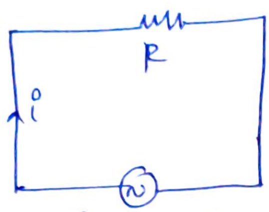
AC Fundamentals.

Form factor $= \dfrac{E_{rms}}{E_{avg}} = 1.11$

AC through pure resistor.



$v = V_m \sin \omega t$

$v = iR$

$\Rightarrow \dfrac{v}{R} = i \Rightarrow i = \dfrac{V_m \sin\omega t}{R} \Rightarrow \boxed{i = I_m \sin\omega t}$

Note: Voltage & current in ~~same~~ phase.

→ Instantaneous Power

$P_{inst} = v \cdot i$

$= V_m I_m \sin^2 \omega t$

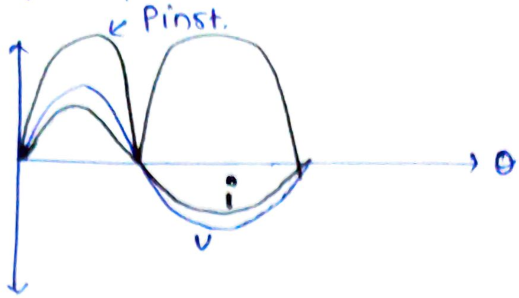
$$\boxed{P_{inst} = V_m I_m \left[\frac{1 - \cos 2\omega t}{2}\right]}$$

→ Average Power over cycle

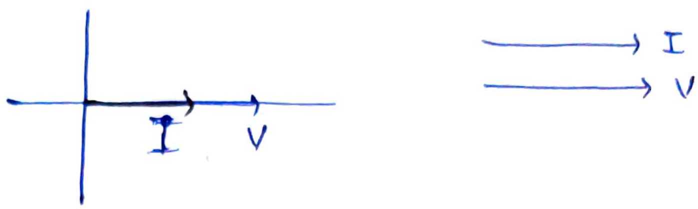
$$\Rightarrow P_{av} = \frac{\int_0^{2\pi} P_{ins}\, d\theta}{2\pi} = \frac{V_m I_m}{2\pi \times 2}\left[\theta - \frac{\sin 2\omega t}{2}\right]_0^{2\pi}$$

$$\Rightarrow P_{av} = \frac{V_m I_m}{4\pi} \times 2\pi \Rightarrow \boxed{P_{av} = \frac{V_m I_m}{2}} = \boxed{VI}$$ ← RMS values.

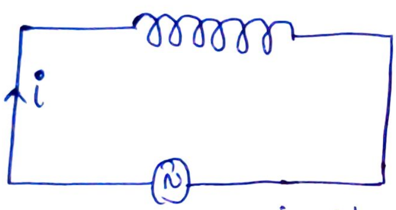
⇒ in wave form



⇒ Phasor diagram.



⇒ AC through pure inductor.



$v = V_m \sin\omega t$

Now, $v = L\frac{di}{dt}$

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

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

$\boxed{X_L = \omega L}$ ← inductive Reactance.

⇒ $i = \cancel{V_m} - I_m \sin(\pi/2 - \omega t)$

⇒ $\boxed{i = I_m \sin(\omega t - \pi/2)}$

→ Current legs the voltage by $\pi/2$.

→ instantaneous power

$$P_{inst.} = v \cdot i$$

$$= -V_m I_m \sin\omega t \cdot \cos\omega t$$

$$\boxed{P_{inst.} = -\frac{V_m I_m}{2} \sin 2\omega t}$$

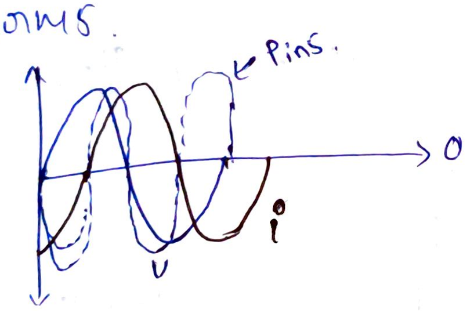
→ Average value of power:

$$P_{avg} = \frac{1}{2\pi} \int_0^{2\pi} P_{inst.} \, d\theta$$

$$= \frac{-V_m I_M}{2\pi \times 2} \int_0^{2\pi} \sin 2\omega t \, d\theta = 0$$

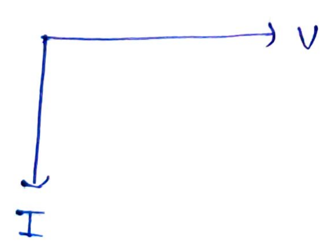
⇒ P_{avg} consume by purely inductive circuit is always zero.

→ Wave forms.

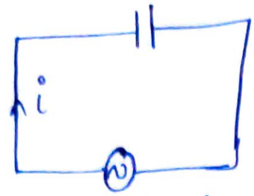


→ Frequancy of fluctuation of power is twice the frequancy of voltage or current.

→ phasor diagram



⇒ AC through pure capacitor



$v = V_m \sin\omega t$

Now, $q = Cv$

$\Rightarrow q = CV_m \sin\omega t$

$\Rightarrow \frac{dq}{dt} = i = CV_m \frac{d \sin\omega t}{dt} = \omega C V_m \cos\omega t$

$\Rightarrow i = \frac{V_m}{(1/\omega C)} \cancel{\cos}\sin(\omega t + \pi/2)$

$\Rightarrow i = \frac{V_m}{X_C} \sin(\omega t + \pi/2) = I_m \sin(\omega t + \pi/2)$ $\left[\because X_C = \frac{1}{\omega C}\right.$

↑ capacitive reactance.

⇒ Current leads the voltage by $\pi/2$.

→ instantaneous power

$P_{ins.} = v.i$

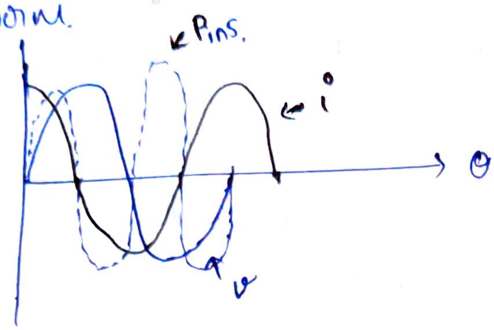
$= V_m I_M \sin\omega t . \sin(\omega t + \pi/2)$

$= \frac{V_m I_M}{2} \sin 2\omega t$

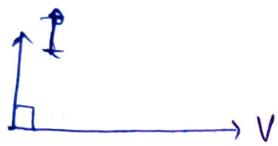
→ Average power over a cycle

$P_{avg.} = \frac{1}{2\pi}\int_0^{2\pi} P_{in}. d\theta = 0$

- The average power consumed by pure capacitor is always zero.
- frequency of fluctuation of power is twice the freq. of voltage or current.
- Wave form.

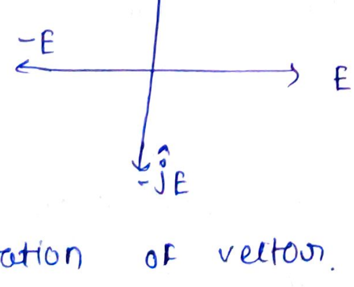


- Phasor diagram.



⇒ complex representation.

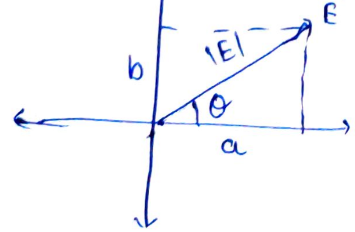
- operator '$\hat{j}$'
- if any quantity is multiplied by ($\hat{j}$) → Rotation by $\pi/2$ in anti-clockwise way.



Representation of vector.

Polar form

→

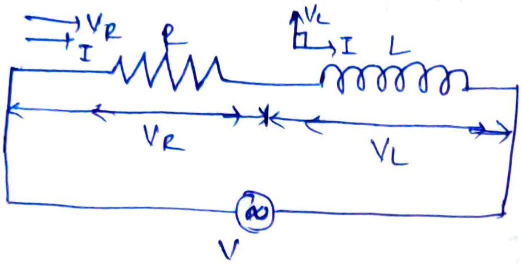


Rectangular form

$$\boxed{\begin{aligned} \vec{E} &= a + \hat{j}b \\ &= |E|\cos\theta + \hat{j}\,|E|\sin\theta \\ &= |E|\,(\cos\theta + \hat{j}\sin\theta) \\ &= |E|\,e^{j\theta} = |E| \angle\theta \end{aligned}}$$

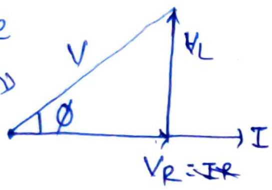
⇒ some circuits. (series circuits.

① series R-L circuit.



V = rms value of applied voltage.
I = rms value of current
$V_R = IR$, $V_L = IX_L$

Voltage Δ ⇒



→ From this we get
$V^2 = V_L^2 + V_R^2$

$\Rightarrow\ V^2 = I^2 X_L^2 + I^2 R^2$

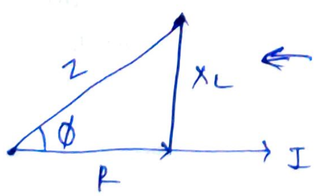
$\Rightarrow\ V^2 = I^2 (X_L^2 + R^2)$

$\Rightarrow\ V^2 = I^2 Z^2$ (∵ Z = impedance of the circuit.

$\Rightarrow$ $\boxed{Z = \sqrt{R^2 + X_L^2} \quad \& \tan\phi = \frac{V_L}{V_R}}$

(when ϕ is phase diff. b/w V_0 & I).

→ From above we can say current lags the voltage by angle ϕ.



