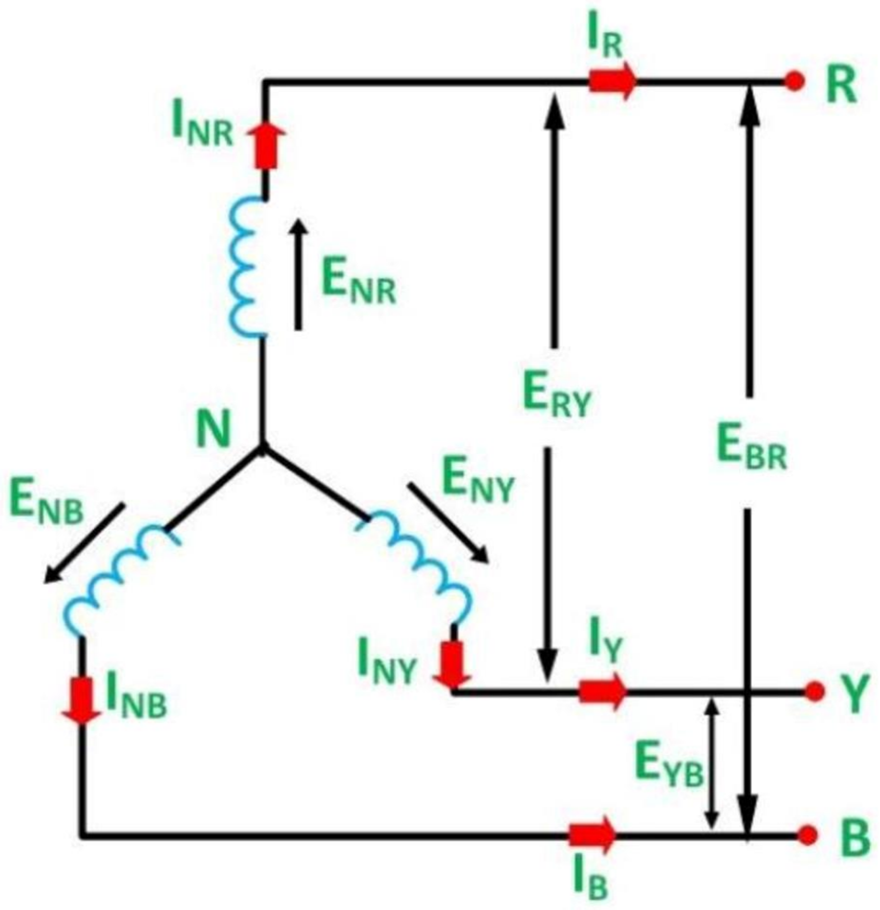
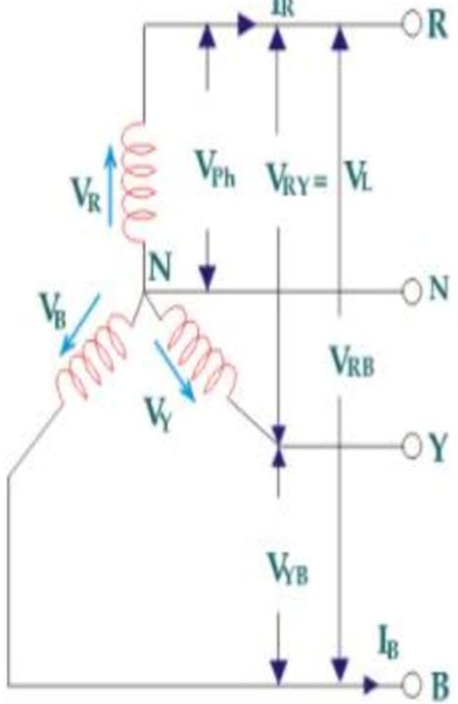
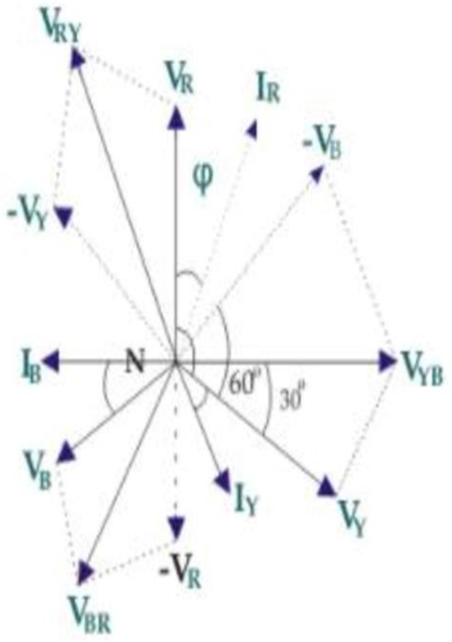


