Basic Electrical Technology

[ELE 1051]

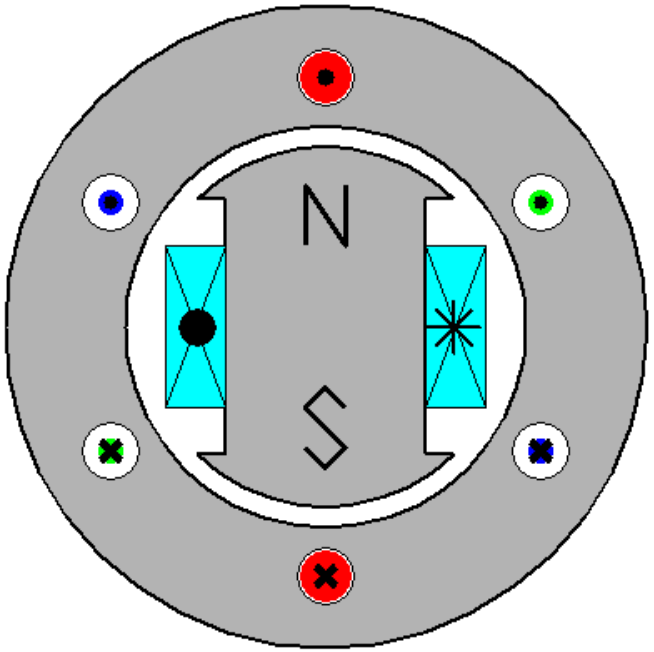
4. Three Phase AC Circuits

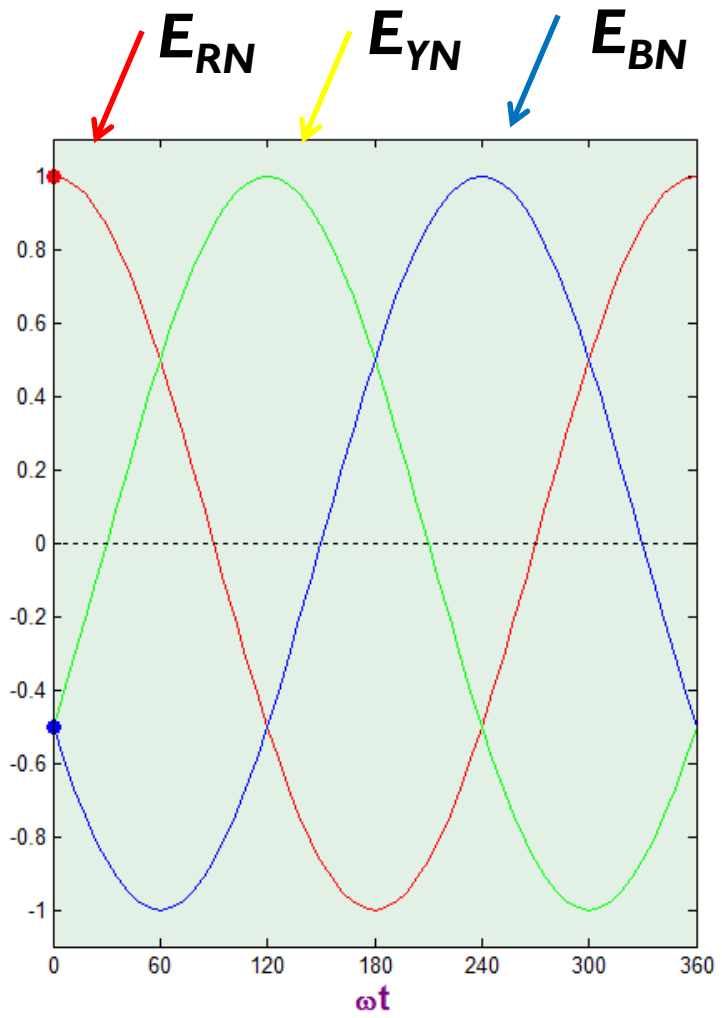
L21 – Generation & Representation of three phase supply

Topics Covered

- *Generation of Three Phase Supply*
- *Representation of Three Phase Excitation*
- *Relationship between Phase and Line Voltages*
- *3 Phase Supply & Loads*

Generation of Three Phase





Courtesy : www.ece.umn.edu

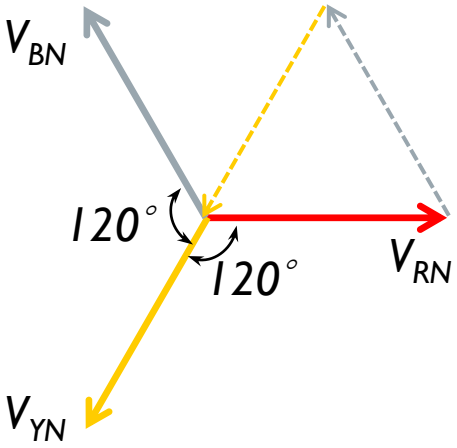
3 Phase Excitation (Phase Voltages)