← impedance triangle

& therefore ϕ can be $\tan^{-1} \frac{X_L}{X_R}$

∴ $\boxed{\tan\phi = \frac{X_L}{X_R}}$

Now, if $v = V_m \sin\omega t$

$i = I_m \sin(\omega t - \phi)$

where $I_m = \frac{V_m}{Z}$

→ Instantaneous power

$P_{in} = v.i = V_m I_m \sin\omega t \cancel{\omega} \sin(\omega t - \phi)$

$$\boxed{P_{in} = \frac{V_m I_m}{2}\left[\cos\phi - \cos(2\omega t - \phi)\right]}$$

→ Average value of power over cycle.

$$P_{av} = \frac{1}{2\pi}\int_0^{2\pi} P_{in}\, d\theta$$

$$= \frac{1}{2\pi}\left[\int_0^{2\pi} \frac{V_m I_M}{2}\cos\phi - \int_0^{2\pi} \cancel{\cos} \frac{V_M I_M}{2}\cos(2\omega t - \phi)\, d\theta\right.$$

$$= \frac{V_m I_m}{(2\pi)(2)}\left[\cos\phi\, [\theta]_0^{2\pi} + [\sin(2\omega t - \phi)]_0^{2\pi}\right]$$

$$= \frac{V_m I_m}{2(2\pi)}\left(\cos\phi\,(2\pi - 0) + 0\right)$$

$$\Rightarrow \boxed{P_{av} = \frac{V_m I_m}{2}\cos\phi}$$

$$\Rightarrow \boxed{P_{av} = VI\cos\phi}$$

[∵ V = rms value of V_m
I = rms value of I_m.

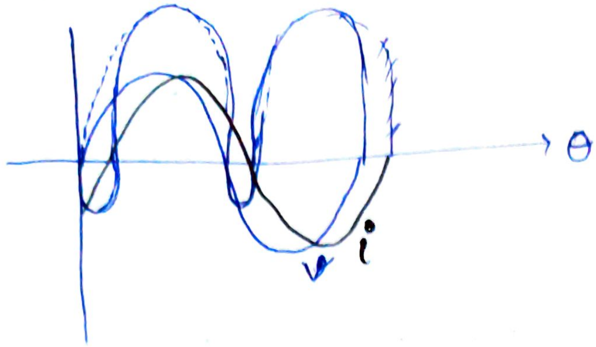
Also, $P_{av} = \cancel{\phi} IZ\, I\, R/Z$

$\Rightarrow P_{av} = I^2 R$

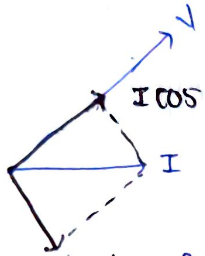
$\cos\phi$ is known as power factor of circuit & also we know that

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

→ Wave form



→ Pharor & Ressolution of current in components



$\therefore P = P_{active} = VI\cos\phi = I^2R$ (watt) (active power)

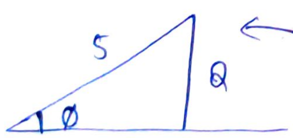
& $Q = P_{reactive} = VI\sin\phi = I^2X_L$ (~~watt~~ VAR) (Reactive power)

↑ Reactive volt ampere.

$P = VI$

$S = P = I^2Z$ (VA) (Apparant power)

↑ volt ampere.



← Power triangle.

→ Example!

① $R = 200\ \Omega$ ② $L = 638$ mH

$e = 200\sin 100\pi t$

Find expression of current, power factor & power

we have $\omega = 100\pi$

$\therefore X_L = \omega L = 200.433$

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

$= \sqrt{(200)^2 + (200.49)^2}$

$= 283.15\ \Omega$

$\theta = \tan^{-1}\frac{X_L}{R}$

$= 45.06^\circ$

$= 45^\circ$

$\therefore \boxed{I = \frac{200}{\sqrt{2}\,(283.15)} = 0.5\ A}$

$i = I_m \sin(\omega t - \phi) \doteq 0.707 \sin(100\pi t - \pi/4)$

$\cos\phi = \cos 45^\circ = 0.707$ (lag)

$\boxed{P_{active} = 50\ \text{watt}}$

=) in complex form

$I = V/Z = \frac{200}{\sqrt{2}} \angle 0$

But $Z = R + jX_L = 283.15$

All other are same.

(2). $v(t) = 141.4 \sin(314t + 10^\circ)$

$i(t) = 14.14 \sin(314t - 20^\circ)$

Find pf, power and elemen values.

$\boxed{\cos\phi = pf = \cos(10 - (-20)) = \cos 30 = 0.866 \text{ (lag)}}$

$\boxed{P = VI\cos\phi = 865.7 \text{ watts}}$

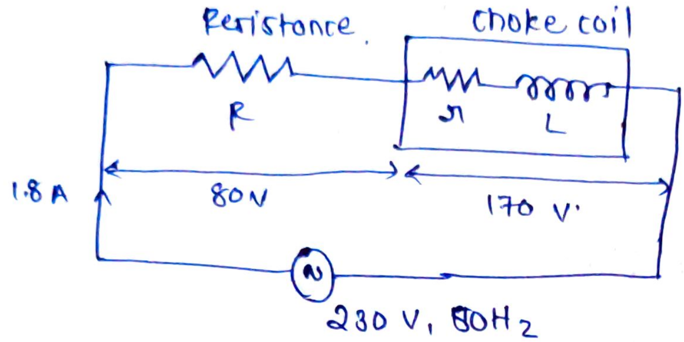
$\boxed{Z = \frac{V_m}{I_m} = 10}$

Also $R = Z\cos\phi = 10 \times 0.866 = 8.66\ \Omega$

$X_L = Z\sin\phi = 10 \times 0.5 = 5\ \Omega$

=) $5 = 314 \times L$

③ A pure resistance is connected in series with a choke coil across 230 volt, 50Hz. supply. the current passing through circuit is 1.8 A & voltage across the Resistance & choke coil are 80 volt & 170 volt respectively. Calculate the resistance & inductance of the choke coil. & also determine power consumed by circuit.



$\Rightarrow$ $R = \frac{V_R}{I} = \frac{80}{1.8} = 44.44\,\Omega$

→ impedance of choke coil.

$Z = \frac{V_{choke}}{I} = \frac{170}{1.8} = \cancel{44}\ 94.44\,\Omega = \sqrt{r^2 + X_L^2}$

$\Rightarrow (94.44)^2 = r^2 + X_L^2$ — ①

→ Total impedance of circuit.

$Z = \frac{V}{I} = \frac{230}{1.8} = 127.77\,\Omega$

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

$z_1 = R + j0$, $\quad z_2 = r + jX_L$ $\quad \Rightarrow Z = (R+r) + jX_L$

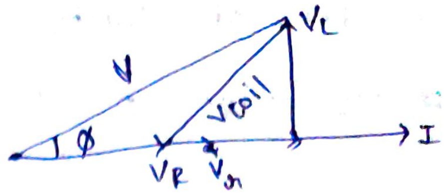
$\Rightarrow \cancel{Z}\ (127.77)^2 = (44.44)^2 + 88.88\,r + r^2 + X_L^2$

$\Rightarrow (127.77)^2 = (44.44)^2 + 88.88\,r + (94.44)^2$

$r = 61.1\,\Omega$, $X_L = 72$, $L = 229$ mH.

overall power factor

$\cos\phi = \dfrac{R+r}{Z} = 0.826$ (lag)

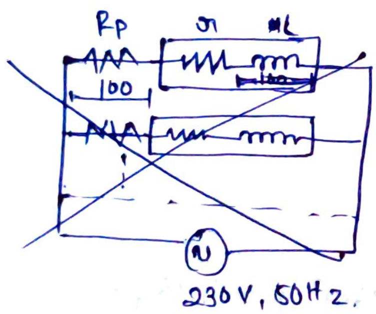


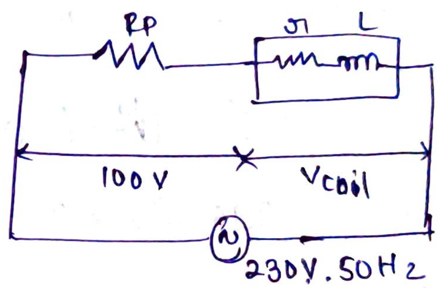
Now, $P = VI\cos\phi$

$\Rightarrow P = 230 \times 1.8 \times 0.826$

$= 342$ Watt.

(4). It is desired to run a bank of ~~10 watt-lang~~ ~~hundor~~ Ten 100 watt, 100 volt lamps in parallal from a 230 V, 50 Hz supply by insulting a choke coil in series with the bank of lamps. if choke boil has a power factor of 0.2) find Resistance & inductance of choke coil.





✗ we have $\cos\phi = 0.2$ $\boxed{\text{wrong Answer}}$

$V = 230$, $V_L = 100$ $\Rightarrow V_R = \sqrt{(230)^2 - (100)^2} = 207.12$.

~~100~~ $P = VI\cos\phi$

$\Rightarrow 100 = 230 \times I \times 0.2$ $\Rightarrow I = 50/23$ A.

$\therefore$ $\boxed{r = \dfrac{V_R}{I} = 95.27\,\Omega}$ $X_L = 46$ ✗

Now $46 = 2\pi \times 50 \times L$

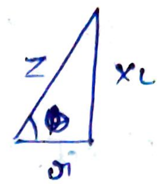
$\Rightarrow L =$

R_p = Req. of Bulbs

$\cancel{P = VI\cos\phi}$ $\quad P = \frac{V_R^2}{R}$

$\Rightarrow R = \frac{(100)^2}{100} \Rightarrow \boxed{R = 100\,\Omega}$ → Resistance of single lamp.

$\therefore \boxed{R_p = 10\,\Omega}$



$\therefore \cos\theta = 0.2 = \frac{r}{Z_{coil}}$

$\Rightarrow r^2 = 0.04\,(r^2 + X_L^2)$ $\quad (I = 10A)$

$Z_{circuit} = \frac{V}{I} = \frac{230}{10} = 23$

$(23)^2 = (\overset{10}{R} + r)^2 + (X_L)^2$

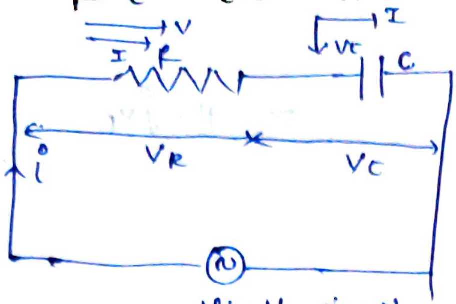
$\Rightarrow 3.96\, r^2 = X_L^2$

$\Rightarrow 529 = 100 + 20r + \cancel{r^2\ 4.96r^2}\ r^2 + \frac{3.96}{0.04} r^2$

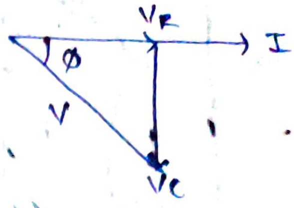
$\Rightarrow r = 3.76\,\Omega$

$X_L = 18.38\,\Omega$.

