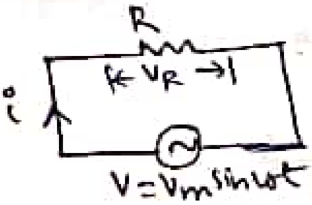
(iv) $A/B = \dfrac{15\angle{-30}}{25\angle{32}}$ $\quad$ $\underline{\underline{15 \div 25 \angle{-30-32}}}$ $\quad$ ①

$= \underline{\underline{0.6\angle{-62^\circ}}}$

AC Circuits:

The basic fundamental elements in a circuit are resistor, inductor, capacitor.

a) Resistive Circuit.

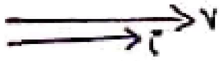


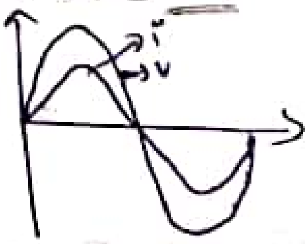
Purely resistive Ckt is the resistor R connected in series with the ckt.

V_R is the voltage drop across the resistor

$V_R = iR$.

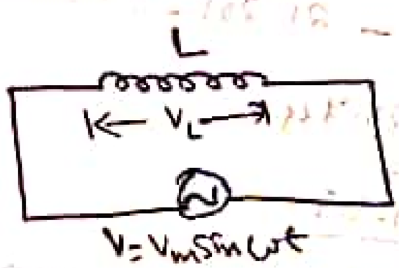
In resistive circuit, voltage & current are in phase





~~b) Capacitive C~~

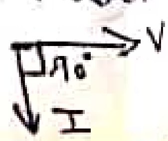
b) Inductive Circuit.



(Source voltage, $v = V_m \sin\omega t$)

Here, the inductor is connected in series with the volt

★ Here current lags the voltage by an angle 90°



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Here the supply voltage is $v = V_m \sin \omega t$ — ①.

Voltage across the inductor is V_L.

②

$$\therefore V_L = L\frac{di}{dt} \quad \text{— ②}$$

~~Equating ① & ② ⇒ $V_m \sin\omega t$~~

Equating supply voltage or source voltage with voltage across the inductor.

$$\Rightarrow V_m \sin \omega t = L\frac{di}{dt}.$$

$$di = \frac{V_m}{L}\sin\omega t \, dt.$$

Integrating on both sides,

$$i = \frac{V_m}{L}\int \sin\omega t \, dt$$

$$= \frac{V_m}{L}\left(\frac{-\cos\omega t}{\omega}\right)$$

$$= \frac{V_m}{L\omega}(-\cos\omega t).$$

$$\boxed{i = \frac{V_m}{L\omega}\sin(\omega t - \pi/2)}.$$

This is in the form $\boxed{i = I_m \sin(\omega t - \pi/2)}$ ⇒ Current lags the voltage by $\pi/2$

where $I_m = \dfrac{V_m}{L\omega}$

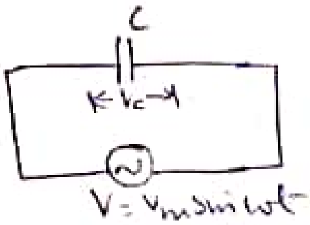
$\boxed{L\omega = X_L}$ is called Inductive reactance.

$\boxed{\omega = 2\pi f}$

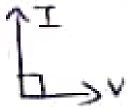
~~c) Capacitive Circuit~~.

The average power in an inductive circuit is zero.

c) Capacitive Circuit



In a capacitive circuit, the current leads the voltage by 90°



For a capacitor, charge accumulated, q = Capacitance X Volt

Q = CV

$$q = CV$$
$$= C V_m \sin \omega t$$

Since the current is the rate of change of charge ie,

$$I = \frac{dq}{dt}$$
$$= \frac{d}{dt}(C V_m \sin \omega t)$$
$$= C V_m [\cos \omega t (\omega)]$$
$$= C\omega V_m \cos \omega t$$
$$= C\omega V_m \sin\left(\omega t + \frac{\pi}{2}\right)$$
$$= \frac{V_m}{1/C\omega} \sin\left(\omega t + \frac{\pi}{2}\right)$$

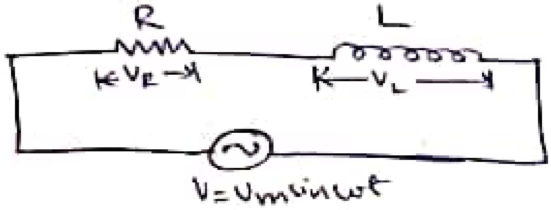
This is in the form $\boxed{i = I_m \sin(\omega t + \pi/2)}$

where $\boxed{I_m = \frac{V_m}{1/C\omega}}$

The term $\frac{1}{C\omega}$ is called Capacitive reactance

$$\boxed{X_C = \frac{1}{C\omega}}$$

RL Circuit

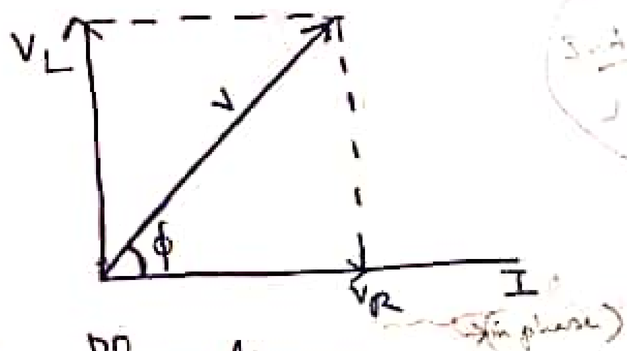


V_R is the voltage drop across the resistor.
V_L is the voltage drop across the inductor.

$$V_R = IR.$$

$$V_L = I\underbrace{X_L}$$ → reactance (inductive reactance)

In Inductive circuit, current lags the voltage by $90°$.