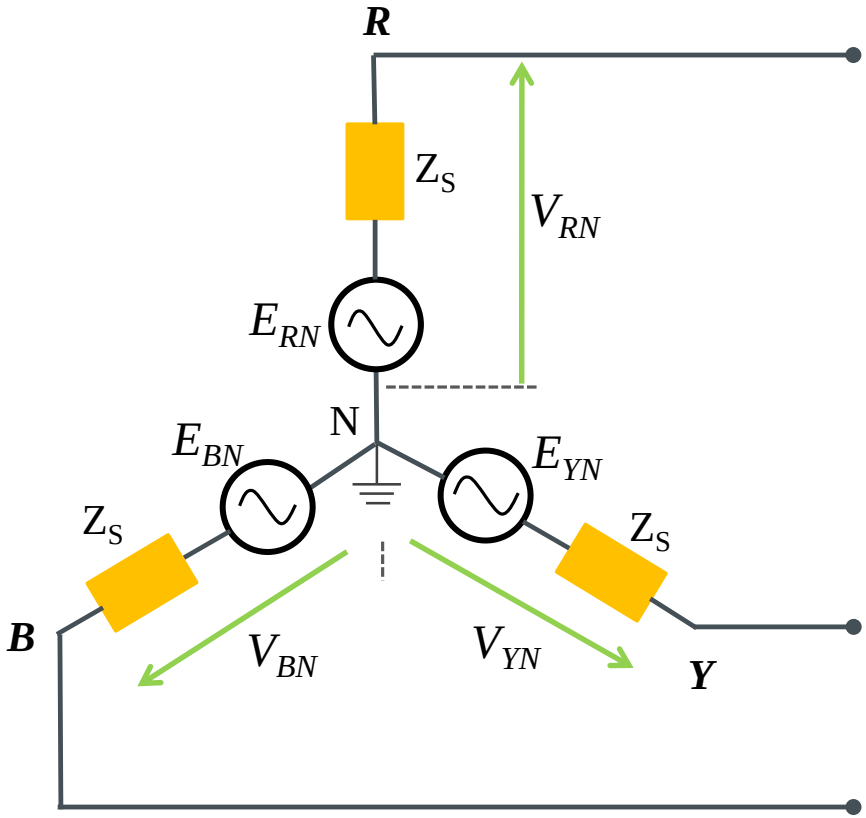
Phase Voltages,

$$\hat{V}_{RN} = V_m \, Sin(\omega t)$$

$$\hat{V}_{YN} = V_m \, Sin(\omega t - 120°)$$

$$\hat{V}_{BN} = V_m \, Sin(\omega t - 240°)$$



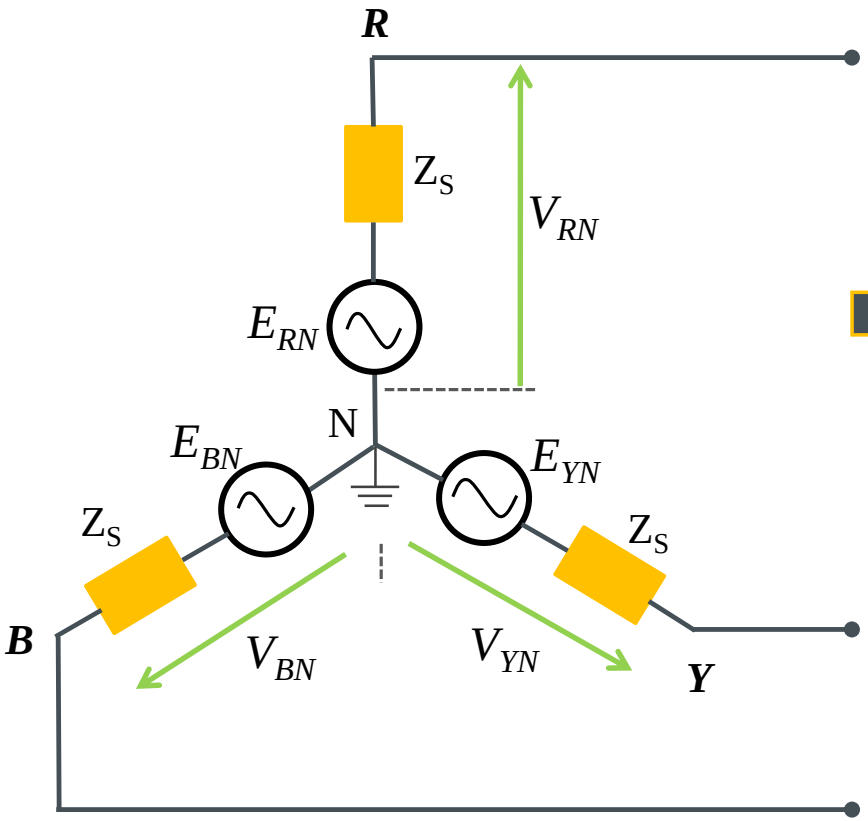


Three Phase Source

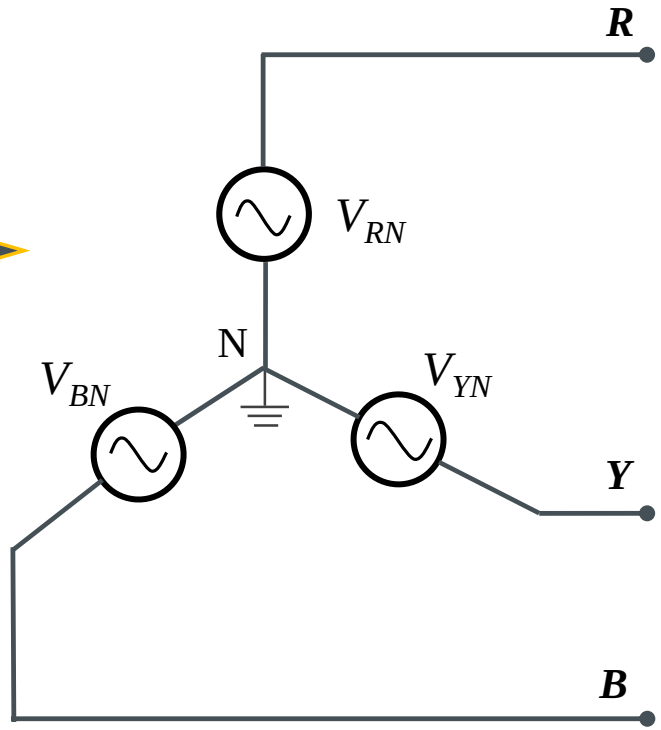
Summing up the phase voltages,

$$\hat{V}_{RN} + \hat{V}_{YN} + \hat{V}_{BN} = 0$$

3 Phase Excitation (Phase Voltages)..

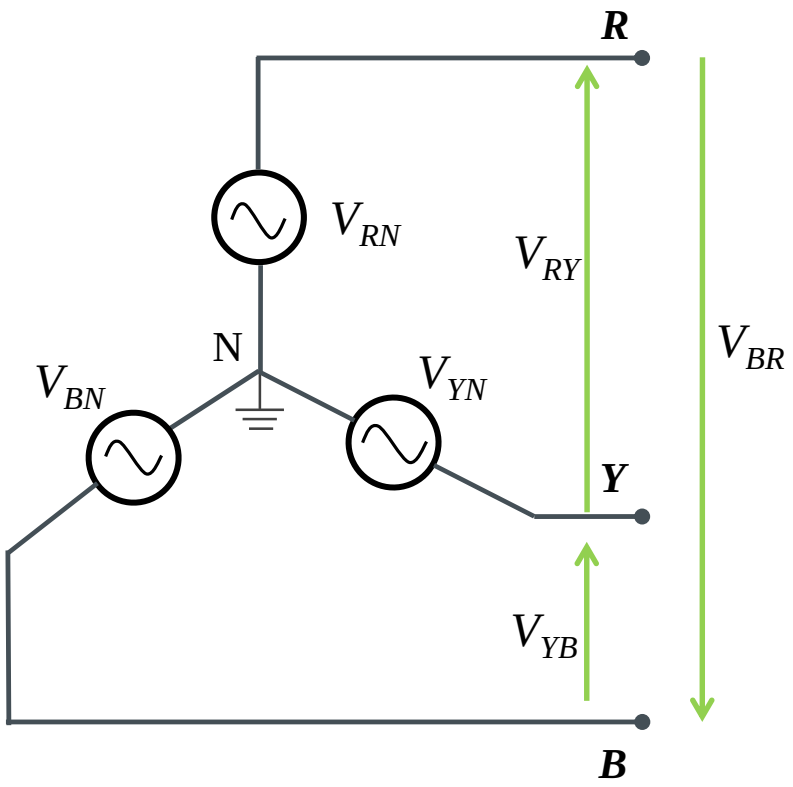


Three Phase Source

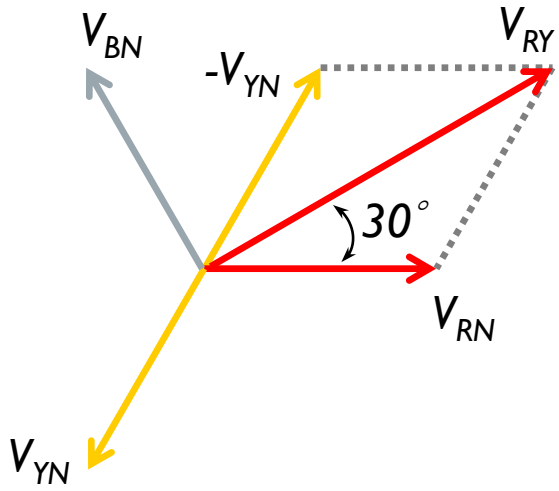


Three Phase Source

3 Phase Excitation (Line Voltages)



Three Phase Source



Line Voltages,

$$\hat{V}_{RY} = \hat{V}_{RN} - \hat{V}_{YN}$$