⇒ Series R-C circuit.



$v = V_m \sin\omega t$



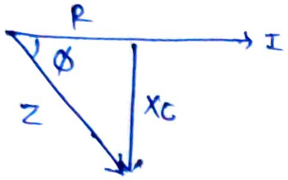
$V^2 = V_R^2 + V_C^2$

$\Rightarrow V^2 = I^2(R^2 + X_C^2)$

$\Rightarrow V^2 = I^2 Z^2$

$\Rightarrow \therefore Z = \sqrt{R^2 + X_C^2}$

↑ impedence of circuit



$\Rightarrow \boxed{\phi = \tan^{-1} \frac{X_C}{R}}$

→ current leads the applied voltage by angle ϕ.

→ if $v(t) = V_m \sin\omega t$

then $i(t) = I_m \sin(\omega t + \phi)$ where $I_m = \frac{V_m}{Z}$

→ $P_{instantaneous} = v(t) \cdot i(t)$

$= \frac{V_m I_m}{2} 2\sin\omega t \sin(\omega t + \phi)$

$$\boxed{P_{in} = V \cdot I\,[\cos\phi - \cos(2\omega t + \phi)]}$$

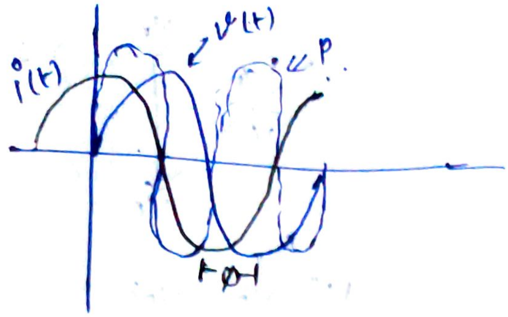
→ Average value of power over a cycle.

$P_{av} = \frac{1}{2\pi}\int_0^{2\pi} P_{in}\,d\theta \Rightarrow P_{av} = \frac{1}{2\pi} VI \int_0^{2\pi} \cos\phi - \cos(2\omega t + \phi)\, d\theta$

$\Rightarrow P_{av} = \frac{VI}{\cancel{2\pi}} \times \cancel{2\pi} \times \cos\phi$

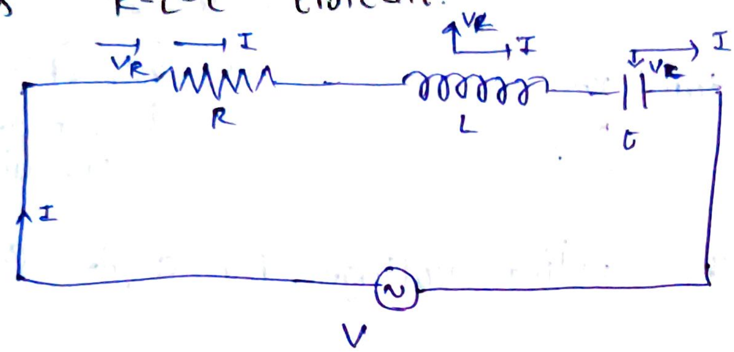
$\Rightarrow \boxed{P_{av} = VI\cos\phi}$

→ Waveform



$Z = R - \hat{j} X_C$

* Series R-L-C circuit.

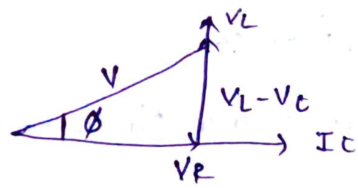


Three possibilities

① $X_L > X_C$ ② $X_L < X_C$ ③ $X_L = X_C$

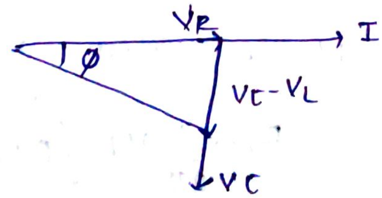
Now, for

① $X_L > X_C$



$V = \sqrt{V_R^2 + (V_L - V_C)^2}$

② $X_L < X_C$



Now, for both ① & ②.

$$V_\phi^2 = V_R^2 + (V_L - V_C)^2$$

$$\Rightarrow V^2 = I^2 \left[R^2 + (X_L - X_C)^2\right]$$

$$\Rightarrow V = IZ$$

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

Also, $Z = R + \hat{j}(X_L - X_C)$

$\Rightarrow$ phase angle

$$\phi = \tan^{-1} \frac{X_L - X_C}{R}$$

$\Rightarrow v = V_m \sin(\omega t)$

$\Rightarrow i = I_m \sin(\omega t \pm \phi)$

$\Rightarrow I_m = \frac{V_m}{Z}$

Now, +ve sign if $X_L > X_C$

-ve sign if $X_C > X_L$

Now instantaneous power.

$$P_{ins} = v.i = \frac{V_m I_m}{2} . 2 \sin \omega t \, \sin(\omega t \pm \phi)$$

$$\Rightarrow \boxed{P_{ins} = \frac{V_m I_m}{2}\left[\cos\phi - \cos(\omega t \pm \phi)\right]}$$

Now. Average power over a cycle.

$$P_{avg.} = \int_0^{2\pi} \frac{P_{in} \, d\theta}{2\pi}$$

$$\Rightarrow P_{avg} = \frac{V_m I_m}{2} \cos\phi$$

$$\Rightarrow \boxed{P_{avg} = VI \cos\phi}$$

Now in vector form.

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

$$\Rightarrow I = \frac{V \angle \phi}{|Z| \angle \pm \phi}$$

$$\Rightarrow I = \frac{V}{|Z|} \angle \mp \phi$$

(3) $X_L = X_C$
- It becomes purely resistive.
- Resonance condition.

Now $X_L = X_C$

$$\Rightarrow \omega L = \frac{1}{\omega C}$$

$$\Rightarrow \omega_r^2 = \frac{1}{LC}$$

$$\Rightarrow \boxed{\omega_r = \frac{1}{\sqrt{LC}} \text{ Rad/s}} \Rightarrow \boxed{f_r = \frac{1}{2\pi\sqrt{LC}} \text{ Hz}}$$

1. voltage & current are in phase
2. P.F. $\cos\phi = 1$ or $\phi = 0$.
3. The impedence is minimum.
4. Current is maximum.
5. Voltage across L or C is more than the supply voltage. (voltage magnification).

- This voltage magnification is equal to quality factor of the circuit.

$$Q\text{-factor} = \frac{V_L}{V} = \frac{X_L}{R} = \frac{\omega_r L}{R} = \frac{1}{R}\sqrt{\frac{L}{C}}$$

Now, $V_L = QV$ & Q is always greater than 1.

A150.

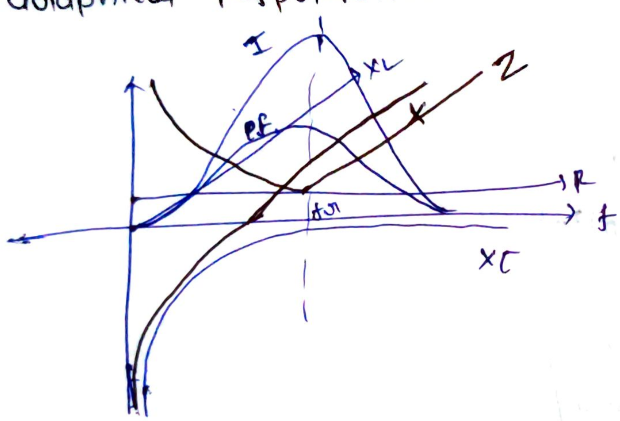
$$Q\text{-factor} = 2\pi \frac{\text{Max. stored energy}}{\text{Energy dissipate per cycle}}$$

$$= 2\pi \times \frac{\frac{1}{2} I_m^2 L}{\left(\frac{I_m}{\sqrt{2}}\right)^2 . R\left(\frac{1}{f}\right)}$$

$$\Rightarrow = \frac{2\pi \times L \times f}{R} = \frac{\omega_r L}{R} = \frac{1}{R}\sqrt{\frac{L}{C}}$$

$\Rightarrow$ variation of parameters with frequancy.

$\rightarrow$ Graphical Repreresentation of Resonance.



① Resistance independent of F.

② $X_L = 2\pi f L$

$\Rightarrow X_L \propto f$

③ $X_C = \frac{1}{2\pi f C}$

$\Rightarrow X_C \propto \frac{1}{f}$

Rectangular hyperbolic.

④. Net Reactance $X = X_L - X_C$.

⑤ impedence $Z = \sqrt{R^2 + X^2}$

⑥ current $I = \frac{V}{Z}$

⑦ Power

⇒ Numericals

① A Resistor & capacitor are connected in series across 150 V AC supply. the current taken by circuit is 6 amp. when frequency of supply is 50 Hz. current reduced to 5 A. when frequency of supply is 40 Hz. Determine value of R & C.

$$Z_1 = \frac{150}{6} = 25 \quad \Rightarrow \quad 625 = R^2 + \cancel{4\pi^2} \frac{1}{\cancel{4\pi^2}(100\pi)^2 C^2} \quad -①$$

$$Z_2 = \frac{150}{5} = 30 \quad \Rightarrow \quad 900 = R^2 + \frac{1}{(80\pi)^2 C^2} \quad -②$$

By ① & ② we get.

$$900 = 625 - \frac{1}{(100\pi)^2 C^2} + \frac{1}{(80\pi)^2 C^2}$$

$$\Rightarrow 275 = \frac{1}{\pi^2 C^2}\left[\frac{1}{6400} - \frac{1}{10000}\right]$$

$$\Rightarrow C^2 = \frac{1}{275\pi^2}\left[\left(\frac{1}{80}\right)^2 - \left(\frac{1}{100}\right)^2\right]$$

$$\Rightarrow C^2 = \frac{1}{\pi^2 275}\left[\left(\frac{1}{80}+\frac{1}{100}\right)\left(\frac{1}{80}-\frac{1}{100}\right)\right]$$

$$\Rightarrow C^2 = \cancel{\frac{1}{\pi^2 275\, 8}} \quad \Rightarrow C = 1.43 \times 10^{-4}\ F$$

$$\Rightarrow \boxed{C = 143\ \mu F}$$

By putting value in ① we get

$$\boxed{R = 11.64\ \Omega}$$

(2) voltage $v = 100 \sin(314t)$ is applied to a circuit consisting of $25\,\Omega$ Resistor & $80\,\mu F$ capacitor in series. Determine

i) An expression for current flowing at any instant.
ii) Power consume.
iii) Potential difference across capacitor at the instant when current is $\frac{I_M}{2}$ of it

Solution: $\omega = 314$

$$\therefore \quad Z = \sqrt{625 + \left(\frac{1}{314 \times 80 \times 10^{-6}}\right)^2}$$

$$\Rightarrow Z = 47\,\Omega.$$

Now, $\phi = \tan^{-1}\frac{X_C}{R} \Rightarrow \phi = \cancel{\tan^{-1}} \tan^{-1}\frac{39.8}{25} = \angle 57.8°$

$$\therefore \quad i = \frac{V_M}{Z}\sin(\overset{314}{\cancel{100}}t + 57.8°)$$

$$\Rightarrow \quad i = 2.127 \sin(314t + 57.8°)$$

$$\Rightarrow \quad i = 2.127 \sin(314t + 1)$$

Now $P = I^2R = \frac{(2.127)^2}{2} \times 25 = 56.5$.

