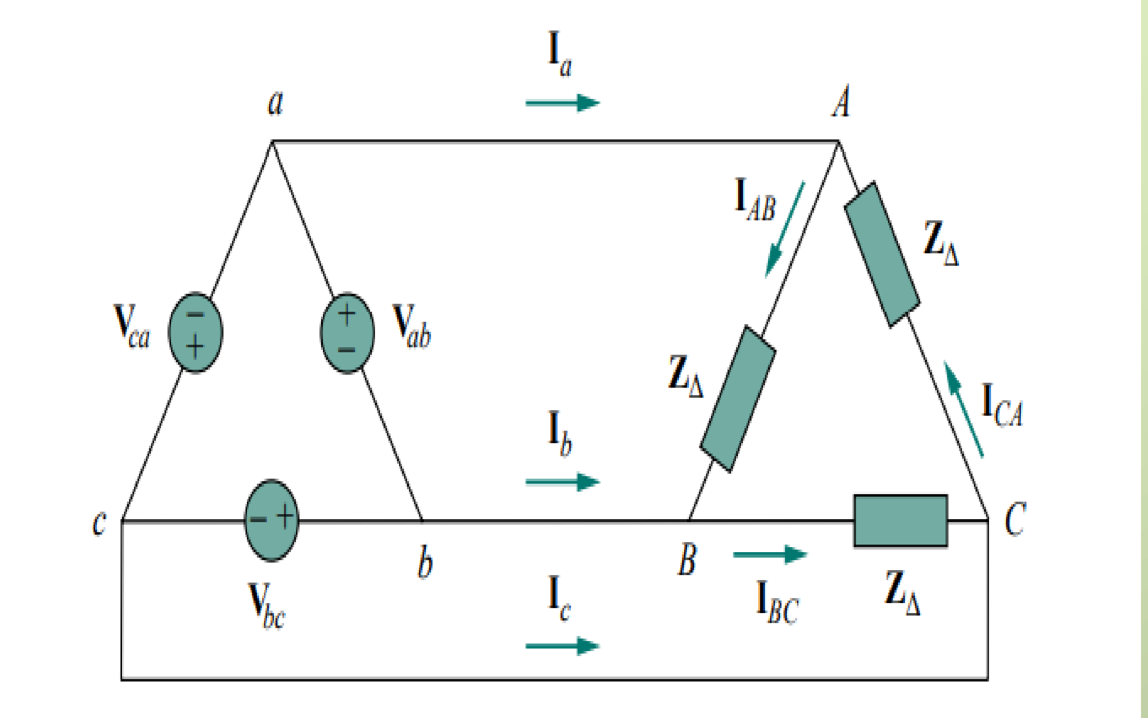


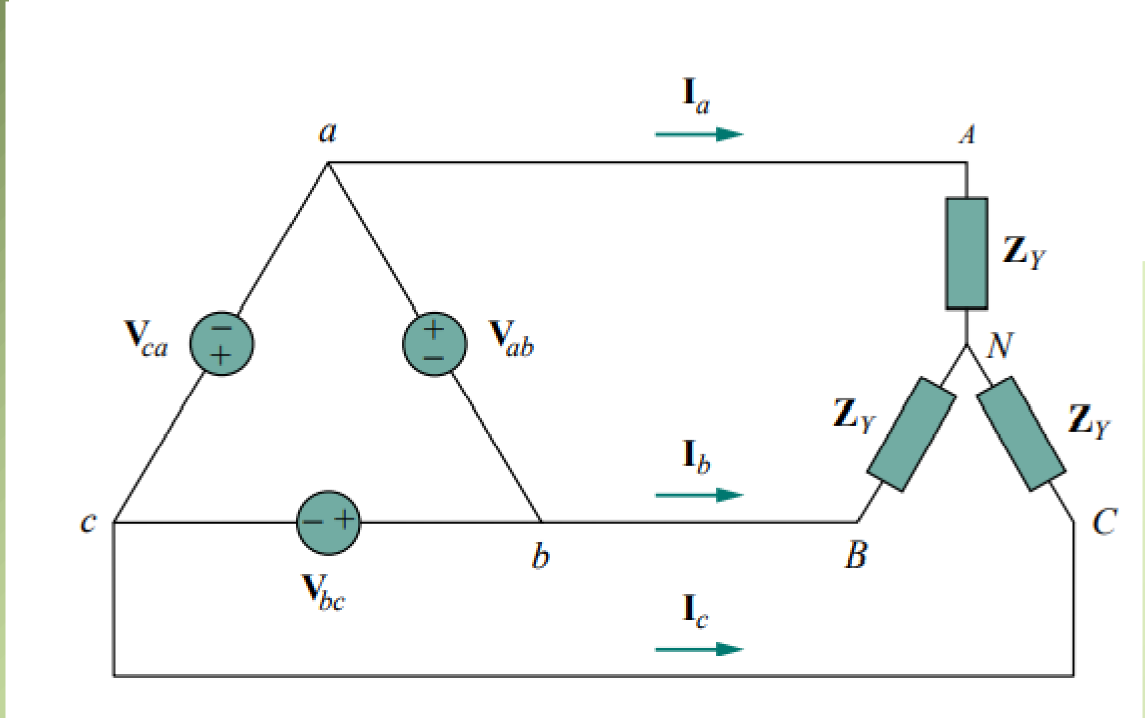
Possible Configurations

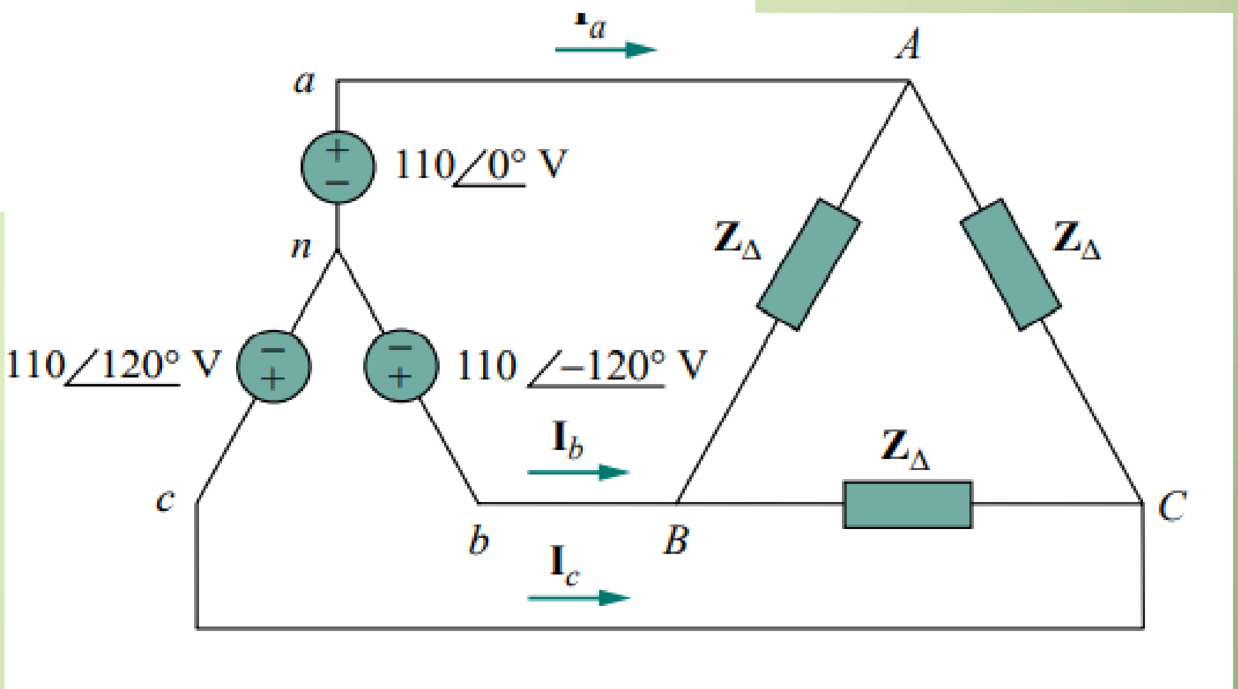
- Because both the three-phase source and the three-phase load can be both wye- or delta-connected, we have four possible connections:

1. Y-Y connection
2. Y-Delta connection
3. Delta-Delta Connection
4. Y-Y Connection

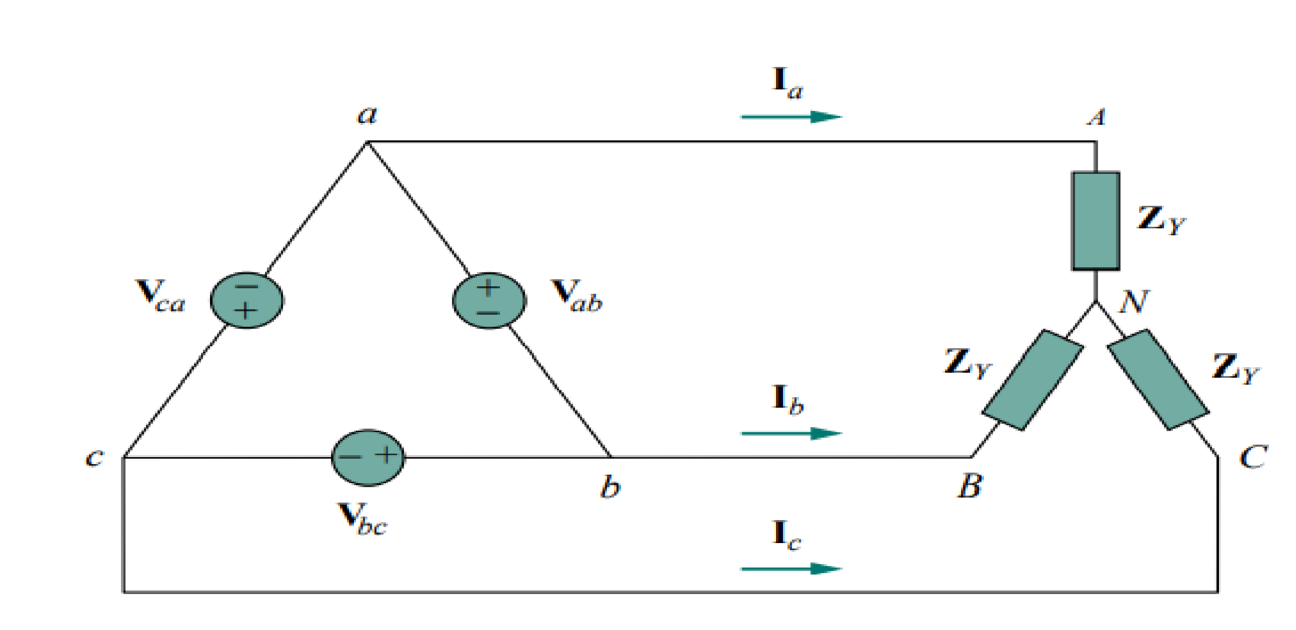

I_a
a
A
V_{an}
I_n
Z_Y
n
N
V_{cn}
V_{bn}
Z_Y
Z_Y
c
I_b
C
B
I_c
b


I_a
a
A
I_{AB}
Z_Δ
V_{ca}
V_{ab}
Z_Δ
I_{CA}
I_b
c
C
b
B
V_{bc}
I_c
I_{BC}
Z_Δ


I_a
a
A
Z_Y
N
V_{ca}
V_{ab}
Z_Y
Z_Y
I_b
c
C
b
B
V_{bc}
I_c


I_a
A
a
110/0° V
n
Z_Δ
Z_Δ
110/120° V
110 /−120° V
I_b
Z_Δ
c
C
b
B
I_c

Problems of Delta-Wye System

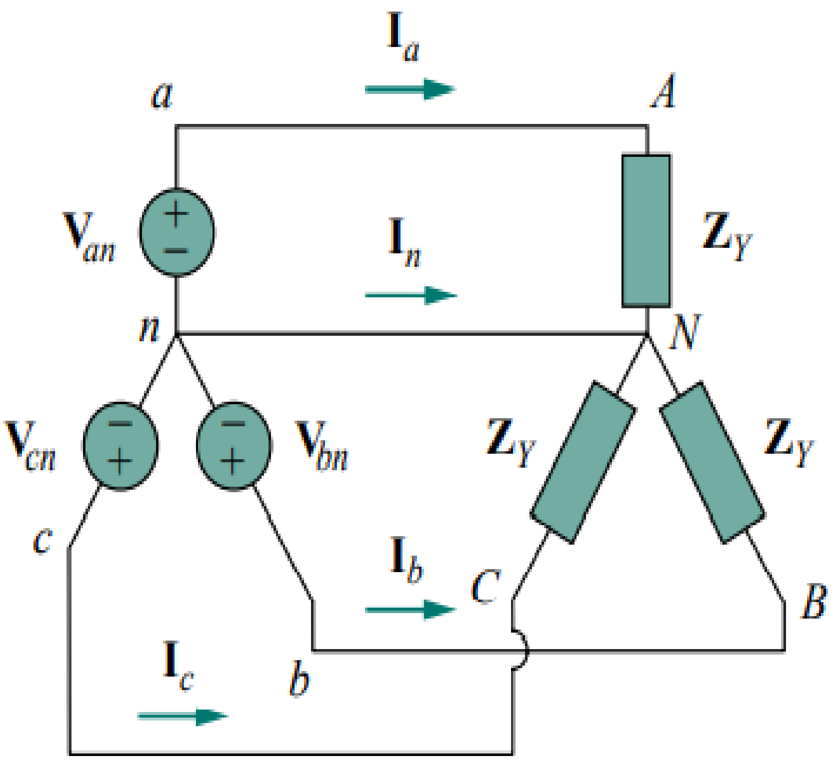


In a wye-connected load, the neutral may not be accessible
So. a balanced delta-connected load is more common than a balanced Y-connected load