I_R
R
I_NR
E_NR
E_RY
E_BR
N
E_NB
E_NY
I_Y
I_NY
Y
I_NB
E_YB
B
I_B



I_R
R
V_R
V_{Ph}
V_{RY} = V_L
N
N
V_B
V_Y
V_{RB}
Y
V_{YB}
I_B
B



V_{RY}
V_R
I_R
$-V_B$
φ
$-V_Y$
I_B
N
V_{YB}
60°
30°
V_B
I_Y
V_Y
$-V_R$
V_{BR}

- Let us say, the magnitude of the voltage across the red phase i.e. magnitude of the voltage between neutral point (N) and red phase terminal (R) is V_R.
- The magnitude of the voltage across yellow phase is V_Y and the magnitude of the voltage across blue phase is V_B.
- n the balanced star system, magnitude of phase voltage in each phase is V_{ph}.
  $\therefore V_R = V_Y = V_B = V_{ph}$
- We know in the star connection, line current is same as phase current. The magnitude of this current is same in all three phases and say it is I_L.
  $\therefore I_R = I_Y = I_B = I_L$, Where, I_R is line current of R phase, I_Y is line current of Y phase and I_B is line current of B phase. Again, phase current, I_{ph} of each phase is same as line current I_L in star connected system.
  $\therefore I_R = I_Y = I_B = I_L = I_{ph}$.

Now, let us say, the voltage across R and Y terminal of the star connected circuit is V_{RY}.

The voltage across Y and B terminal of the star connected circuit is V_{YBBR}.

From the diagram, it is found that

$V_{RY} = V_R + (- V_Y)$

Similarly, $V_{YB} = V_Y + (- V_B)$

And, $V_{BR} = V_B + (- V_R)$

Now, as angle between V_R and V_Y is 120°(electrical), the angle between V_R and $- V_Y$ is 180° – 120° = 60°(electrical).

$$V_L = |V_{RY}| = \sqrt{V_R^2 + V_Y^2 + 2V_R V_Y \cos 60^o}$$
$$= \sqrt{V_{ph}^2 + V_{ph}^2 + 2V_{ph} V_{ph} \times \frac{1}{2}}$$
$$= \sqrt{3}V_{ph}$$
$$\therefore V_L = \sqrt{3}V_{ph}$$

Thus, for the star-connected system line voltage = √3 × phase voltage.

Line current = Phase current

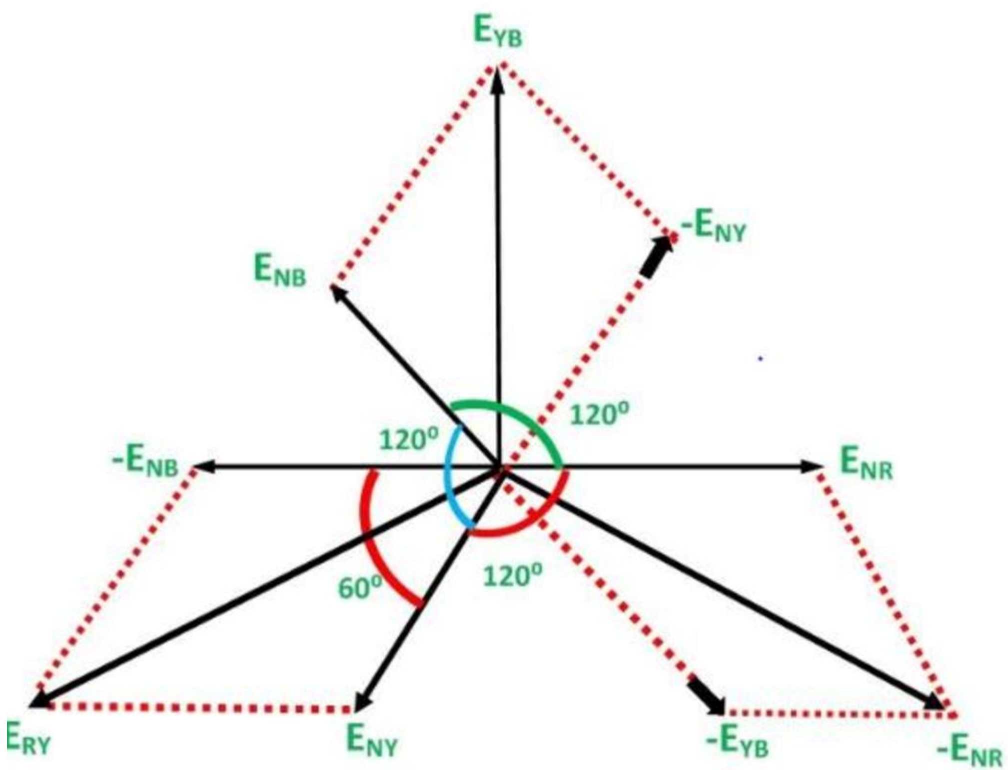
As, the angle between voltage and current per phase is φ, the electric power per phase is