Now, $V_C = iX_C$

$$\Rightarrow \quad V_C = 2.127(39.8)\sin(314t + 1 - \pi/2)$$

$$\Rightarrow \quad V_C = 84.65 \sin(314t + 1 - \pi/2)$$

Now at $I = \frac{I_M}{2}$

$$\Rightarrow \quad \frac{1}{2} = \sin(314t + 1) \quad \Rightarrow \quad 314t + 1 = 5\pi/6$$

$$\Rightarrow \quad \boxed{V_C = 73.5\ V}$$

(3) A circuit takes current of 3 A and power factor of 0.6 lagging when connected to 175 V, 50 Hz supply. another circuit takes current of 5 A at PF 0.707 leading when connected to same supply. if the two circuits are now connected in series across 230 V, 50 Hz supply calculate. I, P & PF.

CKS 1

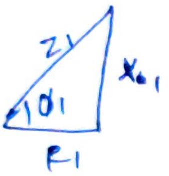
$V_1 = 175\,V$

$\nu = 50\,Hz$

$I_1 = 3\,A$.

$\cos\phi_1 = 0.6$ (lag)

$Z_1 = \frac{V_1}{I_1} = \frac{175}{3} = 58.33\,\Omega$



$\Rightarrow R_1 = 35\,\Omega$

$X_1 = 46.66\,\Omega$

$\Rightarrow Z_1 = 35 + \hat{j}\,46.66\,\Omega$

CKS 2

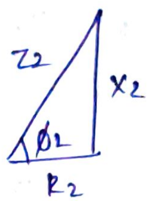
$V_2 = 175\,V$

$f_2 = 50\,Hz$

$I_2 = 5\,A$

$\cos\phi_2 = 0.707$ (lead)

$Z_2 = \frac{175}{5} = 35\,\Omega$



$\Rightarrow R_2 = 24.745$

$X_2 = 24.745$

$\Rightarrow Z_2 = 24.745 - \hat{j}\,24.745$

case (3).

$V = 230\,V$.

NOW, $Z = Z_1 + Z_2$

$\Rightarrow Z = 59.745 + \hat{j}\,21.915$

$\Rightarrow Z = 63.64\,\angle 20.14\,\phi$

PF $\cos\phi = 0.988$ (lag)

$I = \frac{230}{63.64} = 3.62\,\angle -20.14$.

$P = (3.62)^2 \times 59.745$

$\Rightarrow P = 783$ Watt.

(4) A Resistance of 24 Ω, capacitance of 150 uf & inductance of 0.16 H are connected in series with each other to supply of 240V, 50Hz. calculate current in circuit potential diff. across each. frequency to which the supply would be connected so that current would be at unity power factor & find current at this frequency.

we have

$R = 24\,\Omega$ $C = 150\ \mu F$ $L = 0.16\ H$

$V = 240\ V$ $f = 50\ Hz$.

$X_L = 50.26\ \Omega$

$X_C = 21.22\ \Omega$

$\therefore$ $Z = \sqrt{576 + (29.04)^2} = 37.67\ \Omega \angle 50.43$

Now. $I = \frac{V}{Z} = \frac{240 \angle 0}{37.67 \angle 50.43} = 6.37 \angle -50.43$

Now, $V_R = 152.88\ V$ $V_L = 320.15\ V$ $V_C = 135.17\ V$

$f_r = \frac{1}{2\pi\sqrt{LC}} = \cancel{4.87 \times 10^{-3}\ Hz}$ 32.5 Hz.

& $I_r = \frac{240}{24} = 10\ A$. Now. $Q = \frac{V_L}{V} = 2.09$

(5) A Resistance, a capacitor and a variable inductance are connected in series across 200 V, 50 Hz supply. the maximum current which can be obtain by varying the L is 314 mA. & voltage across capacitor is 300 V, calculate the elements well.

$R = ?$ $C = ?$ $L = ?$

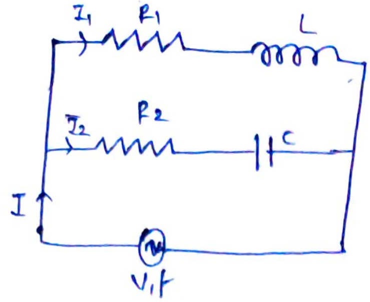
$V_C = 300$ $A = 314 \times 10^{-3}\ A$. $f = 50\ Hz$

$R = \frac{V}{A} = \frac{200}{314 \times 10^{-3}} = \cancel{6 \times 10^{2}\ \Omega}$ 636.94 Ω

$X_C = \frac{V_C}{I} = \frac{300}{0.314} = 955.41\ \Omega \Rightarrow C = 3.33\ \mu F$

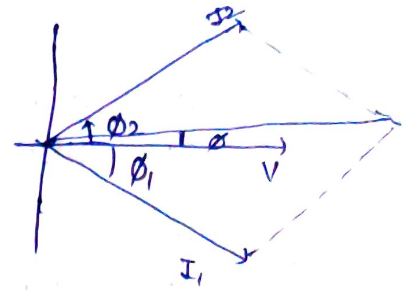
$X_L = X_C \Rightarrow L = 3.04\ H$.

⇒ Parallel circuits.



$Z_1 = R_1 + \hat{j}X_L = |Z_1| \angle \phi_1 = \sqrt{R_1^2 + X_L^2} \angle \tan^{-1}\frac{X_L}{R}$

$Z_2 = R_2 - \hat{j}X_L = |Z_2| \angle \phi_2 = \sqrt{R_2^2 + X_C^2} \angle \tan^{-1}\frac{X_C}{R_2}$



Now, $I_1 = \dfrac{V\angle 0}{Z_1 \angle \phi_1} = |I_1| \angle -\phi_1$

$I_2 = \dfrac{V\angle 0}{Z_2 \angle -\phi_2} = |I_2| \angle \phi_2$

$I = I_1 + I_2$

$\Rightarrow I = a_1 - \hat{j}b_1 + a_2 + \hat{j}b_2$

$\Rightarrow I = (a_1 + a_2) + (b_2 - b_1)\hat{j}$

$I = \dfrac{V}{Z_1} + \dfrac{V}{Z_2} \Rightarrow \dfrac{V}{Z} = V\left(\dfrac{1}{Z_1} + \dfrac{1}{Z_2}\right) \Rightarrow \dfrac{1}{Z} = \dfrac{Z_2 + Z_1}{Z_1 Z_2}$

$\Rightarrow \boxed{Z = \dfrac{Z_1 Z_2}{Z_1 + Z_2}}$ $\boxed{\dfrac{V}{Z} = V.Y}$ ← Admittance

$Y = \dfrac{1}{Z}$ mho.

$\boxed{Y = G \pm \hat{j}B}$ ← suceptance

↑ couductance

↳ B_L → inductive

↳ B_C → capacitive.

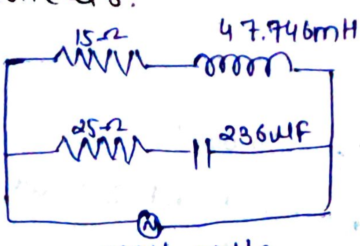
let $Y_1 = \dfrac{1}{Z_1} = \dfrac{1}{R_1 + \hat{j}X_L} = \dfrac{R_1 - \hat{j}X_L}{R_1^2 + X_L^2}$

$Y_1 = g_L - \hat{j}b_L$

simillarly. $Y_2 = \dfrac{R_2 + \hat{j}X_C}{R_2^2 + X_C^2} = g_C + \hat{j}b_C$

⇒ Numericals.

1)



Find I, P.F & Power.

$X_L = 2\pi f L = 15\,\Omega$

$X_C = \frac{1}{2\pi f C} = 13.48\,\Omega = 13.5\,\Omega$

$Z_1 = 15 + \hat{j}\,15 = 21.21 \angle 45^\circ$

$Z_2 = 25 + \hat{j}\,13.5 = 28.40 \angle -28.33$

Now, $I_1 = \frac{V}{Z_1} = \frac{200 \angle 0}{21.21 \angle 45} = 9.42 \angle -45^\circ = 6.67 - j6.67$

$I_2 = \frac{V}{Z_2} = \frac{200}{28.4} \angle 28.33 = 7.04 \angle 28.33 = 6.19 + \hat{j}\,3.34$

Now, $I = I_1 + I_2 = 12.86 - \hat{j}\,3.33$

$\therefore\ I = 13.28 \angle 14.5$.

Now, PF is $\cos 14.5^\circ = 0.96$ (lag)

Power $= VI\cos\phi$

$= 200 \times 13.28 \times 0.96$

$= 2549.76$ W

2) It is desired to raise the power factor of circuit to unity by connecting a capacitor in parallel to circuit. determine the value of capacitance.