Phasor diagram.

In this circuit, resistance and inductor are connected in series.

Let V is the rms value of voltage.

Let I be the rms value of current.

From the phasor diagram, the applied voltage V is the vector sum of V_R & V_L.

$$V = \sqrt{V_R^2 + V_L^2}$$

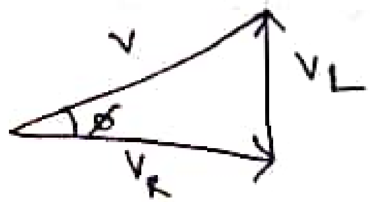
$$= \sqrt{(IR)^2 + (IX_L)^2} = I\sqrt{R^2 + X_L^2}$$

$$\boxed{V = I\sqrt{R^2 + X_L^2}}$$

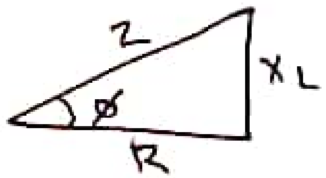
$$\boxed{V = IZ}$$

where $\boxed{Z = \sqrt{R^2 + X_L^2}}$, impedance of RL circuit.

Voltage triangle of RL circuit



Impedance triangle



Power in RL circuit

In series RL circuit, the power consumed by indicator is zero. Power is dissipated only in resistance.

ie, Average Power, $P = V_R \cdot I$

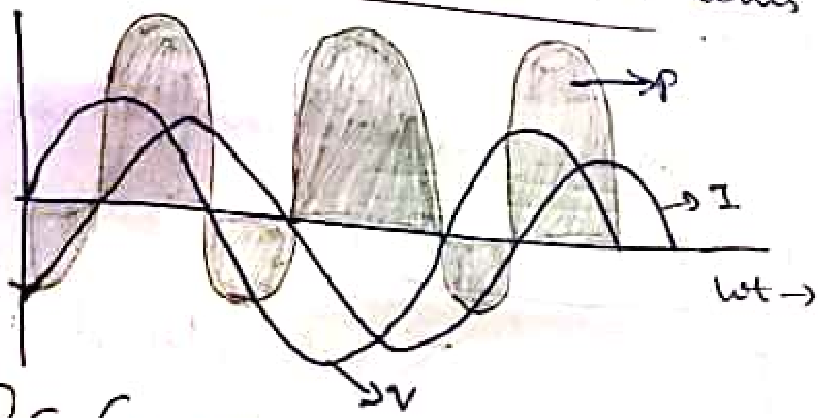
$= V\cos\phi \, I$ [From voltage triangle]

$$\boxed{P = VI\cos\phi}$$

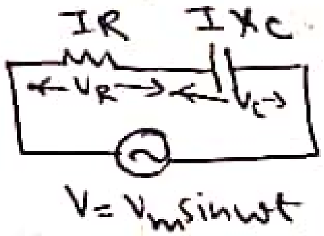
The term $\cos\phi$ is called power factor of the circuit

$\boxed{\cos\phi = \frac{R}{Z}}$ → From impedance triangle.

Voltage, current, power wave forms



RC Circuit



V and I are the rms of voltage and current.

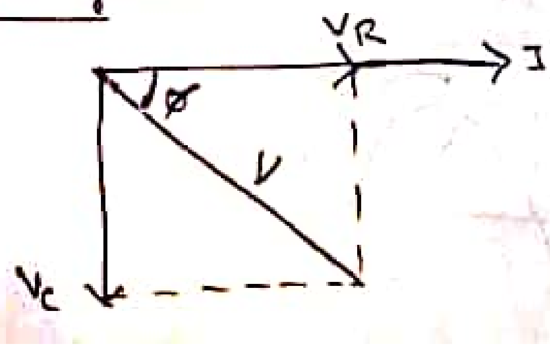
V_R is the voltage drop across resistor, $V_R = IR$.

V_C → voltage drop across capacitor, $V_C = IX_C$.

where X_C → capacitive reactance

$$X_C = \frac{1}{C\omega}.$$

Phasor diagram



From the phasor diagram, applied voltage V is the vector sum of V_R and V_C

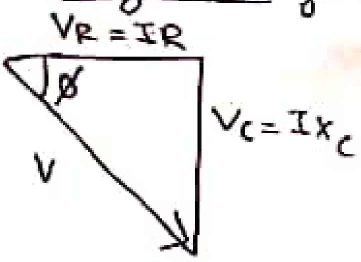
$$V = \sqrt{V_R^2 + V_C^2}$$

$$= \sqrt{(IR)^2 + (IX_C)^2} = I\sqrt{R^2 + X_C^2}$$

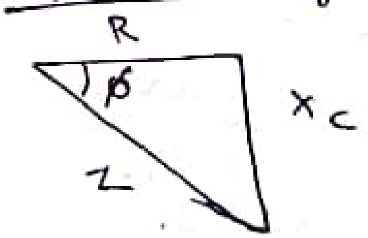
$$\boxed{V = I\sqrt{R^2 + X_C^2}}$$

$\boxed{V = IZ}$ where Z is called impedance of RC circuit $\boxed{Z = \sqrt{R^2 + X_C^2}}$

Voltage triangle



Impedance triangle :



Power in RC circuit :

In RC circuit, the power consumed by capacitor is zero. Power is consumed by resistance only.