$$= V_m\, Sin(\omega t) - V_m\, Sin(\omega t - 120°)$$

$$= \sqrt{3} \times V_m\, Sin(\omega t + 30)$$

3 Phase Excitation (Line Voltages)…

Similarly,

$$\hat{V}_{YB} = \hat{V}_{YN} - \hat{V}_{BN}$$

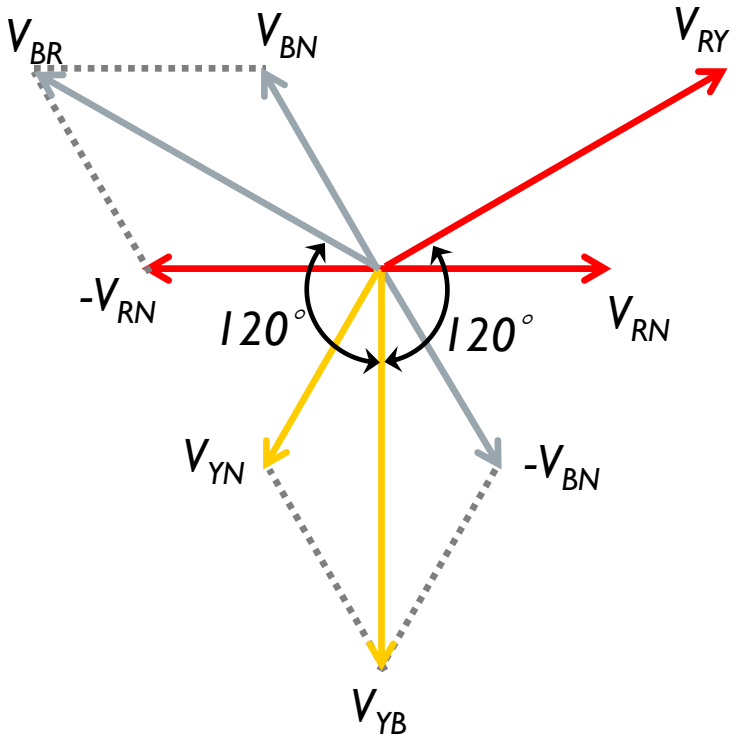
$$= V_m \, Sin(\omega t - 120) - V_m \, Sin(\omega t - 240°)$$

$$= \sqrt{3} \times V_m \, Sin(\omega t - 90)$$

$$= V_{RY} \, Sin(\omega t - 120)$$

$$\hat{V}_{BR} = \hat{V}_{BN} - \hat{V}_{RN}$$

$$= V_{RY} \, Sin(\omega t + 120)$$



Summing up the Line voltages,

$$\hat{V}_{RY} + \hat{V}_{YB} + \hat{V}_{BR} = 0$$

In a Three Phase balanced Supply, the summation of Phase voltages and summation of Line Voltages is zero.