$I = I_1 + I_2 + I_C$

$\Rightarrow I = 12.86 - \hat{j}\,3.33 + \frac{200}{-\hat{j}\,X_C}$

P.F = 1

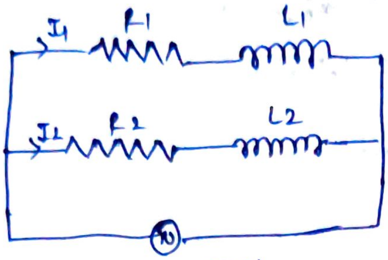
$\Rightarrow$ imaginary part of $I = 0$

$\Rightarrow -3.33 + \frac{200}{X_C} = 0 \Rightarrow X_C = 60.06\,\Omega$

$\Rightarrow \frac{\cancel{200}^2}{\cancel{3.33}} = \cancel{2\pi \times 50} \times C \Rightarrow C = \cancel{0.197}$

$C = 52.9\ \mu F \approx 53\ \mu F$.

(3) A choke coil takes a current of 10 A. & dessipates 1410 watt when connected to a 200 V, 50 Hz supply. when another coil is connected in parallel with it, the total current taken from supply is 20 A. at a p.f of 0.866 Determine the current and overall p.f. when the coils are connected in series across same supply.



200 V, 50 Hz.

Now, $I_1 = 10$ A. $\cancel{\cos\phi_1 =}$ $P_1 = 1410$ W

$I = 20$ A $\cos\phi = 0.866$

Now, $P_1 = VI\cos\phi_1$

$\Rightarrow \cos\phi_1 = \dfrac{1410}{10 \times 200} = 0.705$ — (1)

$\cancel{Z_1 = R_1 + \hat{j}X_{L1}}$

& $P_1 = 100 \times R_1 \Rightarrow R_1 = 14.1\ \Omega$ — (2)

Now, $\cos\phi_1 = \dfrac{R_1}{Z_1} \Rightarrow Z_1 = \dfrac{R_1}{\cos\phi_1} \Rightarrow Z_1 = 20\ \Omega$ — (3)

$\therefore Z_1 = \cancel{14.99}\ 14.10 + \hat{j}\ \cancel{0.246}\ 14.18 \Rightarrow X_{L1} = \cancel{0.246}\ 14.18\ \Omega$

$\Rightarrow L_1 = \dfrac{\cancel{0.246}\ 14.18}{100\pi} = \cancel{783\ \mu H}\ 45$ mH — (4)

$I_1 = 10\angle -45.17° = 7.05 - \hat{j}7.09$

$I = 20\angle -30°.00 = 17.32 - \hat{j}\,10$

$I - I_1 = I_2 = 10.27 - \hat{j}\,2.91 = 10.67\angle -15°.8$

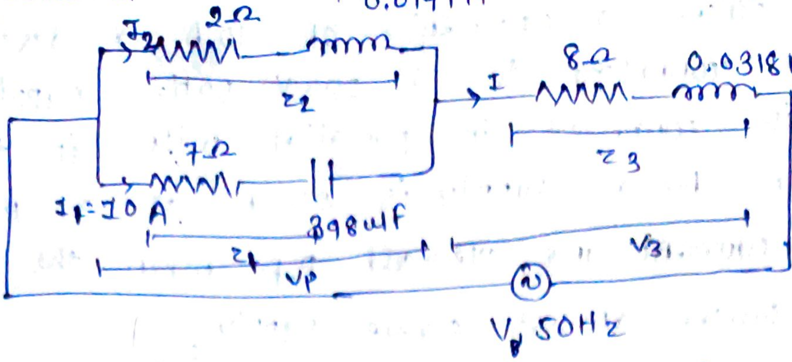
$Z_2 = \dfrac{200}{10.67\angle 15°.8} = 18.74\angle +15°.8 = 18.03 + \hat{j}\,5.10$ — (5)

$Z = 32.13 + \hat{j}19.28 = \cancel{37.39}\ 47 \angle \cancel{15.7}\ 30.96°$ — (6)

$\boxed{I = V/Z\angle\phi = \cancel{5.98}\ 5.33\angle \cancel{-15.7}\ -30.96°\ A}$

$\boxed{P.f = 0.86\ (\text{lag})}$

→ series parallel circuit



V = ? $Z_1 = 7 - j8 = 10.63 \angle -48.81 \ \Omega$

$Z_2 = 2 + \hat{j}\, \cancel{1.9}\, 5.99 = 6.32 \angle 71.56 \ \Omega$

$Z_3 = 8 + \hat{j}\, 9.98 = 128 \angle 51.34 \ \Omega$

Now, $Z = \dfrac{Z_1 Z_2}{Z_1 + Z_2} + Z_3$

let I_1 is reference. ∴ $I_1 = 10 \angle 0$ A.

Now, $V_p = I_1 Z_1 = 10\angle 0 \, . \, 10.63 \angle -48.81$

$\boxed{V_p = 106.3 \angle -48.81}$ —— ①

Now, $I_2 = \dfrac{106.3 \angle -48.81}{6.32 \angle 71.56} = 16.81 \angle -120.37 = -8.5 - \hat{j}\, 14.5$

Now, $I = I_1 + I_2$

$= \cancel{16.5}\ 1.5 - \hat{j}\, 14.5 = \cancel{23.5}\ 14.58 \angle \cancel{-38.09}\ 84.09$

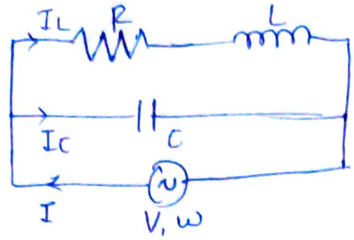
∴ $\cancel{V_3 = \dfrac{23.5 \angle -38.09}{128 \angle 51.34}}$ $\cancel{128 \angle 51.34} = \cancel{30082}$

$\cancel{V_3} =$ $V_3 = 14.58 \angle -38.09 \, . \, 128 \angle 51.34$

$= 186.624 \angle 13.25$

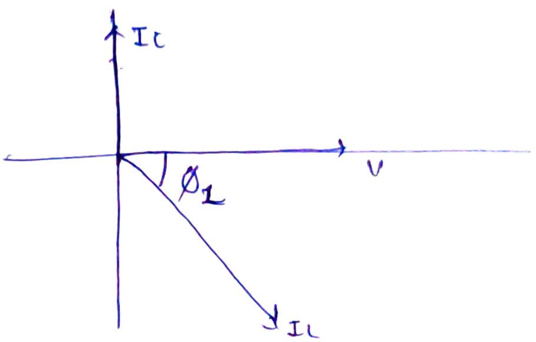
(8) Resonance in parallel circuit.

① R-L parallel with C.



This circuit is under resonance when reactive component of total current is zero.

$I_{react} = [I_C - I_L \sin\phi_L)$



$\Rightarrow I_C = I_L \sin\phi_L$

$\Rightarrow \frac{V}{X_C} = \frac{V}{Z_L} \cdot \frac{X_L}{Z_L}$

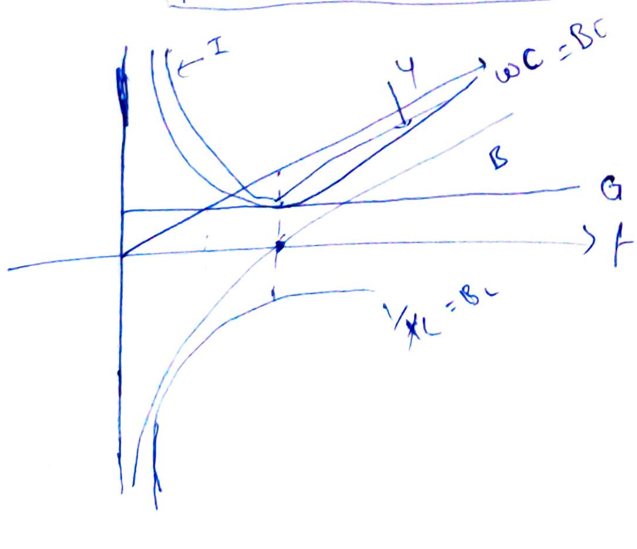
$\Rightarrow Z_L^2 = X_L \cdot X_C$

$\Rightarrow Z_L^2 = \frac{L}{C}$ $\Rightarrow \boxed{Z_L = \sqrt{\frac{L}{C}}}$

OR. $\frac{L}{C} = R^2 + L^2$

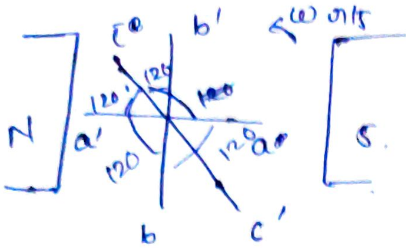
$(2\pi f_r L)^2 = \frac{L}{C} - R^2$

$\Rightarrow \boxed{2\pi f_r = \sqrt{\frac{1}{LC} - R^2/L^2}}$ $\therefore \boxed{f_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}}$



you will get current magnification

* Poly phase circuits *

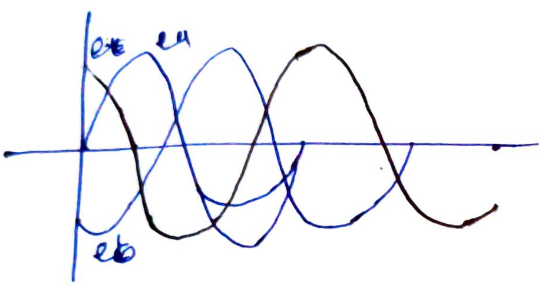


$e_a = E_m \sin \omega t$

$e_b = E_m \sin(\omega t - 120)$

$e_c = E_m \sin(\omega t - 240$

- Three identicle coils rotating in anti-clockwise direction in a uniform magnetic fied. 120° from each other.



- Resultant instantoneous. emf.