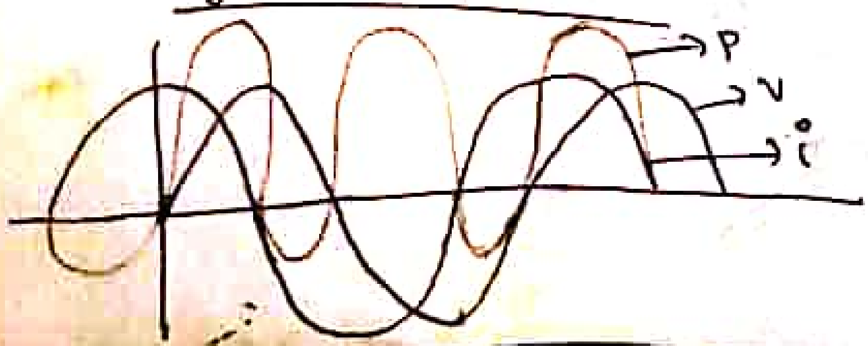
$$P = V_R I$$

$$= V\cos\phi\, I$$

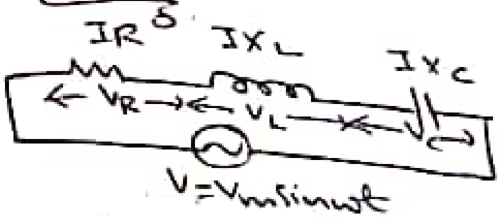
$\boxed{P = VI\cos\phi}$ where the term $\cos\phi$ is called power factor

ie, $\boxed{\cos\phi = \frac{R}{Z}}$

Voltage, current, power waveform



RLC Circuit.

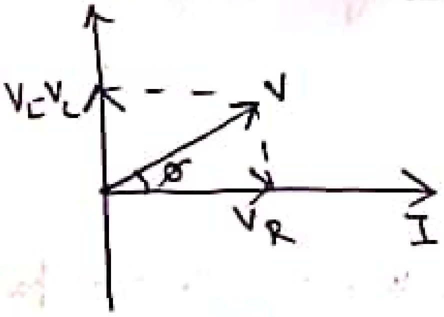


V, I are the rms value of current and voltage.

V_R is the voltage drop across the resistor, $V = IR$.
V_L is the voltage drop across the inductor, $V_L = IX_L$
V_c is the voltage drop across the capacitor, $V_c = IX_C$.

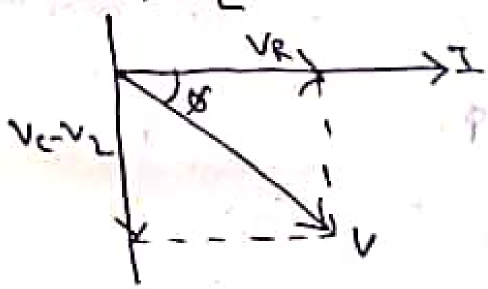
Case 1

$V_L > V_C$



Case 2

$V_C > V_L$



The applied voltage is the vector sum of V_R, V_L and V_C. The current I is leading or lagging depending on V_L and V_C

If $V_L > V_C$, current is lagging
If $V_C > V_L$, current is leading

Consider the case, $V_L > V_C$, $V = \sqrt{V_R^2 + (V_L - V_C)^2}$

$$= \sqrt{IR^2 + (IX_L - IX_C)^2} = I\sqrt{R^2 + (X_L - X_C)^2}$$

$$\boxed{V = I\sqrt{R^2 + (X_L - X_C)^2}} \qquad \boxed{V = IZ}$$

$V_C > V_L \Rightarrow$
$V = \sqrt{V_R^2 + (V_C - V_L)^2}$
$V = I\sqrt{R^2 + (X_C - X_L)^2}$

where Z is called impedance of circuit where $\boxed{Z = \sqrt{R^2 + (X_L - X_C)^2}}$

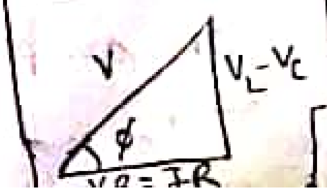
Power in RLC Circuit

Average power consumed by RLC circuit is equal to the power consumed by resistor, $P = V_R I$

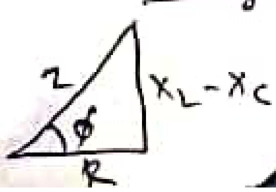
$P = V\cos\phi\, I$ $\qquad \boxed{P = VI\cos\phi}$

where $\boxed{\cos\phi = \frac{R}{Z}}$

Voltage triangle



Impedance triangle



Different types of Power.

1) Active Power. (P)

Active Power is the actual power dissipated in a circuit. It is represented by letter 'P'.

$$\boxed{P = VI\cos\phi}$$

Unit is Watts.

where V & I are the rms values of voltage & current and $\cos\phi$ is the power factor.

2) Reactive Power (Q)

It is the power associated with the reactive components (capacitance and inductance) of the circuit. It is also called Wattless component. It is given by the eqn,

$$\boxed{Q = VI\sin\phi.}$$

Unit is Volt ampere reactive → VA_r.

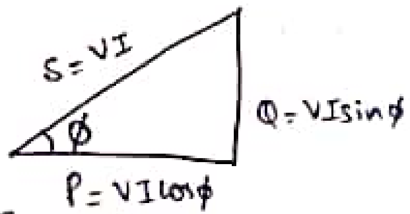
3) Apparent Power (S).

$$\boxed{S = VI}$$

The product of rms values of voltage & current in an ac circuit is called apparent power.

Unit is Volt amperes → VA.

4) P... T... ... :



Power triangle.

The power factor is defined as the ratio of active power to apparent power.

ie, $\cos\phi = \dfrac{\text{active Power (P)}}{\text{apparent Power (S)}}$ or, $\boxed{\cos\phi = \dfrac{P}{S}}$

For a sinusoidal voltage, Power factor is the cosine of ~~cosine of~~ angle b/w voltage and current.

Power factor is a unit less quantity.

$\boxed{\cos\phi = \dfrac{R}{Z}}$ → Resistance, → Impedance

Range of power factor is in b/w 0 & 1.

Note:

- Resistive circuit (R)

Voltage & current are in phase.

- Inductive Circuit (L)

Current lags

Voltage leading

$X_L = L \cdot \omega$. (inductive reactance)

- Capacitive Circuit (C)

Current leading

Voltage lagging.