Relation b/w Phase & Line Voltages

Phase Voltages

$$\hat{V}_{RN} = V_m \, Sin(\omega t)$$

$$\hat{V}_{YN} = V_m \, Sin(\omega t - 120°)$$

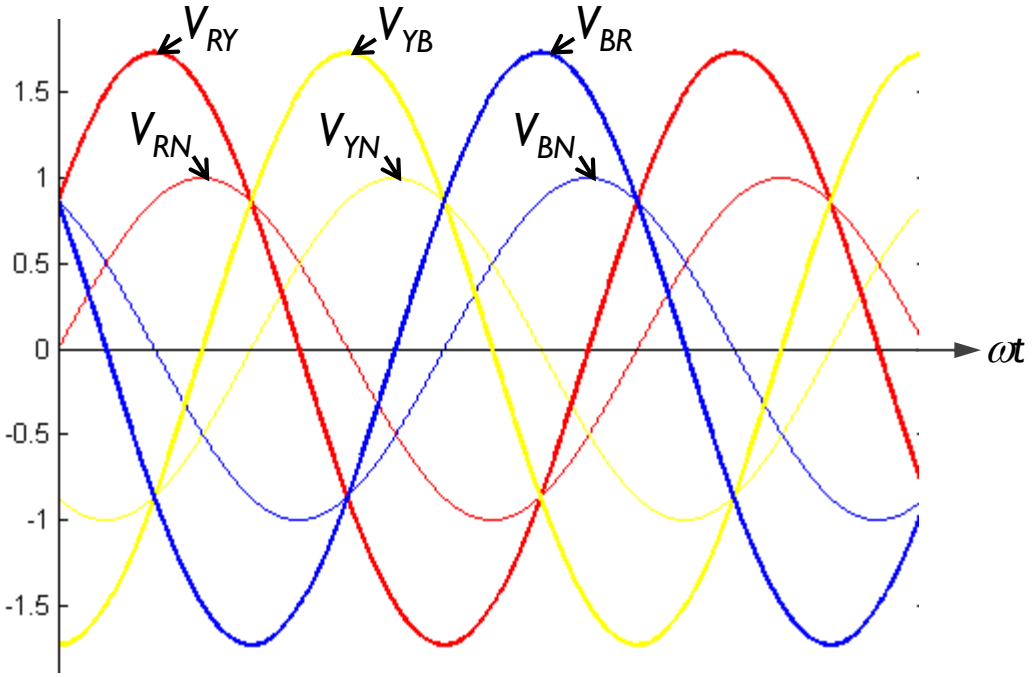
$$\hat{V}_{BN} = V_m \, Sin(\omega t - 240°)$$

Line Voltages

$$\hat{V}_{RY} = \sqrt{3} \times V_m \, Sin(\omega t + 30)$$

$$\hat{V}_{YB} = \sqrt{3} \times V_m \, Sin(\omega t - 90)$$

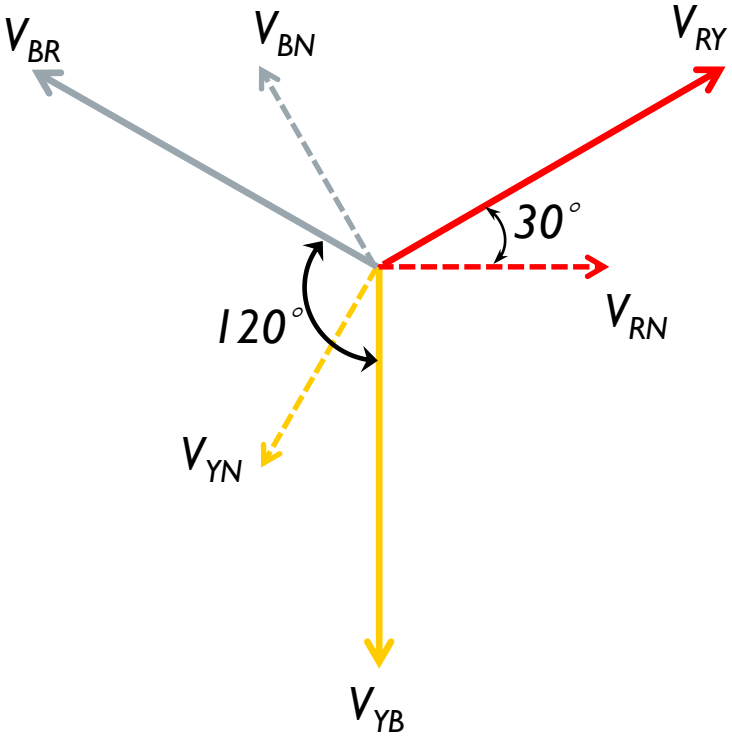
$$\hat{V}_{BR} = \sqrt{3} \times V_m \, Sin(\omega t + 150)$$



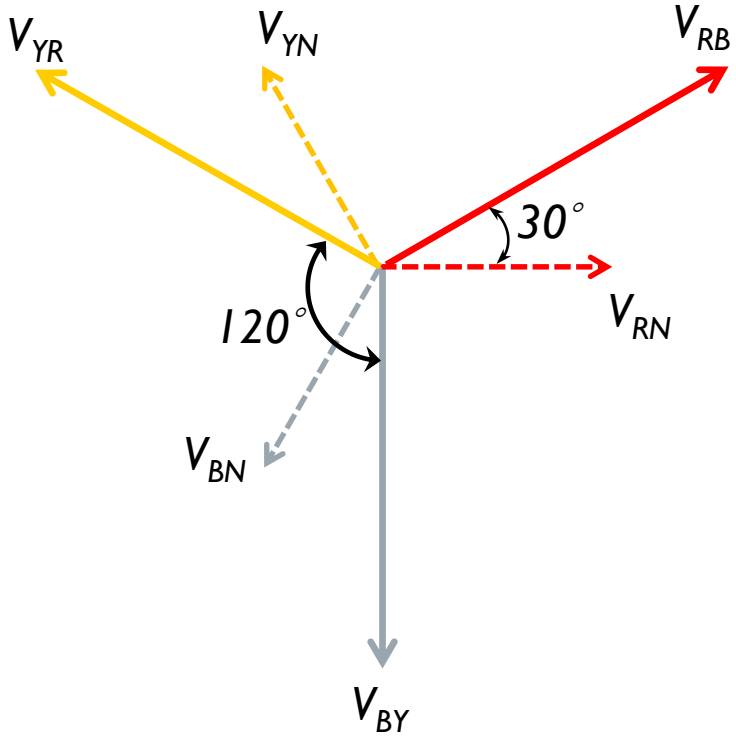
$$|V_{Line}| = \sqrt{3} \, |V_{Phase}|$$

Phase Sequence

1. RYB



2. RBY



Phase Sequence is the order in which three phases attain their peak or maximum values

Exercise- I

Given the phase voltage V_{RN} of a 3 phase balanced RYB system as 240V, express the phase and line voltages mathematically. Also sketch the phasor diagram.