$$V_{ph} I_{ph} cos\phi = \frac{V_L}{\sqrt{3}} I_L \cos\phi$$

So the total power of three phase system is

$$3 \times \frac{V_L}{\sqrt{3}} I_L \cos\phi = \sqrt{3} V_L I_L \cos\phi$$

or Diagram of Star Connection is shown below.



$$E_{RY} = \sqrt{E_{NY}^2 + E_{NR}^2 + 2E_{NY}E_{NR}\cos 60^0} \quad \text{o}$$

$$E_L = \sqrt{E_{ph}^2 + E_{ph}^2 + 2E_{ph}E_{ph} \times 0.5} \quad \text{or}$$

$$E_L = \sqrt{3E_{ph}^2} = \sqrt{3}\,E_{ph} \ \text{(in magnitude)}$$

Similarly,

$$E_{YB} = E_{NB} - E_{NY} \quad \text{or} \quad E_L = \sqrt{3}\,E_{ph} \quad \text{and}$$

$$E_{BR} = E_{NR} - E_{NB} \quad \text{or} \quad E_L = \sqrt{3}\,E_{ph}$$

Hence, in Star Connections Line voltage is root 3 times o

$$\text{Line voltage} = \sqrt{3} \times \text{Phase voltage}$$

$$E_{NR} = E_{NY} = E_{NB} = E_{ph}$$

$$E_{RY} = \sqrt{E_{NY}^2 + E_{NR}^2 + 2E_{NY}E_{NR}\cos 60^\circ} \quad \text{or}$$

$$E_L = \sqrt{E_{ph}^2 + E_{ph}^2 + 2E_{ph}E_{ph} \times 0.5 \quad \text{or}}$$

$$E_L = \sqrt{3E_{ph}^2} = \sqrt{3}\, E_{ph} \ \text{(in magnitude)}$$

Similarly,

$$E_{YB} = E_{NB} - E_{NY} \quad \text{or} \quad E_L = \sqrt{3}\, E_{ph} \quad \text{and}$$

$$E_{BR} = E_{NR} - E_{NB} \quad \text{or} \quad E_L = \sqrt{3}\, E_{ph}$$

Hence, in Star Connections Line voltage is root 3 times of phase voltage.