$X_C = \frac{1}{C\omega}$ (capacitive reactants)

$\omega = 2\pi f$.

- RC circuit

Impedence, $Z = \sqrt{R^2 + X_C^2}$

- RL circuit.

$Z = \sqrt{R^2 + X_L^2}$

- RLC circuit:

$Z = \sqrt{R^2 + (X_L - X_C)^2}$

or

$Z = \sqrt{R^2 + (X_C - X_L)^2}$

- Different Powers
- Power factor.

1. A resistor of 50Ω and an inductor of 0.1 H...., are connected in Series across a 200 V, 50 Hz supply. Find the impedence, power factor, current, active power and reactive Power.

RL circuit.

$R = 50\Omega$, $L = 0.1H$, $V = 200V$, $f = 50Hz$.

Impedence, $Z = \sqrt{R^2 + X_L^2}$

$X_L = L\omega$

$\omega = 2\pi f$
$= 2\pi 50 = \underline{\underline{314.159}}$

$X_L = 0.1 \times 314.159$
$= \underline{\underline{31.4159}}\,\Omega$

2.

$$Z = \sqrt{50^2 + 31.4159^2}$$

$$= 59.0504\ \Omega$$

Power factor, $\cos\phi = \frac{P}{S}$

or

$\cos\phi = \frac{R}{Z}$.

$\therefore \cos\phi = \frac{50}{59.0504}$.

$= 0.8467$.

Current, $I = \frac{V}{Z}$

$= \frac{200}{59.0504}$

$= 3.386\ A$

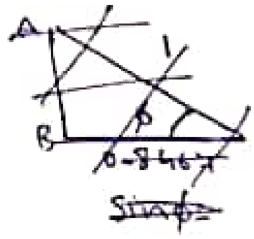
$I = \frac{V}{R}$ as RL circuits inductive reactance should be considered, $\therefore I = \frac{V}{Z}$

Active Power, $P = VI\cos\phi$

$= 200 \times 3.386 \times \cos\phi$

$= 200 \times 3.386 \times 0.8467$

$= 573.385\ W$.



Reactive Power, $Q = VI\sin\phi$

$= 200 \times 3.386 \times \sin\phi$

$\cos\phi = 0.8467$.

$\therefore \phi = 32.145$

$Q = 200 \times 3.386 \times \sin(32.145)$

$= 360.313\ VA_r$.

2- A resistor of $50\ \Omega$ & an capacitor of $100\ \mu F$ are connected in series across a $100\ V$, $50\ Hz$ supply. Find the impedance, current, power factor, active power, Reactive power, Voltage across resistor & capacitor -

RC circuit

$R = 50\,\Omega$, $C = 100\,\mu F$ $= 100 \times 10^{-6} F$, $V = 100 V$, $f = 50 Hz$

Z = Impedance, $Z = \sqrt{R^2 + X_c^2}$

$$\cancel{= 50}$$

$$X_c = \frac{1}{C\omega}$$

$$\omega = 2\pi f$$

$$= 2\pi \times 50$$

$$= 314.159$$

$$X_c = \frac{1}{100 \times 10^{-6} \times 314.159}$$

$$= \cancel{318.310\,\Omega}\ 31.831\,\Omega$$

$$\therefore Z = \sqrt{50^2 + 318.310^2}$$

$$= \cancel{322.213\,\Omega}\ 59.3\,\Omega$$

Current is leading in RC circuit

Current, $I = \frac{V}{Z}$

$$= \cancel{\frac{100}{322.213}}\ \frac{100}{59.3}$$

$$= \cancel{0.3103 A}\ 1.686 A$$

Powerfactor. $\cos\phi = \frac{R}{Z}$.

$$= \cancel{\frac{50}{322.213}}\ \cancel{\frac{50}{1.686}}\ \frac{50}{59.3}$$

$$= \cancel{0.155} = 0.843$$

(14)

Active Power, $P = VI\cos\phi$

$= 100 \times \overset{1.686}{\cancel{0.3103}} \times \overset{0.843}{\cancel{0.557}}$

$= \cancel{48.127 W}$ 142.129 W

Reactive Power, $Q = VI\sin\phi$

$\phi = \cos^{-1}(\overset{0.843}{\cancel{0.557}})$

$= \cancel{81.077}$ 32.541

$\therefore Q = 100 \times \overset{1.686}{\cancel{0.3103}} \times \sin(\overset{32.541}{\cancel{81.077}})$

$= \cancel{30.654 VA_r}$ $\cancel{10.415 VA_r}$

90.69 VA_r

Voltage across resistor, $V_R = IR$

$= 1.686 \times 50$

$= 84.3 V$

Voltage across capacitor, $V_C = IX_C$

$= 1.686 \times 31.831$

$= 53.66 V$

3. A resistor of 50Ω & a inductor of 0.1H and a capacitor of 40μF are connected in series & the combination is connected across a 100 V, 50Hz supply. Find the impedance, power consumed & power factor

$R = 50\Omega$, $L = 0.1H$, $C = 40\mu F = 40 \times 10^{-6} F$, $V = 100V$, $f = 50Hz$

RLC circuit

$L = 0.1$, $C = 40 \times 10^{-6} F$

Here L is bigger

Impedance, $Z = \sqrt{R^2 + (X_L - X_C)^2}$

$= \cancel{50^2}$ $X_L = L\omega$

$= 0.1 \times 2\pi \times 50$

$= 31.415 \Omega$

$$X_C = \frac{1}{C\omega}$$

$$= \frac{1}{40\times10^{-6}\times 2\pi\times 50}$$

$$= 79.57\,\Omega$$

$$\therefore Z = \sqrt{50^2 + (31.415 - 79.57)^2}$$

$$= 69.418\,\Omega.$$

~~Power consumed, P = VI cos ϕ~~

Power factor, $\cos\phi = \frac{R}{Z}$

$$= \frac{50}{69.418}$$

$$= 0.720$$

Here in RLC circuit ; L > C

∴ Current lags.