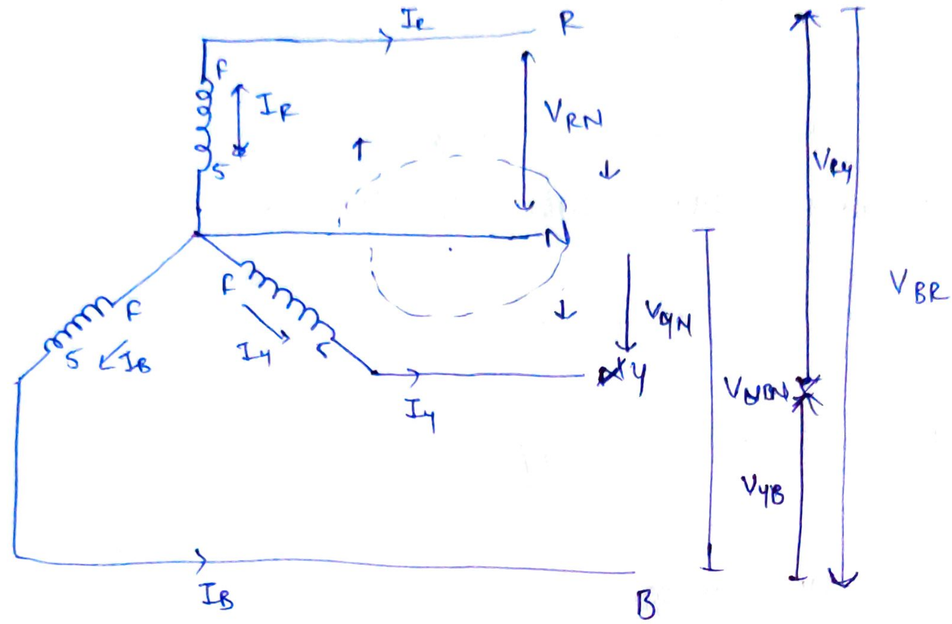
$= e_a + e_b + e_c$

$= E_m[\sin \omega t + \sin(\omega t - 120) + \sin(\omega t - 240)$

$= E_m[\sin \omega t + 2 \sin(\omega t - 180) \cos 60]$

$= 0$

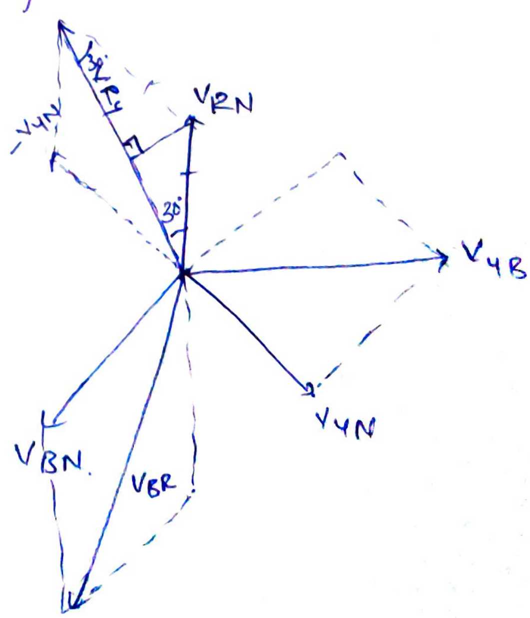
⇒ Star connection :



- sometimes its called Y - connection.

R = Red   Y = Yellow   B = Blue   N = Black

- $V_{RN} = V_{YN}$ & V_{BN} are called phase voltage : V_{ph}.
- $V_{RY} = V_{BR} = V_{YB} = V_L$ are called line voltages.
- $I_R = I_Y = I_B = I_L$ are called line currents & current passing through winding is called phase current.



Now, from Fig. $I_L = I_{ph}$

Also, $V_{RN} - V_{RY} - V_{YN} = 0$

$\Rightarrow V_{RY} = V_{RN} - V_{YN}$

similarly $V_{YB} = V_{YN} - V_{BN}$

$V_{BR} = V_{BN} - V_{RN}$.

Now, from fig

$V_{RY} = 2 V_{RN} \cos 30$

$= \sqrt{3} V_{RN}$

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

→ Total power $P_{active} = 3 V_{ph} I_{ph} \cos\phi$.

ϕ is phase diff. b/w V_{ph} & I_{ph}.

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

$\Rightarrow \boxed{P = \sqrt{3} V_L . I_L \cos\phi}$ watts

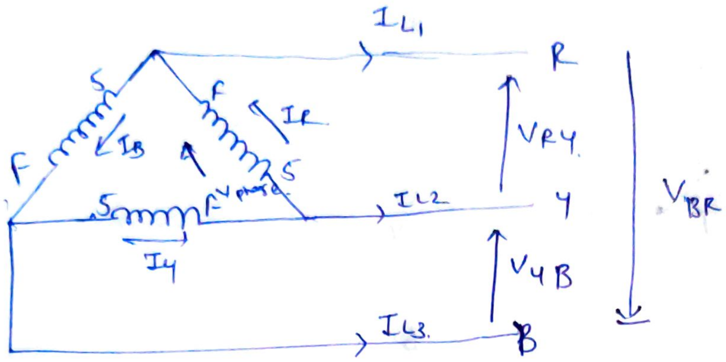
→ $P_{reactive} = 3 V_{ph} I_{ph} \sin\phi$

$= \sqrt{3} V_L I_L \sin\phi$ VAR

→ $P_{apparent} = 3 V_{ph} I_{ph}$

$= \sqrt{3} V_L I_L$ VA

$\Rightarrow$ Delta connection : Δ connection.



→ Now from fig.

$V_L = V_{ph}$

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

$I_{L1} = I_R - I_B$

$I_{L2} = I_R - I_Y$

$I_{L3} = I_B - I_R$

Now, Power

$P_{active} = 3\ V_{ph} I_{ph} \cos\phi$

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

$P_{reactive} = 3\ V_{ph} I_{ph} \sin\phi$

$= \sqrt{3}\ V_L I_L \sin\phi$

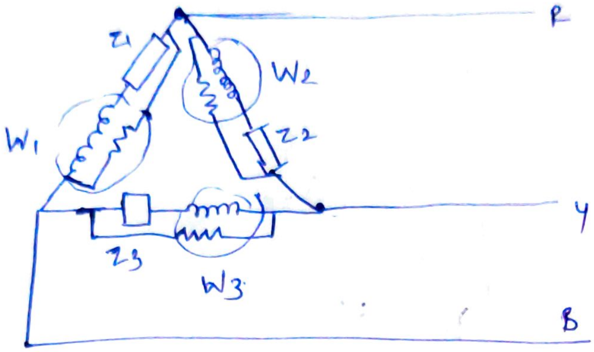
$P_{apparant} = 3 V_{ph} I_{ph}$

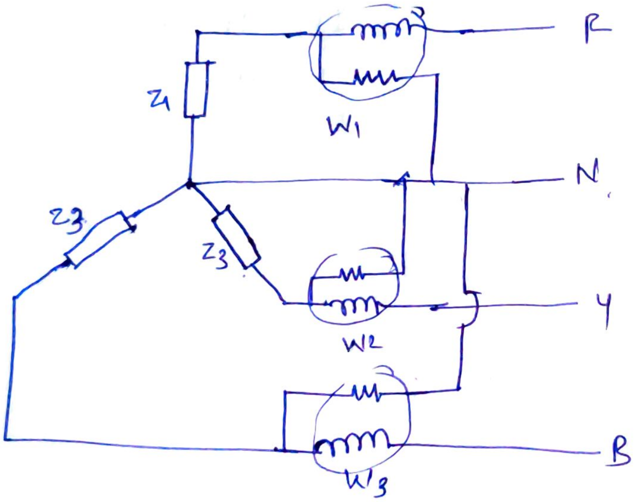
$= \sqrt{3}\ V_L I_L$

=) Measurement of Power

→ Three no. of ways

i) Simplest one is 3 wattmeter method.



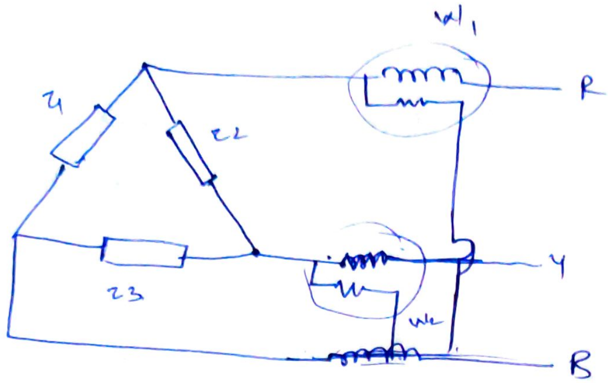


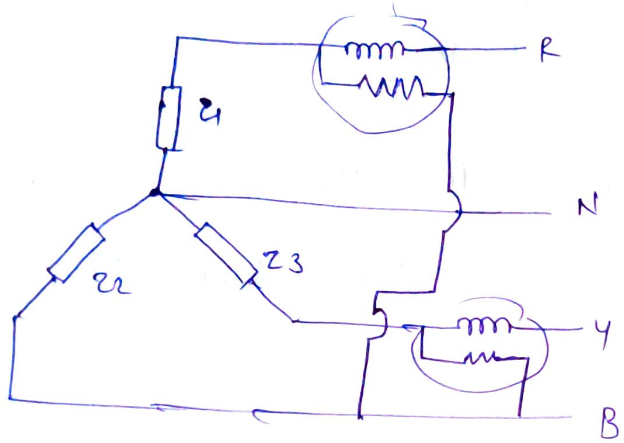
→ if $Z_1 = Z_2 = Z_3$ then it is balanced.

Now, total Power

$P_{active} = W_1 + W_2 + W_3$

ii) 2 wattemeter method.

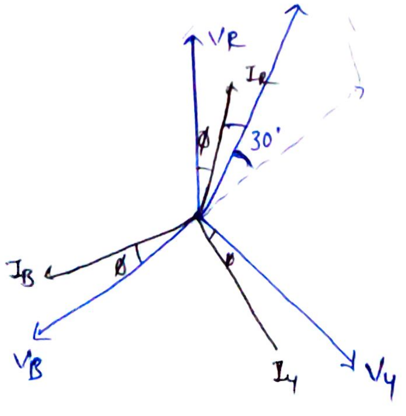




→ connect the current coil of wattmeter in any two lines and pressure coil across the remaining line.

now, current in W_1 = I_R & voltage in W_1 = V_{RB}.

& Now, assume that the phase current is lagging by angle ϕ w.r.t to respective phase voltage.