$$\text{Line voltage} = \sqrt{3} \times \text{Phase voltage}$$

THREE PHASE SYSTEM

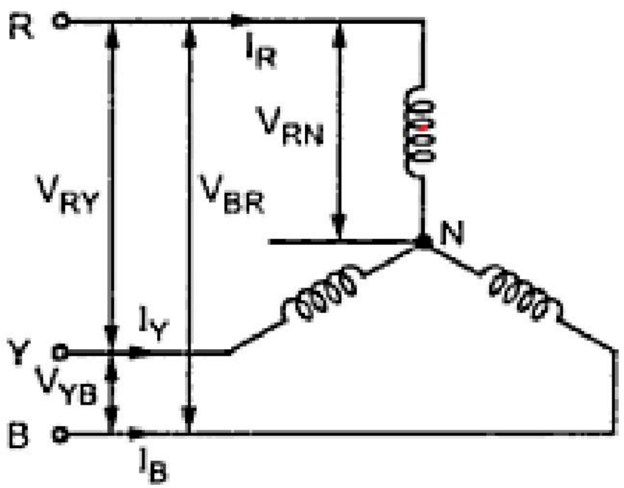
BASICS

Line voltage V_L= voltage between lines

Phase voltage Vph= voltage between a line and neutral

THREE PHASE SYSTEM

BALANCED STAR

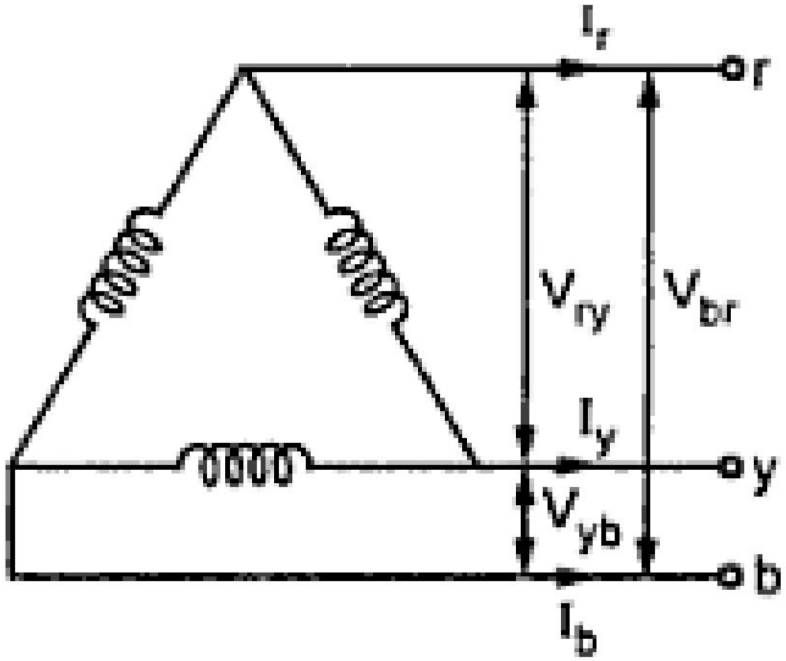


Line Voltage $V_L = \sqrt{3}\ V_{ph}$

Line current $I_L = I_{ph}$

THREE PHASE SYSTEM

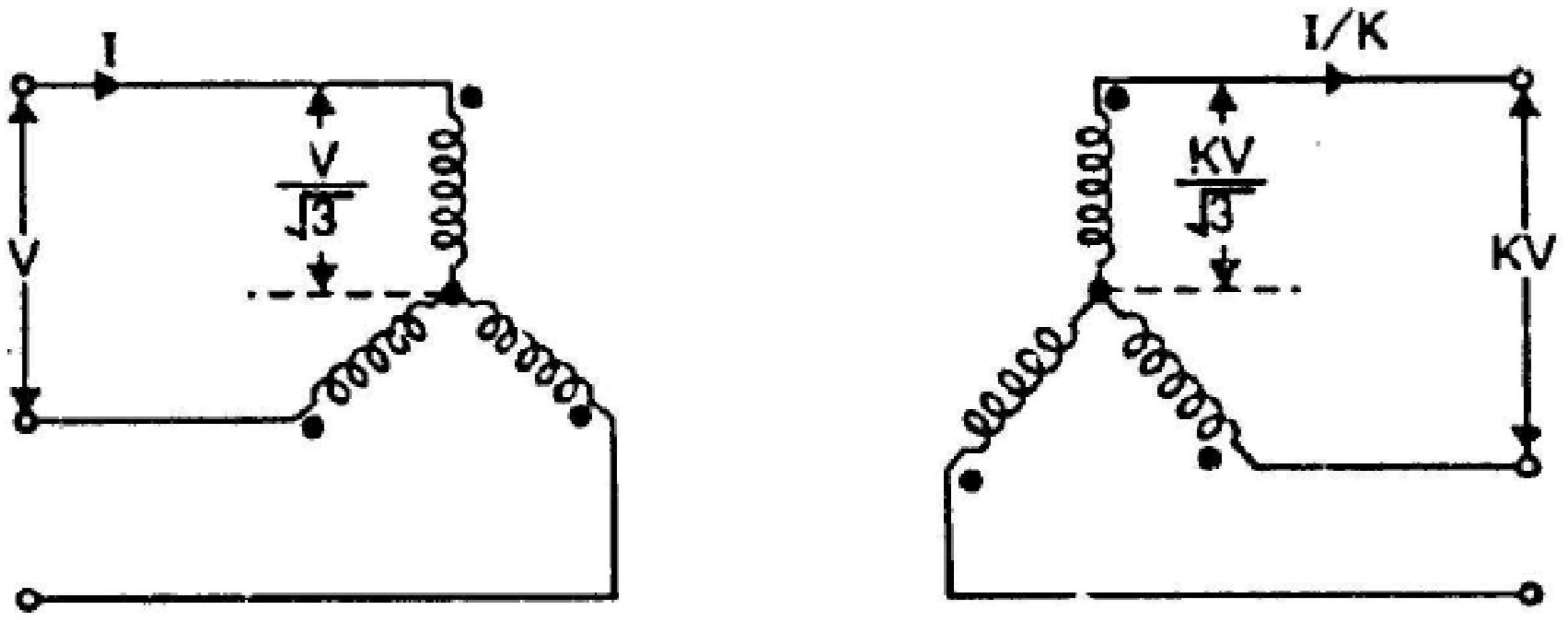
BALANCED DELTA



Line Voltage $V_L = V_{ph}$

Line current $I_L = \sqrt{3}\, I_{ph}$

Star- Star connection



Y – Y Connection

- This connection satisfactory only in balanced load otherwise neutral point will be shifted.