Power consumed, $P = VI\cos\phi$

(Active Power)

$$I = \frac{V}{Z}$$

$$= \frac{100}{69.418}$$

$$= 1.44\,A$$

$$\therefore P = 100 \times 1.44 \times 0.720$$

$$= 103.68\,W$$

3 phase Systems

Advantages of 3 phase System

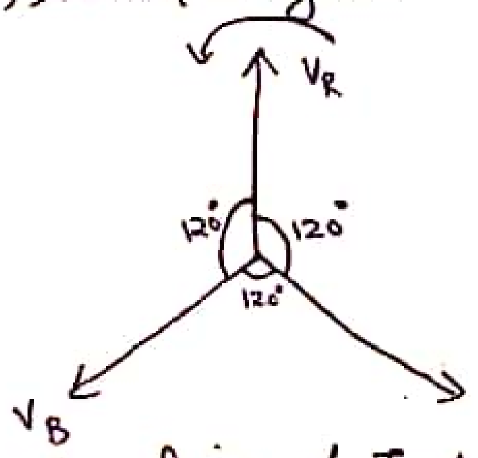
1) 3 phase system has greater output than single phase system.
2) 3 phase motor or system has uniform torque, but a single phase motor has pulsating torque
3) Three phase generators work in parallel without any difficulty.
4) Three phase induction motor is self starting but single phase motors are not self starting.
5) 3 phase induction motor is cheaper.

Generation of Three phase voltage

Red, Yellow, Blue

When three identical coils R, Y, B. R placed at 120° from each other and rotated in a uniform magnetic field, sinusoidal voltage is ~~given~~ developed across each coil. They are V_R, V_Y, V_B.

Phasor diagram



Equations of Induced voltages are,

$V_R = V_m \sin \omega t$

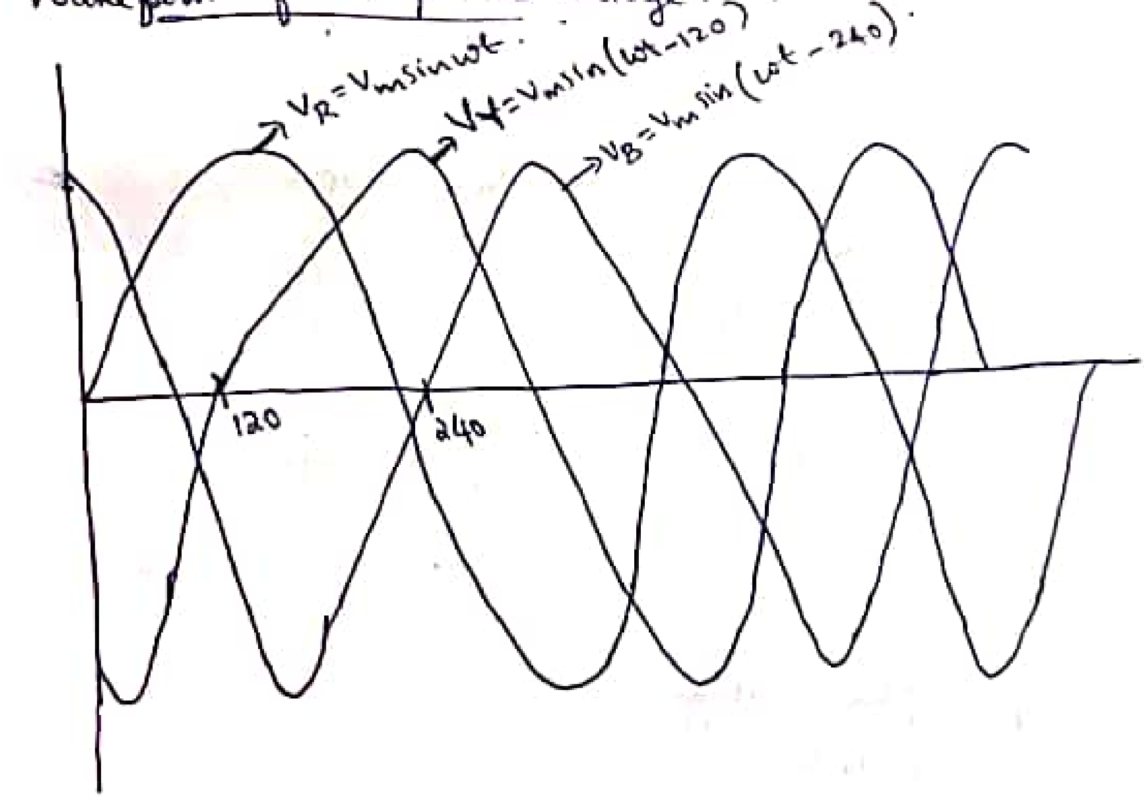
$V_Y = V_m \sin(\omega t - 120°)$

$V_B = V_m \sin(\omega t + 120^\circ)$

or

$= V_m \sin(\omega t - 240^\circ B)$.

Waveform of 3 phase Voltage.



Phase Sequence

The phase sequence of a polyphase gives the order in which the voltages in the three phases or coils reach their maximum positive value.

