# Relation Between Line Voltage and Phase Voltage

## Difference Between Line Voltage and Phase Voltage:

The line voltage is defined as the potential difference between two phases in a three-phase system or polyphase system. It is denoted by $V_L$ volts. The Phase voltage is the potential difference between one phase to the neutral point in any three-phase system or poly-phase systems and it is denoted by $V_{ph}$ in volts. The line voltage and the phase voltages are directly proportional to each other.

### Relation Between Line Voltage and Phase Voltage in Star Connection

The star connection is a Three Phase Four Wire system. The star connection is a type of electrical circuit where similar ends of the three windings are connected to a common point called neutral point or the star point. The star connection is the most preferred circuit system for AC power distribution and it is also known as the Y-system.

### Circuit Diagram

A star connection circuit is drawn as shown below. R, Y, and B are the three phases and N is the neutral point or the star point. $I_R$ ,$I_B$, and $I_Y$ are the line currents in the lines R, B, and Y respectively.

The line voltage and phase voltage in star connection is defined as,

**Line voltage:** The potential difference or the voltage between two lines of the circuit. Here the line voltages are. $V_{RY}$ , $V_{YB}$ , $V_{BR}$

**Phase voltage:** The potential difference or the voltage between a line and the neutral point, from the circuit diagram the phase voltages are $V_{RN}$ , $V_{YN}$ , $V_{BN}$

The line voltage and phase voltage relation in a star connection is calculated by considering the following points:

A balanced symmetrical load is applied across the three-phase voltage system in such a way that current flowing through the three lines will be the same but there will be a phase difference of 120º(out of phase).

The vector sum of all currents in the circuit must be zero.

## Derivation

Relation between line voltage and phase voltage:

Let's start by drawing a phasor diagram for the given star connection. From the phasor diagram or vector diagram the line and phase voltages are considered as:

$V_R = V_y = V_B = V_L$ = Phase voltage

$V_{RY} = V_{YB} = V_{BR} = V_{ph}$ = Line voltage

Extending VR in the backward direction will get -VR and draw a resultant between VR and VB. Similarly, extending Vy in the backward direction will get -Vy and draw a resultant between Vy and VB, and finally VB in the backward direction will get -VB and draw a resultant between Vy and VB.

The resultant vector of the given star connection can be found from the results of vector analysis. The resultant vector drawn is the line voltage of the star connection.

Let us consider the resultant VBY,

$$\sqrt{P^2 + R^2}$$

We know that the resultant vector is given by,

$$\sqrt{2PQ\cos\theta}$$

$\rightarrow$

$\vec{}$

R =

Similarly, the resultant $V_{BY}$ is calculated as,

$\Rightarrow$ VBY = $\sqrt{\left(VB^2\right)+\left(VR^2\right)+2\left(VB\right)\left(VR\right)Cos\theta}$

Here,

VB=VR=VPh and the angle between them is θ = 60°

$\Rightarrow$ VBY = $\sqrt{\left(VPh^2\right)+\left(VPh^2\right)+2\left(VPh\right)\left(VPh\right)Cos60}$

$\Rightarrow$ VBY = $\sqrt{\left(2VPh^2\right)+\left(2VPh^2\right)/2}$

$\Rightarrow$ VBY = $\sqrt{3(VPh)^2}$

$\Rightarrow$ VL = $\sqrt{3\left(VPh\right)}$

This gives the relation between line voltage and phase voltage in star connection and we can observe that the line voltage in the star connection is root three times its phase voltage.

**Note:**

The line and phase voltage are directly proportional to each other. Therefore, if we give an increment to the line voltage, then it will also result in an increase of phase voltage.

## Relation Between Line Current and Phase Voltage

The line current in the star connection is currently flowing through a single-phase or line and the phase current is the current flowing between two phases. Then the relation between line current and the phase current is given by:

$\Rightarrow I_L = I_{Ph}$
$\Rightarrow$ Line current = Phase current

I.e. The line current in a star connection will be the same as its phase current throughout the circuit.

This is the relation between line and phase voltage along with an explanation. Understand the meaning of these two terms and relate them as mentioned in this article.