Solution:

Phase Voltages:

$$\hat{V}_{RN} = 240 \times \sqrt{2} \times Sin(\omega t)$$

$$\hat{V}_{YN} = 240 \times \sqrt{2} \times Sin(\omega t - 120°)$$

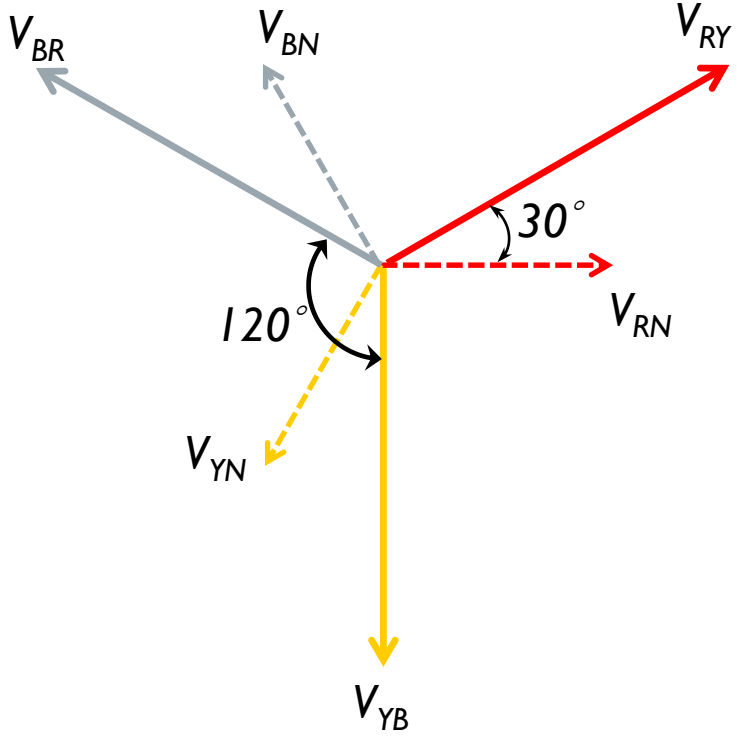
$$\hat{V}_{BN} = 240 \times \sqrt{2} \times Sin(\omega t - 240°)$$

Line Voltages:

$$\hat{V}_{RY} = \sqrt{3} \times 240 \times \sqrt{2} \times Sin(\omega t + 30°)$$

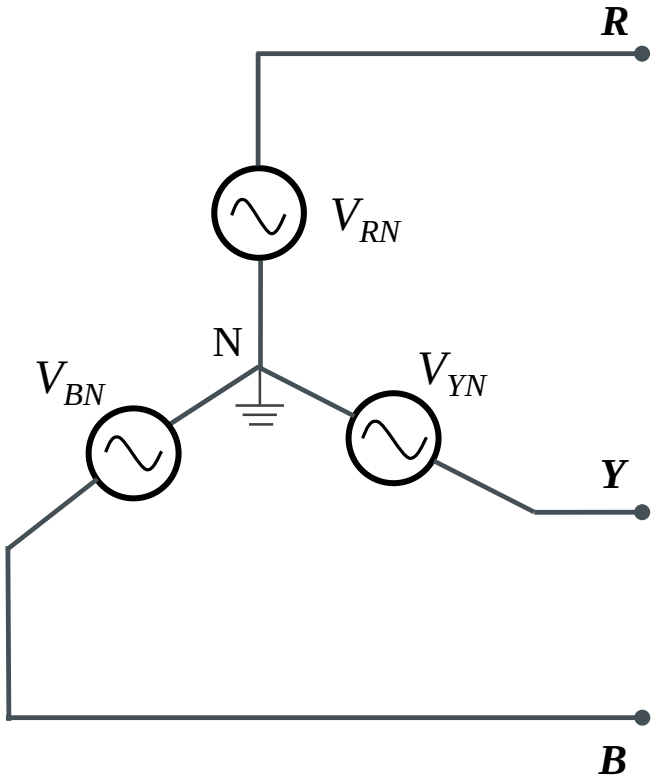
$$\hat{V}_{YB} = \sqrt{3} \times 240 \times \sqrt{2} \times Sin(\omega t - 90°)$$

$$\hat{V}_{BR} = \sqrt{3} \times 240 \times \sqrt{2} \times Sin(\omega t + 150°)$$