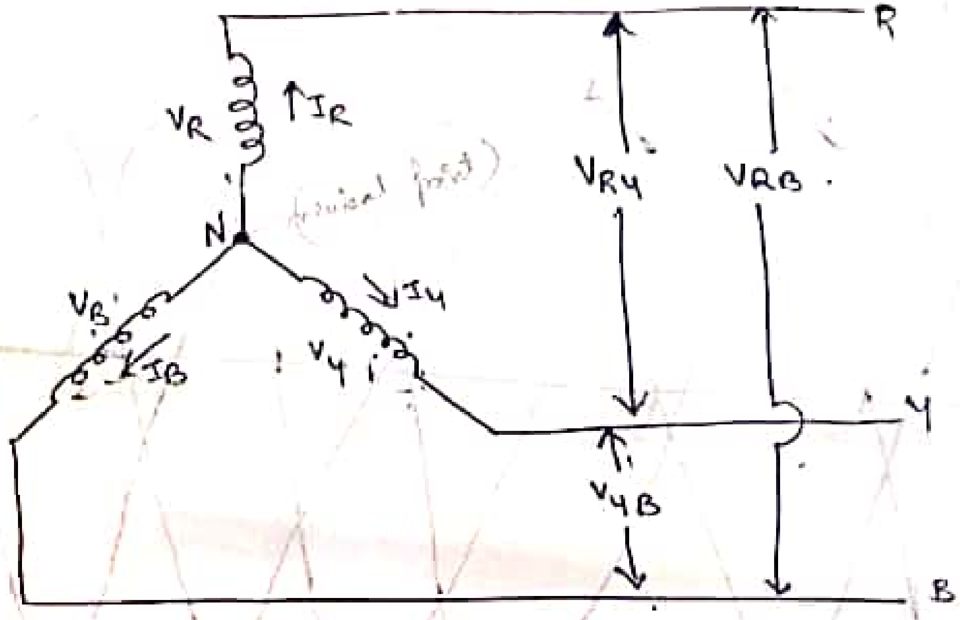
In the diagram voltage in coil R attains maximum positive value first, next in coil Y and then in coil B. Hence the phase sequence is R Y B.

Three Phase Connection.

There are mainly two types of interconnections in 3 phase system.

1) Star Connection

Star Connection:



V_{ph} – phase voltage

V_R, V_Y, V_B.

I_{ph} → phase current

I_R, I_Y, I_B.

V_L → line voltage

V_{RY}, V_{YB}, V_{RB}.

I_L → line current = phase current I_{ph}

$$\boxed{I_L = I_{ph}}$$

In this connection, similar ends (either starting or ending) of the 3 coils are connected together at a point N called neutral point.

Phase voltage V_{ph}

It is the voltage developed across each phase. They are

V_R, V_Y and V_B.

Phase Current I_{ph}.

It is the current flowing through each coil or each phase. They are I_R, I_Y, I_B.

Line Voltage V_L.

It is the voltage between any two phase lines. They are V_{RY}, V_{YB} and V_{RB}.

Line Current I_L.

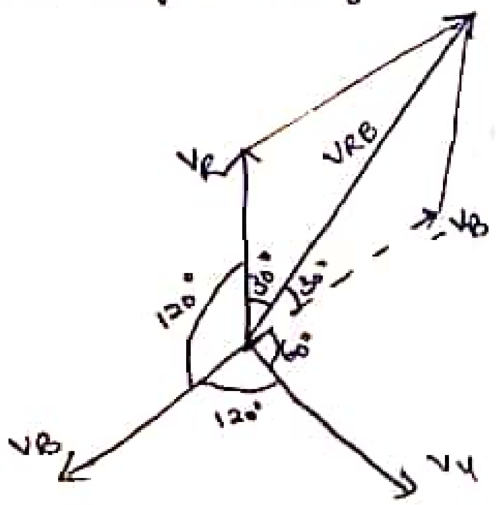
It is the current flowing through each line.

In star connected system, line current = phase current

Voltage in Star connected Circuit.

In star connected system, line voltages are V_{RY}, V_{YB}, & V_{RB} and phase voltages are V_R, V_Y and V_B

Consider the phasor diagram,



Consider the phasor diagram as shown in fig. The voltage b/w R phase and B phase is obtained by the resultant of V_R and $-V_B$. The phase angle b/w V_R and V_B is $60°$. The resultant V_{RB} can be obtained by the following expression.

parallelogram law
$R = \sqrt{a^2 + b^2 + 2ab\cos\theta}$

$$V_{RB} = \sqrt{V_R^2 + V_B^2 + 2V_RV_B\cos 60}$$

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$$= \sqrt{V_{ph}^2 + V_{ph}^2 + 2V_{ph}V_{ph}\cos 60^\circ}$$

$$= \sqrt{V_{ph}^2 + V_{ph}^2 + V_{ph}^2}$$

$$= \sqrt{3}\, V_{ph}.$$

$$\therefore \boxed{V_L = \sqrt{3}\, V_{ph}.}$$

Power in Star Connected System.

(Power in single phase is $P = VI\cos\phi$)

$\therefore$ Power $= 3\times$ single phase power

$$P = 3 \times V_{ph} I_{ph} \cos\phi$$

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

$$\boxed{P = \sqrt{3}\, V_L I_L \cos\phi}$$

Note:

* For a star connected system,

- Line voltage, $V_L = \sqrt{3}\, V_{ph}$.
- Line current, $I_L = I_{ph}$.
- Active Power, $P = \sqrt{3}\, V_L I_L \cos\phi$.
- Reactive Power, $Q = \sqrt{3}\, V_L I_L \sin\phi$.
- Apparent Power, $S = \sqrt{3}\, V_L I_L$.

1. A balanced star connected load $8+j6\,\Omega$ per phase is connected to a 3 phase 400V supply. Find the line current, powerfactor, active power, apparent power & reactive power

$\boxed{Z = R + jx}$

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Load ⇒ Impedence → $Z = 8 + j6\,\Omega$

$\therefore Z_{ph} = 8 + j6\,\Omega$

phase.

$V = 400V$

Voltage comming from supply is line voltage.

(if specified then that voltage if not then that voltage is line voltage)

$\Rightarrow V_L = 400V$.

$I_L = ?$, $\cos\phi = ?$, $P = \sqrt{3}\, V_L I_L \cos\phi$, $Q = \sqrt{3}\, V_L I_L \sin\phi$, $S = \sqrt{3}\, V_L I_L$.