Problems (continued)

Delta connected sources are not common in practice because of the circulating current that will result in the delta-mesh if the three-phase voltages are **slightly unbalanced**

Relation between Line voltage and Phase Voltage



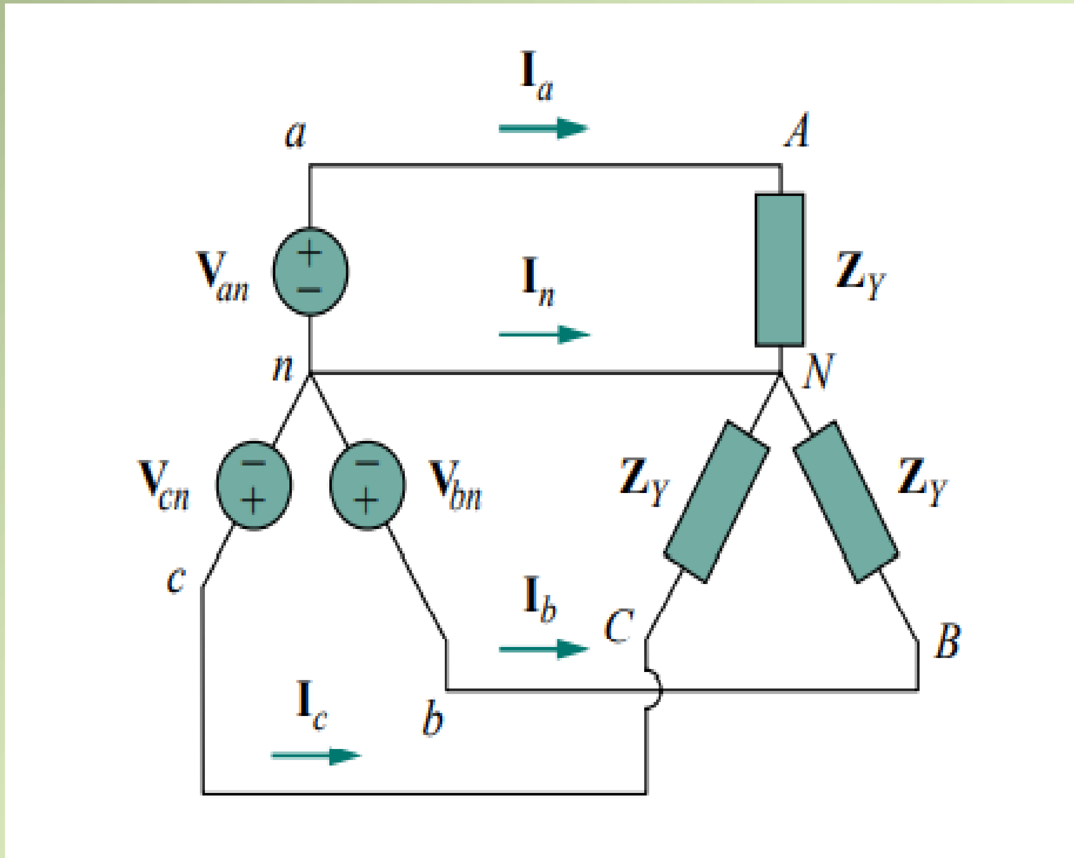
Assuming the positive sequence, the *phase* voltages (or line-to-neutral voltages) are

$$\mathbf{V}_{an} = V_p\underline{/0^\circ}$$
$$\mathbf{V}_{bn} = V_p\underline{/-120^\circ}, \qquad \mathbf{V}_{cn} = V_p\underline{/+120^\circ} \tag{12.10}$$