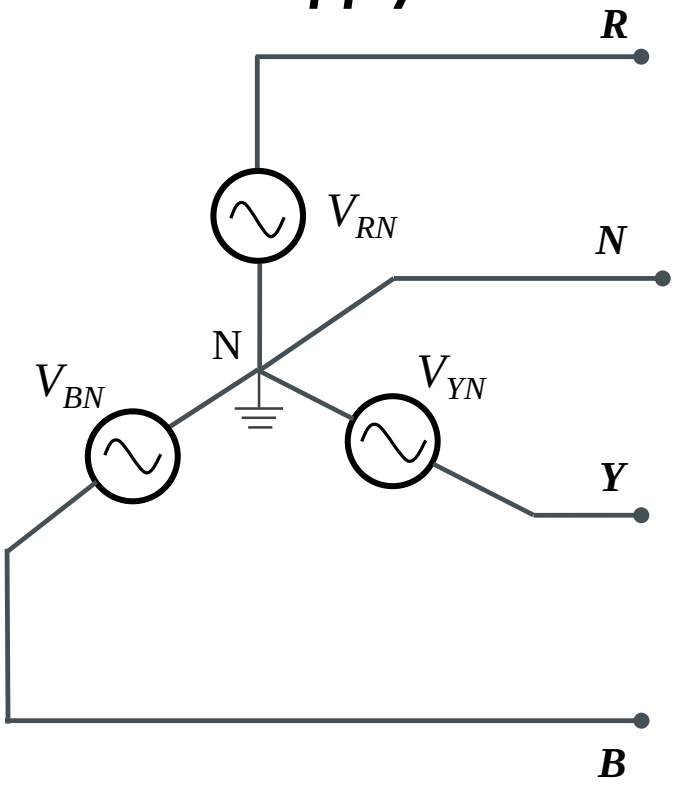


3 Phase 3 Wire & 4 Wire Supply

3 Phase 3 Wire Supply



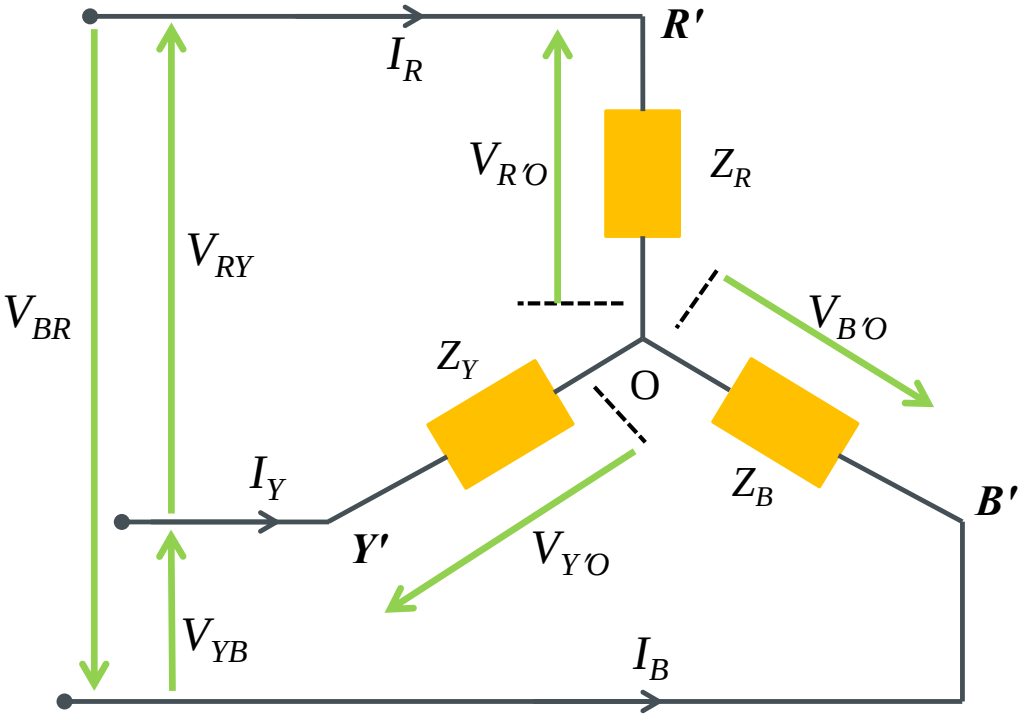
3 Phase 4 Wire Supply

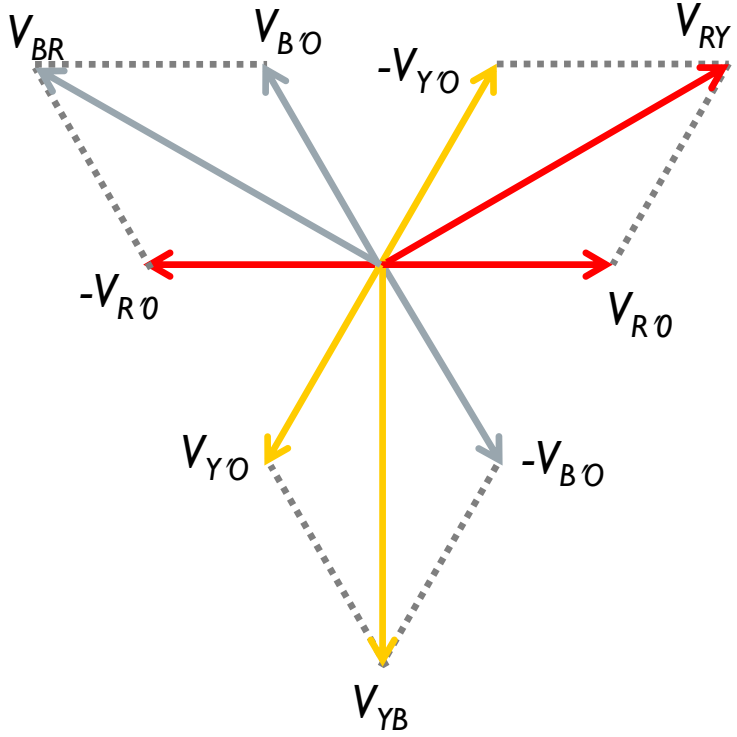


3 Phase Load

- Star Connected Load
- Delta Connected Load

Star Connected Load





Phase Voltages: $V_{R'O}, V_{Y'O}, V_{B'O}$

Line Voltages:

$$\hat{V}_{RY} = \hat{V}_{R'O} - \hat{V}_{Y'O}$$

$$\hat{V}_{YB} = \hat{V}_{Y'O} - \hat{V}_{B'O}$$

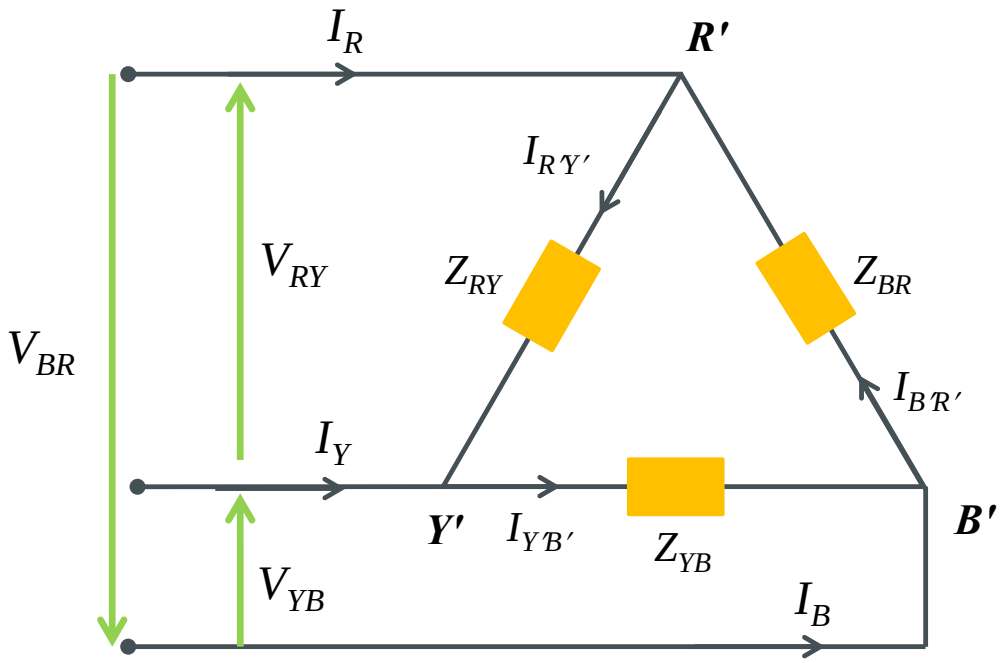
$$\hat{V}_{BR} = \hat{V}_{B'O} - \hat{V}_{R'O}$$

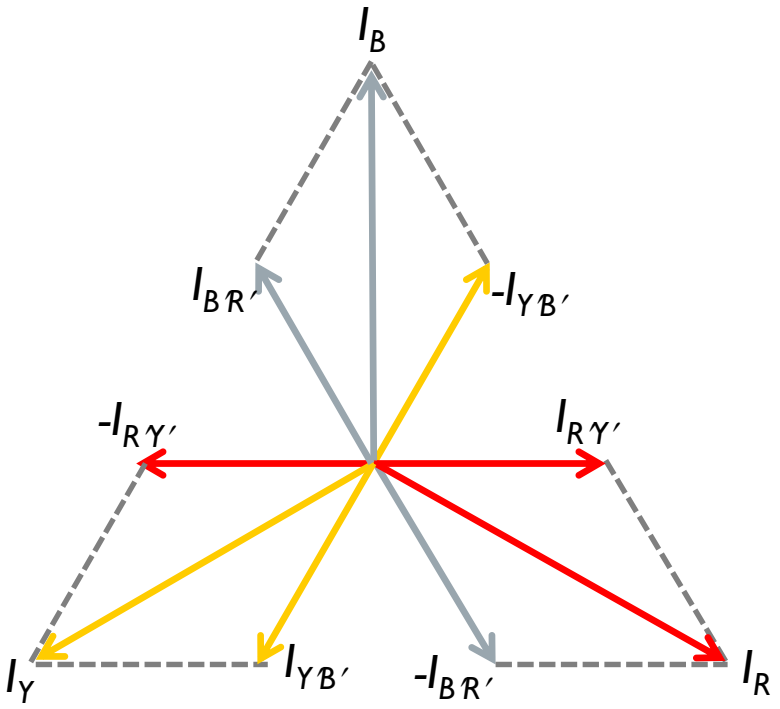
Line Currents = Phase Currents

For Balanced load,

Line Voltage = √3 X Phase Voltage

Delta Connected Load





Phase Currents: $I_{RY'}, I_{YB'}, I_{BR'}$

Line Currents:

$$\hat{I}_R = \hat{I}_{R'Y'} - \hat{I}_{B'R'}$$

$$\hat{I}_Y = \hat{I}_{Y'B'} - \hat{I}_{R'Y'}$$

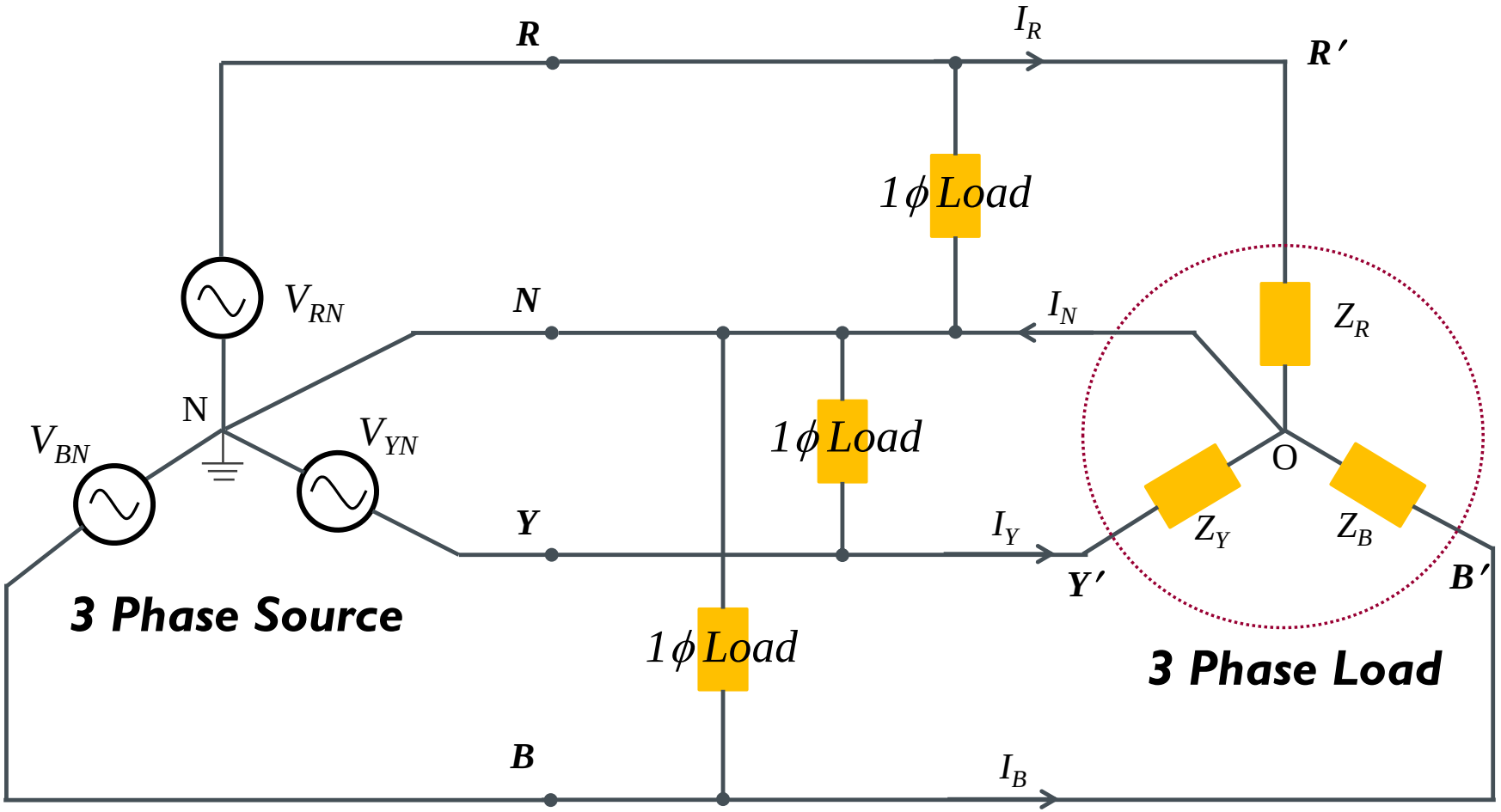
$$\hat{I}_B = \hat{I}_{B'R'} - \hat{I}_{Y'B'}$$