In star connected system, $I_L = I_{ph}$.

$$I_{ph} = \frac{V_{ph}}{Z_{ph}}.$$

$$V_L = \sqrt{3}\, V_{ph} \Rightarrow V_{ph} = \frac{V_L}{\sqrt{3}}$$

$$= \frac{400}{\sqrt{3}}$$

$$= 230.94V.$$

$$\therefore I_{ph} = \frac{230.94}{Z_{ph}}.$$

$\boxed{\text{magnitude, } Z = \sqrt{R^2 + x^2}}$

$$\text{magnitude } Z_{ph} = \sqrt{8^2 + 6^2}$$

$$= 10.$$

[illegible] 20 → magnitude [illegible]

$$\therefore I_{ph} = \frac{230.94}{10}$$

$$= 23.094A.$$

In star connected system, $I_L = I_{ph}$

$= 23.094A$

$= \underline{\underline{23A}}$

Power factor, $\cos\phi = \frac{R}{Z}$.

$= \frac{8}{10} = \underline{\underline{0.8}}$.

[$\cos\phi$ value lies in b/w 0 & 1]

Active Power, $P = \sqrt{3} V_L I_L \cos\phi$

$= \sqrt{3} \times 400 \times 23.094 \times 0.8$

$= \underline{\underline{12799.994\ W}}$

$= \underline{\underline{12.8\ kW}}$

or $\sqrt{3} \times 400 \times 23 \times 0.8$

$= 12747.59$

$= \underline{12.8\ kW}$

Reactive Power, $Q = \sqrt{3} V_L I_L \sin\phi$

$\phi = \cos^{-1}(0.8)$

$= 36.869$

$Q = \sqrt{3} \times 400 \times 23.094 \times \sin(36.889)$

$= 9604.262\ VA_r$

$= \underline{\underline{9.6\ kVA_r}}$.

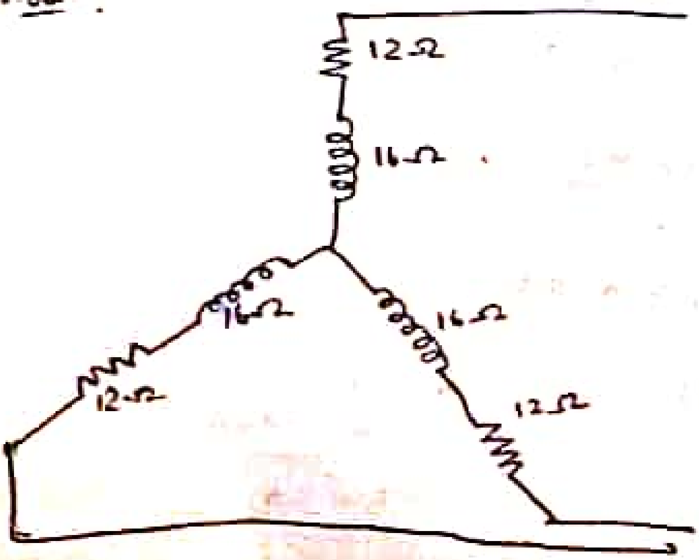
Apparent Power, $S = \sqrt{3} V_L I_L = \sqrt{3} \times 400 \times 23.094$

$= 15999.99\ VA$.

$= \underline{\underline{16\ kVA}}$

2. A star connected 3 phase load has a resistance of $12\,\Omega$ and an inductive reactance of $16\,\Omega$ in each branch. A line to line voltage of 415 V is applied across it. Find the line current, phase current, phase voltage and power factor.

Ans:



$R = 12\,\Omega$, $X_L = 16\,\Omega$

$Z_{ph} = R + jX_L = 12 + j16$.

$I_L = ?$

$I_L = I_{ph}$

$$I_{ph} = \frac{V_{ph}}{Z_{ph}}$$

$$V_{ph} = \frac{V_L}{\sqrt{3}}$$

$$= \frac{415}{\sqrt{3}} = 239.6\,V$$

$$Z_{ph} = \sqrt{12^2+16^2}$$
$$= 20$$

$$\cancel{I_{ph}}\; I_{ph} = \frac{239.6}{20}$$
$$= 11.98$$

In star connected system, $I_L = I_{ph}$

$= 11.98A$

$= 12A$

phase current, $I_{ph} = 11.98A$

(as $I_{ph} = I_L$)

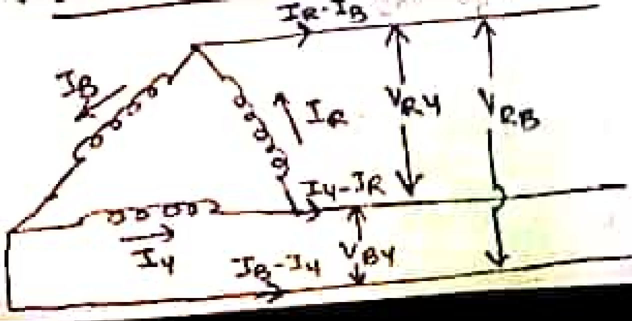
Phase voltage $V_{ph} = ?$

$\Rightarrow V_{ph} = 239.6V$

Power factor, $\cos\phi = \frac{R}{Z}$

$= \frac{12}{20} = 0.6$

3 Phase Delta Connection



$$\left.\begin{array}{l} V_{RY} = V_R \\ V_{RB} = V_B \\ V_{YB} = V_Y \end{array}\right\} \text{line voltage} = \text{phase voltage}$$

$$V_L = V_{ph}$$

In delta connection, the dissimilar ends of 3 phase windings are joined together.

Line voltage – Voltage b/w any two phase lines.

V_{RY}, V_{RB}, V_{YB}.

Phase voltage – V_{ph} – It is the voltage across each winding

V_R, V_Y, V_B.

Since, only one phase winding is connected across two lines, the line voltage V_L is equal to phase voltage V_{ph}.