The *line-to-line* voltages or simply *line* voltages $\mathbf{V}_{ab}$, $\mathbf{V}_{bc}$, and $\mathbf{V}_{ca}$ are related to the phase voltages. For example,

$$\mathbf{V}_{ab} = \mathbf{V}_{an} + \mathbf{V}_{nb} = \mathbf{V}_{an} - \mathbf{V}_{bn} = V_p\underline{/0^\circ} - V_p\underline{/-120^\circ}$$
$$= V_p\left(1 + \frac{1}{2} + j\frac{\sqrt{3}}{2}\right) = \sqrt{3}V_p\underline{/30^\circ} \tag{12.11a}$$

Calculating line currents



$$\mathbf{I}_a = \frac{\mathbf{V}_{an}}{\mathbf{Z}_Y}, \qquad \mathbf{I}_b = \frac{\mathbf{V}_{bn}}{\mathbf{Z}_Y} = \frac{\mathbf{V}_{an}\angle -120^\circ}{\mathbf{Z}_Y} = \mathbf{I}_a\angle -120^\circ$$
$$\mathbf{I}_c = \frac{\mathbf{V}_{cn}}{\mathbf{Z}_Y} = \frac{\mathbf{V}_{an}\angle -240^\circ}{\mathbf{Z}_Y} = \mathbf{I}_a\angle -240^\circ \tag{12.15}$$

We can readily infer that the line currents add up to zero,

$$\mathbf{I}_a + \mathbf{I}_b + \mathbf{I}_c = 0 \tag{12.16}$$

so that

$$\mathbf{I}_n = -(\mathbf{I}_a + \mathbf{I}_b + \mathbf{I}_c) = 0 \tag{12.17a}$$

or

$$\mathbf{V}_{nN} = \mathbf{Z}_n\mathbf{I}_n = 0 \tag{12.17b}$$

Mathematical Problem

Calculate the line currents in the three-wire Y-Y system of Fig. 12.13.