Phase Voltages = Line Voltages

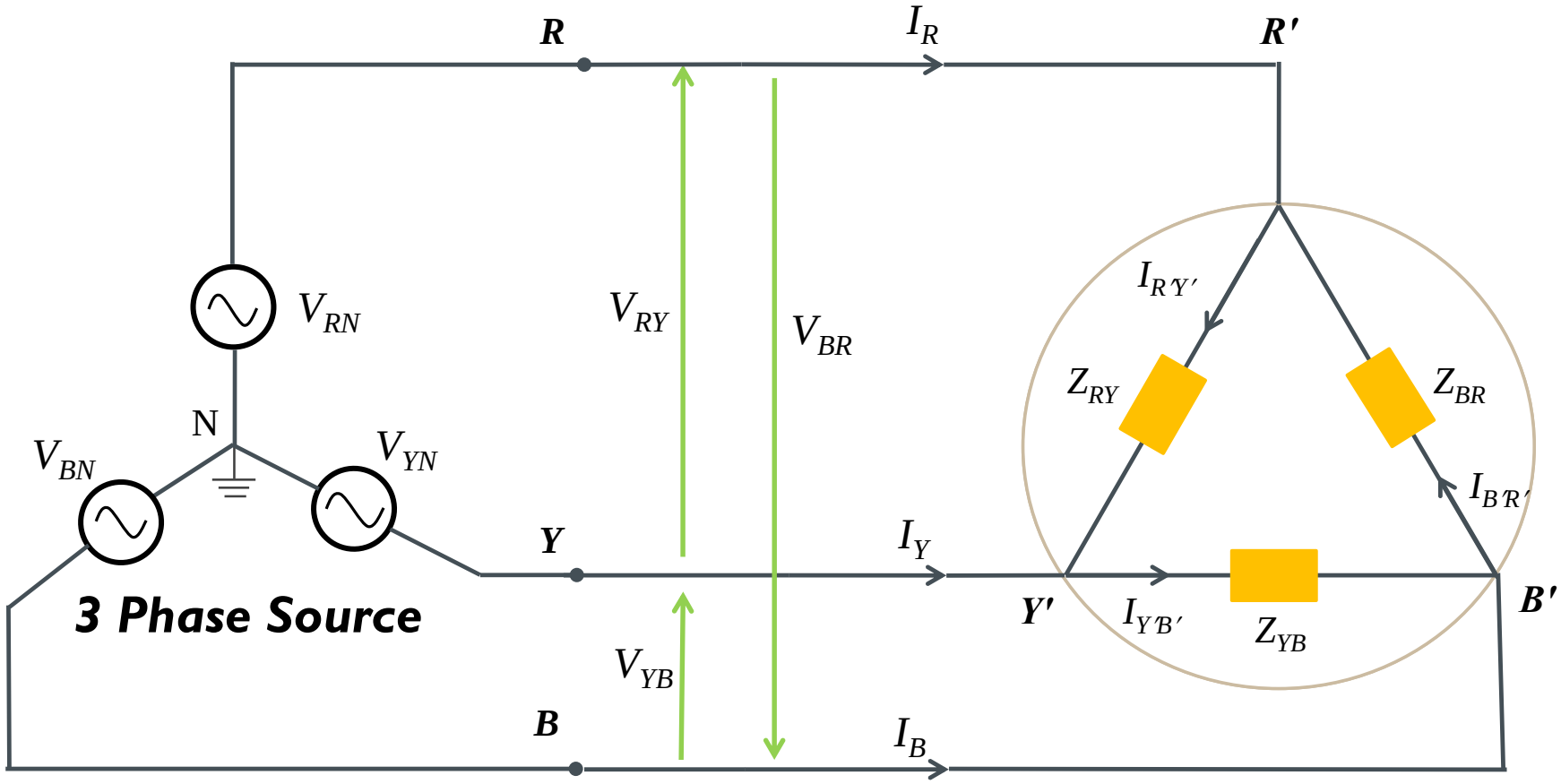
For Balanced load,

Line Current = √3 X Phase Current

3 Phase 4 Wire System



3 Phase 3 wire System



Delta Connected Load

Summary

In a three phase balanced supply,

- ✓ *Summation of phase voltages = zero*
- ✓ *Summation of Line voltages = zero*
- ✓ *Line voltage is $\sqrt{3}$ x Phase Voltage*
- ✓ *In an RYB sequence, V_{RY} leads V_{RN} by 30°*
- ✓ *Power transmission is generally through 3 phase 3 wire network and distribution is through 3 phase 4 wire network.*
- ✓ *For Balanced Star connected load, the line voltage = $\sqrt{3}$ x phase voltage.*
- ✓ *For Balanced Delta connected load, the line current = $\sqrt{3}$ x phase current*