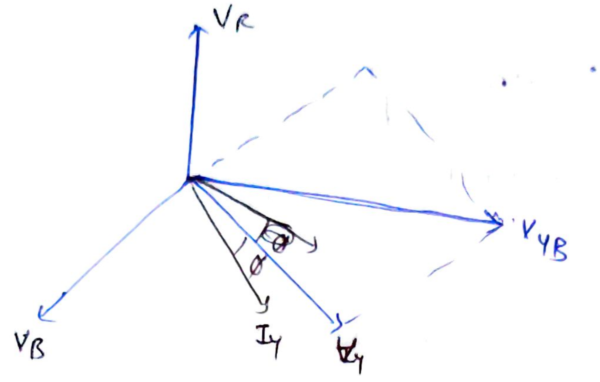


→ From fig. Angle b/w V_{RB} & I_R is $(30-\phi)$

$\therefore$ $W_1 = V_{RB} I_R \cos(30-\phi)$

Now, current in $W_2 = I_Y$ & phase voltage $= V_{YB}$

$= V_Y - V_B$



$\therefore$ from fig. Angle btw V_{YB} & I_Y is $(30+\phi)$

$\therefore$ W_2 Reading $= V_{YB} I_Y \cos(30+\phi)$

Now, $P_{total} = W_1 + W_2$

$= V_{RB} I_R \cos(30-\phi) + V_{YB} I_Y \cos(30+\phi)$

$= V_L I_L [\cos(30-\phi) + \cos(30+\phi)]$

$= V_L I_L [\cos 30 . \cos\phi + \cancel{\sin 30 \sin\phi} + \cos 30 . \cos\phi - \cancel{\sin 30 \sin}]$

$= 2 V_L I_L \frac{\sqrt{3}}{2} \cos\phi$

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

Simillarly :

For Reactive, $W_1 - W_2$

$= 2 V_L I_L \sin 30^\circ . \sin \phi$

$= V_L I_L \sin \phi$

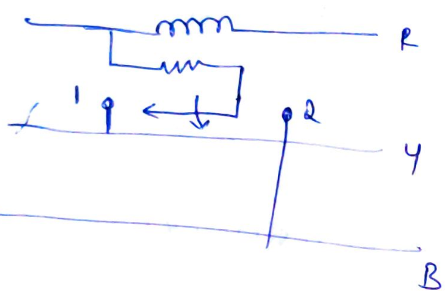
$\therefore$ $\boxed{\text{total reactive power} = \sqrt{3}(W_1 - W_2)}$

① IMP. OF Reactive power

ⓐ. Why votage is multiple of ".

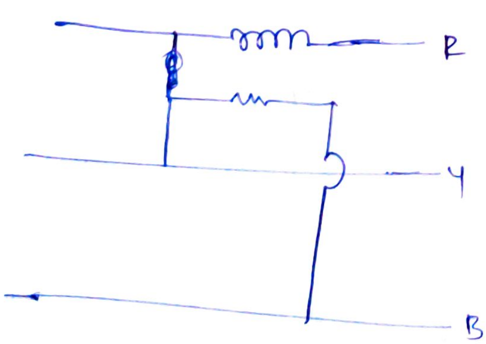
iii) One wattmeter method.

For Active power.



→ Explanation same as (ii).

⇒ Reactive power by one wattmeter method.



Now, current in coil = I_R voltage = V_{YB}

& Angle b/w V_{YB} & $I_R = (90 - \phi)$

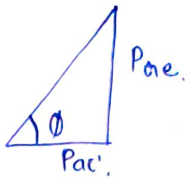
$\therefore$ $W = V_{YB} I_R \cos(90 - \phi)$

$= V_L I_L \sin\phi$

$\therefore$ $\boxed{P_{react} = \sqrt{3}\, W}$

=) Power factor by two wattmeter.

$\tan\phi = \dfrac{P_{re}}{P_{ac}} = \dfrac{\sqrt{3}(W_1 - W_2)}{(W_1 + W_2)}$



=) Variation of wattmeter readings.

$W_1 = \cancel{\sqrt{3}}\, V_L I_L \cos(30 - \phi)$, $W_2 = V_L I_L \cos(30 + \phi)$

① $\phi = 0$. (Resistive load).

$W_1 = W_2$.

② $0 < \phi < 60$

Both wattmeter will read positive values. They are diff.

③ $60 = \phi$

then $W_2 = 0$, then $P_{total} = W_1$

④ $60 < \phi < 90$

$W_1 = +ve$ & $W_2 = -ve$

60 to read the values interchange the terminals of current coil or pressure coil.
Usually pressure coil.
consider the reading with negative sign.

⑤. $\phi = 90°$ (Pure inductive or pure capacitive circuit).
Both wattmeter will read equal & oppo. reading.

=) Practicle Application:

)

)

Numericals :

① 3 identicle coils having resistance of 20 Ω & inductance of 63.661 mH. are connected

i) in star & ii) in delta.

across 440 V, 50 Hz, 3-ϕ supply. Calculate for each case

i) line current & phase current

ii) V_{ph} & V_L iii) P.F iv) Reading on each of two wattmeter connected to ~~major~~ measure P and total P.

Here, $R_{ph} = 20\,\Omega$ $L_{ph} = 63.661 \times 10^{-3}$ H

$\therefore X_{ph} = 20\,\Omega \approx 19.9996$

$\therefore Z_{ph} = 20 + j20$

$= 28.28 \angle 45$

Now, $V_L = 440$ V

i) Star connection,

$V_L = 440 \Rightarrow V_{ph} = \frac{440}{\sqrt{3}} = 254.03$ V

Now, $I_{ph} = \frac{V_{ph}}{Z_{ph}} = \frac{254.03}{28.28 \angle 45} = 8.983 \angle -45$ A.

$\therefore I_L = I_{ph} = 8.983$ A

Now, $\phi = 45^\circ \Rightarrow \cos\phi = P.F = 0.707$ (lag)

Now, $W_1 = V_L I_L \cos(30 - \phi)$

$= 440 \times 8.983 \times \cos(-15^\circ)$

$W_1 = 3817.84$ Watt.

$W_2 = V_L I_L \cos(30 + \phi)$

$= 1022.987$ watt

$\therefore$ total P = 4840.827 watts.

ii) Delta connection

$V_L = V_{ph} = 440$

$\therefore \quad I_{ph} = \frac{440}{28.28 \angle 45} = 15.55 \angle -45^\circ$

$I_L = \frac{I_{ph}\sqrt{3}}{\cancel{\sqrt{3}}} \; \cancel{\quad} = 26.93 \text{ A}$

Now, $W_1 = V_L I_L \cos(30-\phi)$
$= 11445.44$

$W_2 = V_L I_L \cos(30+\phi)$
$= 2998.47$

) $\therefore$ Total $P = 14443.91$ Watt.

$\phi = 45^\circ$ (lag) $\therefore \cos\phi = P.F = 0.707$ (lag)

② The total real power absorbed by a 3-ϕ balanced load is 60 KW and reactive power 1000 KVAR determine the power factor of load & readings of 2 wattmeter connected to measure power.

) Its given that $P_{active} = 60000$ W
$P_{reactive} = 1000000$ VAR

we know that
$\tan\phi = \frac{P_{reactive}}{P_{active}} = \frac{10^6}{6 \times 10^4} = \frac{100}{6} \Rightarrow \phi = \tan^{-1}\frac{50}{3}$

$\therefore \cos\phi = 0.0598$

Now, $W_1 + W_2 = 60000$ & $\sqrt{3}(W_1 - W_2) = 10^6$
$W_1 - W_2 = 577350.2692$

$\therefore W_1 = 318.675$ KW
$W_2 = -258.675$ KW.

(3) A balanced delta connected load is supplied from 3-ϕ, 400 V, 50 Hz supply. The current in each phase is 16 A. & it lags applied voltage by angle of 36.86° calculate.

i) V_{ph} ii) I_L iii) Load parameter if it is two element circuit

iv) Total power v) Reading of two wattmeters.

here, it is delta connection so we know that

i) $V_{ph} = V_L$

$\Rightarrow$ $\boxed{V_{ph} = 400\,V}$

ii) Also. $I_L = \sqrt{3}\, I_{ph}$

$\therefore$ $\boxed{I_L = 27.71\ A}$

iii) Load parameter are resistance & inductor as current lags the voltage.

$Z_{ph} = \dfrac{V_{ph}}{I_{ph}} = 25$

$$\boxed{\begin{aligned} R &= 20.00\ \Omega \\ X_L &= 14.996 \approx 15\ \Omega \\ L_{ph} &= 47.75\ mH. \end{aligned}}$$

iv) Now, $P = \sqrt{3} V_L I_L \cos\phi$

$= 15360.43\ W$

$\Rightarrow$ $\boxed{P = 15.36\ KW}$

v) Now, $W_1 + W_2 = 15360.4\ W.$

Now, $W_1 = V_L I_L \cos(30 - \phi)$

$= 11004.65\ W$

$W_2 = V_L I_L \cos(30 + \phi)$

$= 4868.35\ W.$

(4) power input of star connected load is measured by 2 wattmeter method. Readings of wattmeter are.

$W_1 = 100$ KW. $W_2 = 50$ KW

if the circuit is connected to a supply of 1100 V, 50Hz. determine load parameter for two element circuit.

As it is star connected

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

$V_L = 1100$ V.

$\Rightarrow V_{ph} = 635.08$V.

Now, $P_{active} = W_1 + W_2 = 150$ KW

$P_{reactive} = \sqrt{3}(W_1 - W_2) = 50\sqrt{3}$ KW $= 86.6$ KW.

Now, $p.f = \cos\left[\tan^{-1}\frac{P_{reactive}}{P_{active}}\right] = 0.866$ (~~lag~~) (lag)

Now, $150000 = \sqrt{3}\, V_L I_L \times 0.866$

$\Rightarrow I_L = 90.9$ A.

$\therefore Z_{ph} = \frac{V_{ph}}{I_{ph}} = \frac{635.08}{90.9} = 6.9865$

$= 6.05 + j3.49$

$\therefore R_{ph} = 6.05\ \Omega$

$X_{L\,ph} = 3.49\ \Omega$.

$\Rightarrow L = 11.1$ mH

Note :

in capacitive circuit $W_1 < W_2$

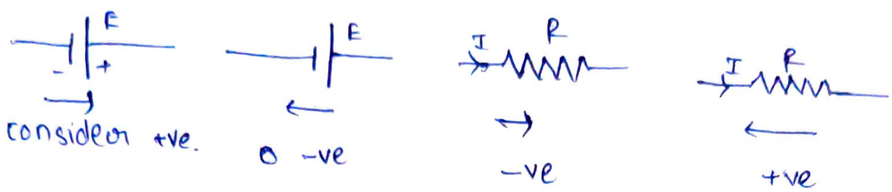
in inductive circuit $W_1 > W_2$.