Star- Star connection

Advantages

1.Requires less turns per winding ie cheaper

Phase voltage is 1/√3 times of line voltage

2.Cross section of winding is large ie stronger to bear stress during short circuit

Line current is equal to phase current

3. Less dielectric strength in insulating materials

phase voltage is less

Star- Star connection

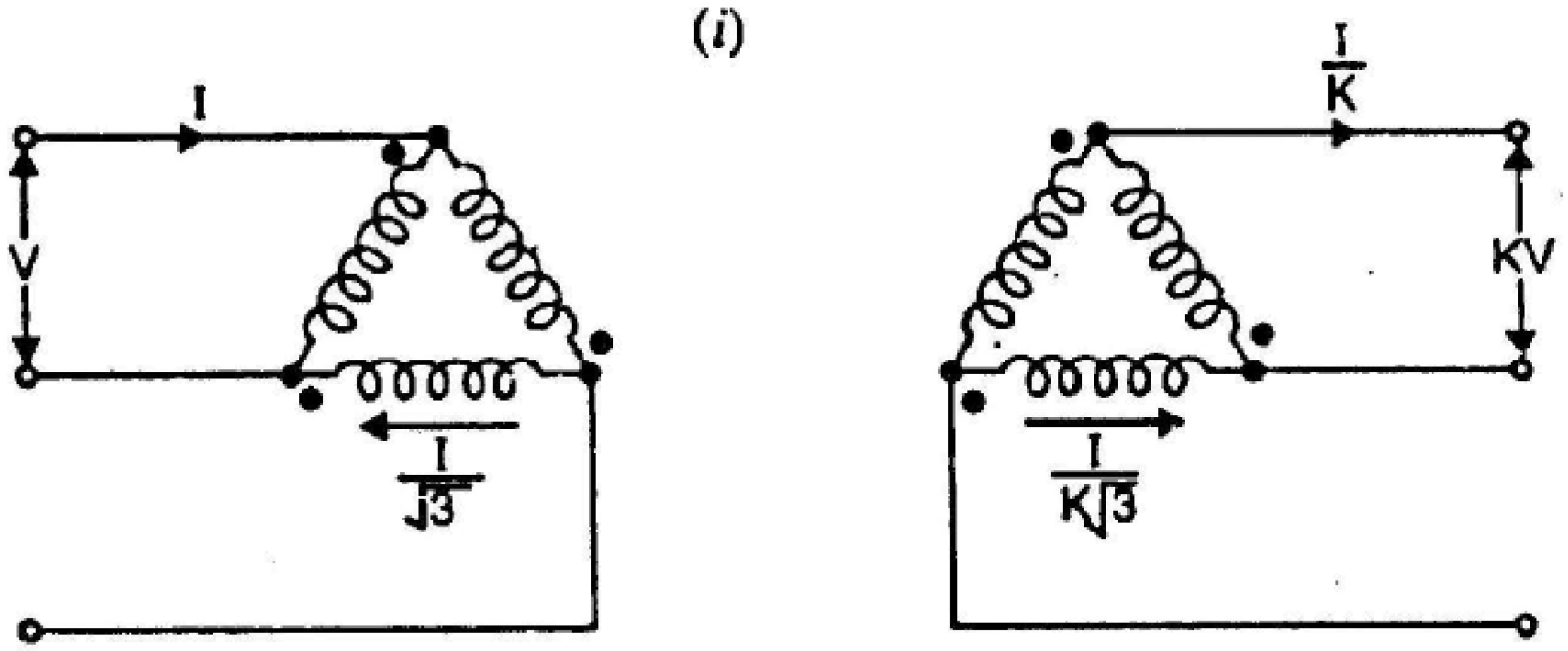
Disadvantages

1.If the load on the secondary side unbalanced then the shifting of neutral point is possible

2.The third harmonic present in the alternator voltage may appear on the secondary side. This causes distortion in the secondary phase voltages

3. Magnetizing current of transformer has 3rd harmonic component

Delta - Delta connection



Δ – Δ Connection

- This connection is used for moderate voltages

Delta - Delta connection

Advantages

1. System voltages are more stable in relation to unbalanced load
2. If one t/f is failed it may be used for low power level ie V-V connection
3. No distortion of flux ie 3^{rd} harmonic current not flowing to the line wire

Delta - Delta connection

Disadvantages

1. Compare to Y-Y require more insulation

2. Absence of star point ie fault may severe