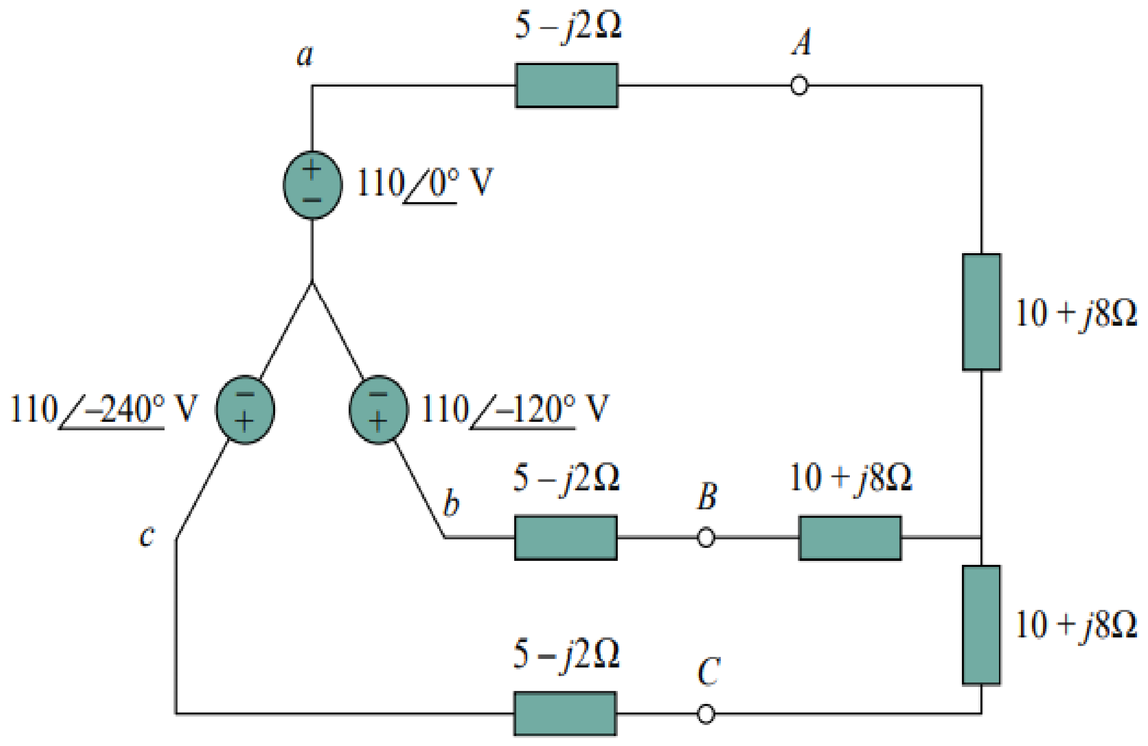
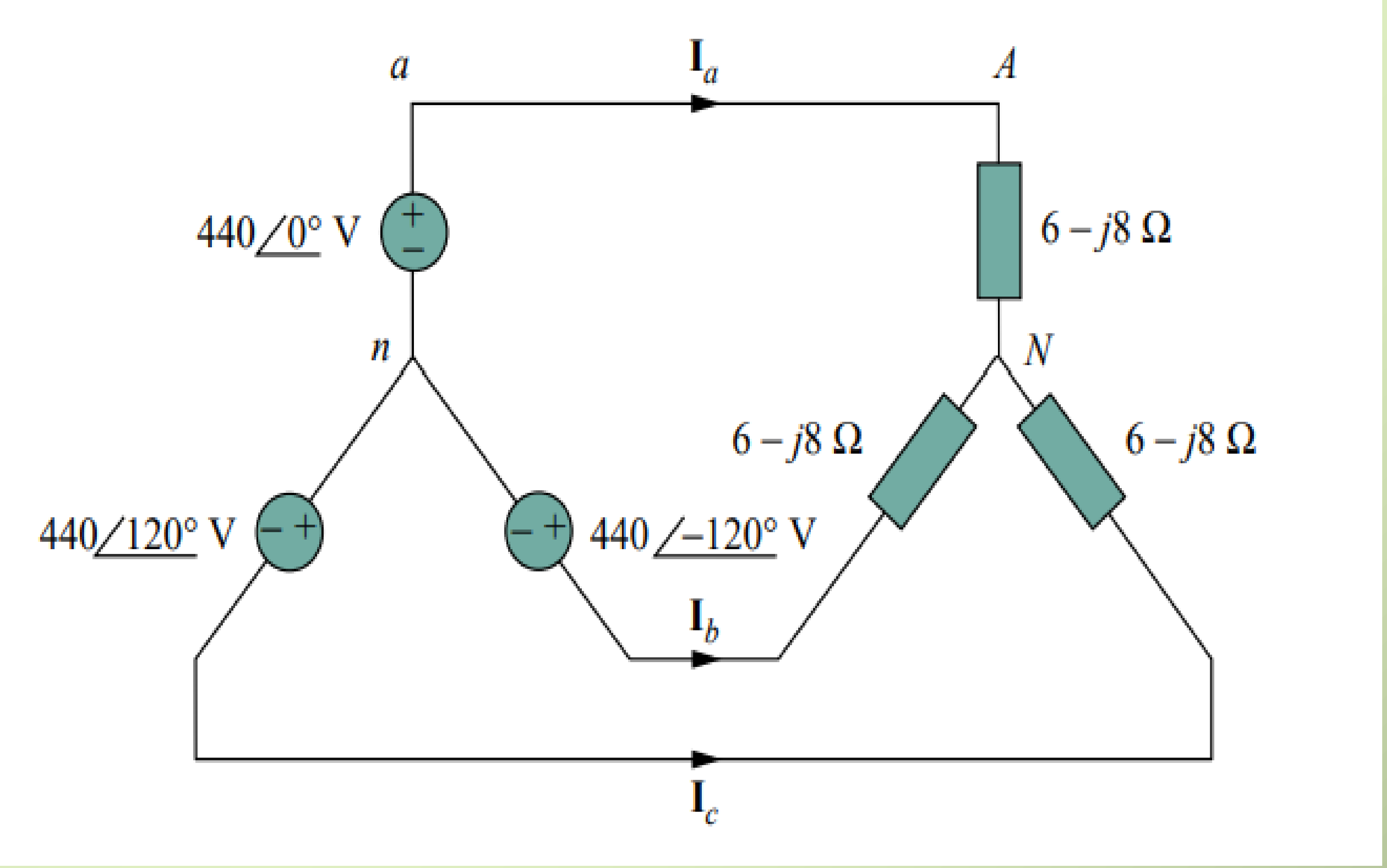


Figure 12.13 Three-wire Y-Y system; for Example 12.2.

Mathematical Problem: Obtain the line currents



Reflection

&

Group Study