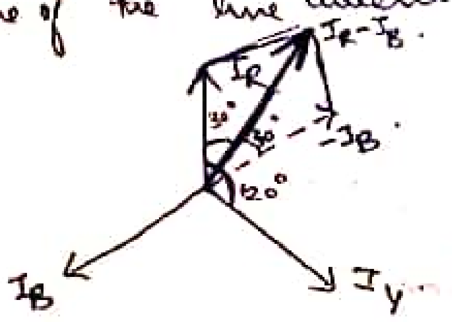
$$\boxed{V_L = V_{ph}}$$

Relation b/w phase current and line current -

Here the phase currents are I_R, I_Y, and I_B.

The line currents are $I_R - I_B$, $I_Y - I_R$ and $I_B - I_Y$.

Consider one of the line current, $I_R - I_B$ -



Parallelogram law,

$$I_R - I_B = \sqrt{I_R^2 + I_B^2 + 2 I_R I_B \cos 60^\circ}$$

$$I_L = \sqrt{I_{ph}^2 + I_{ph}^2 + 2 I_{ph} I_{ph} \tfrac{1}{2}}$$

$= \sqrt{3}\, I_{ph}^2$

$\boxed{I_L = \sqrt{3}\, I_{ph}}$

→ For delta connection,

- $V_L = V_{ph}$
- $I_L = \sqrt{3}\, I_{ph}$
- $P = \sqrt{3}\, V_L I_L \cos\phi$
- $Q = \sqrt{3}\, V_L I_L \sin\phi$
- $S = \sqrt{3}\, V_L I_L$

1. Three impedences (load) of $4+j3\,\Omega$ are connected in delta across 3phase 200V supply. Find the line current, power factor, active power.

$Z_{ph} = R + jX = 4+j3\,\Omega$. (as 3phase, in question only per phase value is given.)

Supply Voltage $= V_L = 200V$.

$I_L = \sqrt{3}\, I_{ph}$ for delta connection

$V_{ph} = V_L$
$= 200V$.

$I_{ph} = \dfrac{V_{ph}}{Z_{ph}}$
$= \dfrac{200}{\sqrt{4^2+3^2}} = \dfrac{200}{5} = \underline{\underline{40\,A.}}$

$\therefore I_L = \cancel{\sqrt{3}\times 40} \; \sqrt{3}\times 40$
$= \underline{\underline{69.282A}}$.

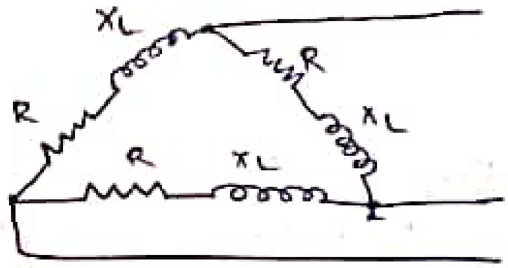
Power factor, $\cos\phi = \dfrac{R}{Z} = \dfrac{4}{\sqrt{4^2+3^2}} = \dfrac{4}{5} = \underline{\underline{0.8}}$.

active power, $P = \sqrt{3} V_L I_L \cos\phi$
$= \sqrt{3} \times 200 \times \cancel{40}\; 69.282 \times 0.8$
$= 19199.991W = \underline{\underline{19.199KW}}$

2. A 3 phase delta connected balanced load connected to 400 V supply draws 17.32 A at 0.8 lagging each phase has a resistor and an inductor connected in series. Find the resistance and reactance per phase.

In delta connection $I_L = \sqrt{3} I_{ph}$, $V_L = V_{ph}$

$V_L = 400V$, $\underset{(\text{Supply})}{I_L} = 17.32A$, $\cos\phi = 0.8$



$R = ?$, $X_L = ?$

$(Z = R + jX)$

$I_L = \sqrt{3} I_{ph}$

$I_{ph} = \frac{I_L}{\sqrt{3}} = \frac{17.32}{\sqrt{3}} = \underline{9.999} A$

$V_L = V_{ph}$

$V_{ph} = \underline{400V}$

$$\left.\begin{aligned} \cos\phi &= \frac{R}{Z} \\ \cancel{\cos\phi} &\cancel{= \frac{P}{S}} \end{aligned}\right\} \Rightarrow \cancel{\frac{R}{Z} = \frac{P}{S}}$$

$\cancel{P = \sqrt{3} V_L I_L \cos\phi}$

$\cancel{= \sqrt{3} \times 400 \times 17.32 \times 0.8}$

$\cancel{= 9599.71 W}$

$\cancel{= 9.599 kW}$

$\cancel{S = \sqrt{3} V_L I_L}$

$\cancel{= \sqrt{3} \times 400 \times 17.32}$

$\cancel{= 11999.64 VA}$

$\cancel{= 11.999 kVA}$

$\cancel{Z = \sqrt{R^2 + X_L^2}}$

$\cancel{X_L = \omega L}$

$\cancel{R = \frac{V}{I}}$ $\underline{\underline{V = IR}}$

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$$R = \frac{V_L}{I_L}$$

$$= \frac{400}{17.32}$$

$$= 23.094\,\Omega$$

$$\cancel{Z = R} \quad \cos\phi = \frac{R}{Z}$$

$$Z_{ph} = \frac{V_{ph}}{I_{ph}}$$

$$= \frac{400}{9.999}$$

$$= 40.004\,\Omega$$

$$\cos\phi = \frac{R}{Z}$$

$$R = Z\cos\phi$$

$$= 40.004 \times 0.8$$

$$= 32.0032\,\Omega$$

$$Z = \sqrt{R^2 + X_L^2}$$

$$Z^2 = R^2 + X_L^2$$

$$X_L^2 = Z^2 - R^2$$

$$X_L = \sqrt{Z^2 - R^2}$$

$$= \sqrt{40.004^2 - 32.0032^2}$$

$$= 24.0024\,\Omega$$

∴ Resistance, $R = 32.0032\,\Omega$

reactance, $X_L = 24.0024\,\Omega$

phase Power measurement