Networks

Topic - 1. Mess current Analysis.

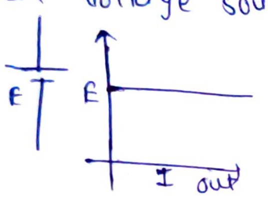
KVL → Algebric sum of voltage around closed path is zero.

KCL → Algebric sum of current at a junction is zero.



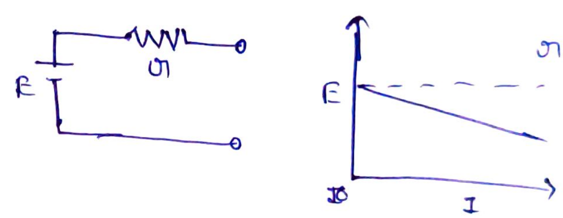
→ Ideal source.

① ideal voltage source.



$E = V_t$

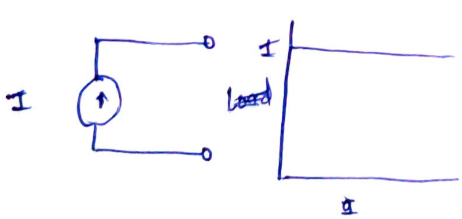
Practicle source.



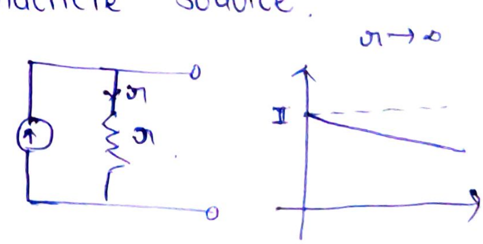
→ r is called internal resistance of the source.

→ For voltage source, it should be small as possible.

② ideal current source



Practicle source.



HPDC Link.

- No. of eqn required = No. of meshes (loops)
- Assume the mesh current } same
- Assume the direction of traversal.
- While writing the mesh eqn. while applying KVL to n^{th} mesh. assume that I_n > any other current.
- While assuming mesh currents, make sure that atleast one current is passing through every element of the network.

→ Method

Make only 1 current through source

$I_1 = -2\,A$.

$\therefore$ $100 - 5(I_1 + I_2) - 10(I_1 + I_2 - I_3) - 30(I_2 - I_3) - 10(I_2) = 0$.

$50 - 30(I_3 - I_2) - 10(I_3 - I_2 - I_1) - 20\,I_3 = 0$

$100 - 5(I_2 - 2) - 10(I_2 - 2 - I_3) - 30(I_2 - I_3) - 10\,I_2 = 0$

$\cancel{140}$ 130 $- 55 I_2 + 40 I_3 = 0$

$\Rightarrow 55 I_2 - 40 I_3 = 130 \Rightarrow 11 I_2 - 8 I_3 = 26 \,] \times 4$ — ①.

$44 I_2 - 32 I_3 = 104$

$50 - 30(I_3 - I_2) - 10(I_3 - I_2 + 2) - 20 I_3 = 0$

$30 - 60 I_3 + 40 I_2 = 0$

$66 I_3 - 44 I_2 = 33$

$\Rightarrow 60 I_3 - 40 I_2 = 30 \Rightarrow 12 I_3 - 8 I_2 = 6$.

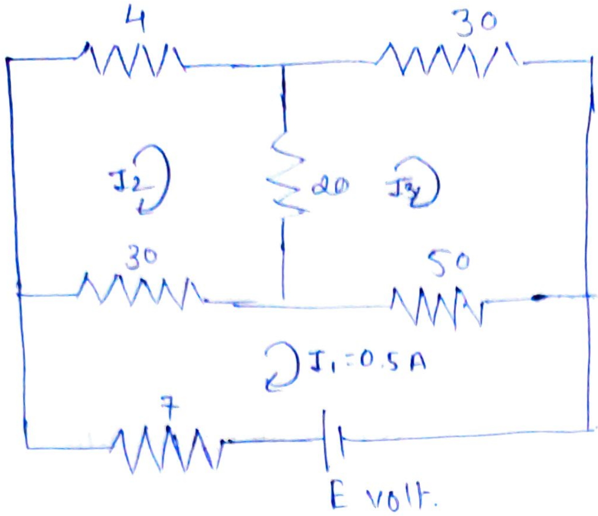
$6 I_3 - 4 I_2 = 3 \,] \times 11$ — ②.

$34 I_3 = 137$

$I_3 = 137/34 = 4.029\,A$.

④.

Q. 1



Find value of E.
So input current in 7 Ω is 0.5 A.

$$E - 7I_1 - 30(I_1 - I_2) - 50(I_1 - I_3) = 0$$

$$-4I_2 - 20(I_2 - I_3) - 30(I_2 - I_1) = 0$$

$$-30I_3 - 50(I_3 - I_1) - 20(I_3 - I_2) = 0$$

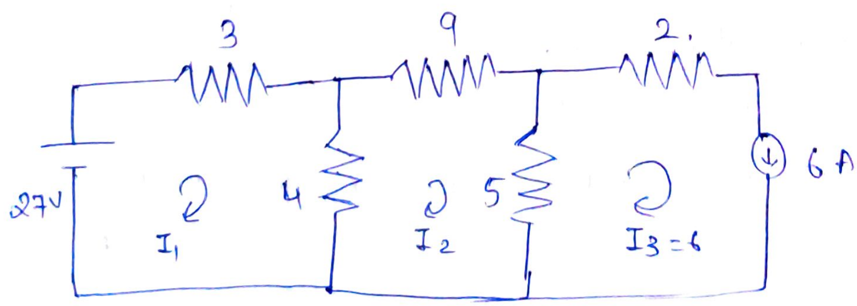
$$\begin{bmatrix} 87 & -30 & -50 \\ -30 & 54 & -20 \\ -50 & -20 & 100 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} E \\ 0 \\ 0 \end{bmatrix}$$

By cramers Rule.

$$I_1 = \frac{\begin{vmatrix} E & -30 & -50 \\ 0 & 54 & -20 \\ 0 & -20 & 100 \end{vmatrix}}{\Delta} = 0.5 = \frac{E(5400-400)}{\Delta} = \frac{5000E}{\Delta} = 0.5$$

$$E = 44.1 \text{ V}$$

Q. 2).



Find power dissipation in 4 Ω.

$\therefore$ $I_3 = 6$ A.

$27 - 3I_1 - 4(I_1 - I_2) = 0$

$-9I_2 - 5(I_2 - \cancel{I_3}) - 4(I_2 - I_1) = 0$

$27 - 7I_1 + 4I_2 = 0$

$30 + 5I_1 - 18I_2 = 0$

$+7I_1 \mp 4I_2 = 27] \times 5 \Rightarrow +35I_1 + 20I_2 = \cancel{27} \times 135$

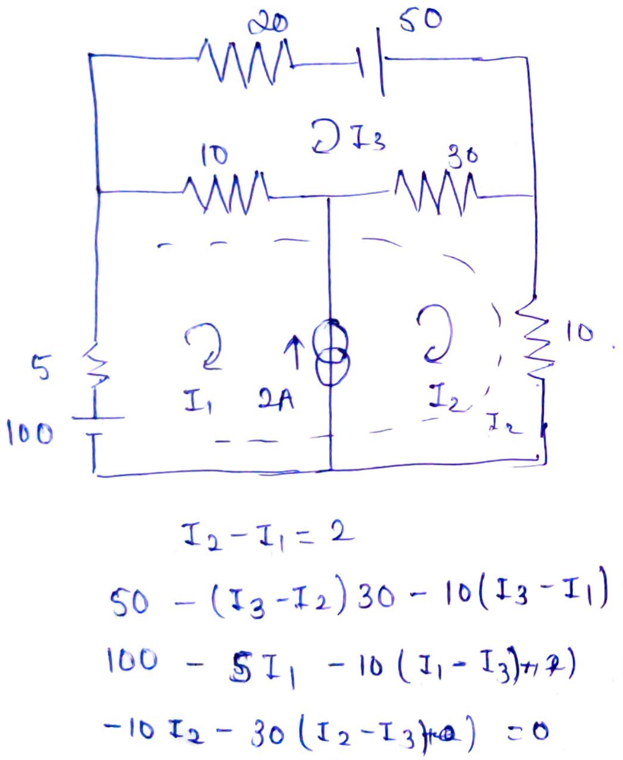
$-5I_1 + 18I_2 = 30] \times 7 \qquad -35I_1 + 126I_2 = 210$

$\Rightarrow +106 I_2 = 345$

$I_1 = +5.7 \qquad I_2 = +345/106$

$\therefore P = I^2R = 130.7W$

9)



Find out current passing through 30 Ω.

super mesh technique.

consider 2 loops to avoid current source.

$\therefore I_2 - I_1 = 2 \rightarrow$ Eqn

$100 - 5I_1 - 10(I_1 - I_3) - 30(I_2 - I_3) - 10I_2 = 0.$

$100 - 15I_1 - 40I_3 - 40I_2 = 0.$

$100 - 15I_1 - 40I_3 - 40I_1 = 80$

$I_2 - I_1 = 2$

$50 - (I_3 - I_2)30 - 10(I_3 - I_1) - 20I_3 = 0.$

$100 - 5I_1 - 10(I_1 - I_3 + 2) = 0$

$-10I_2 - 30(I_2 - I_3 + 2) = 0$

$50 - 30(I_3 - I_1 - 2) - 10(I_3 - I_1) - 20I_3 = 0.$

$50 - 60I_3 + 40I_1 + 60 = 0$

$60I_3 - 40I_1 = 110$ —— ①

$30I_3 \mp 40(2 + I_1) = 0$

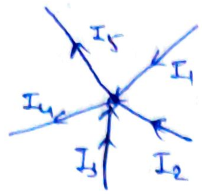
$30I_3 \mp 40I_1 = +80$ —— ②

$30I_3 = 30$

$I_3 = 1$

$I_1 = -5/4$

KCL : In any electrical circuit, the algebraic sum of current meeting at a point is always zero.



$I_1 + I_2 + I_3 - I_5 - I_4 = 0$

i.e $i_1 + i_2 + i_3 = i_4 + i_5$

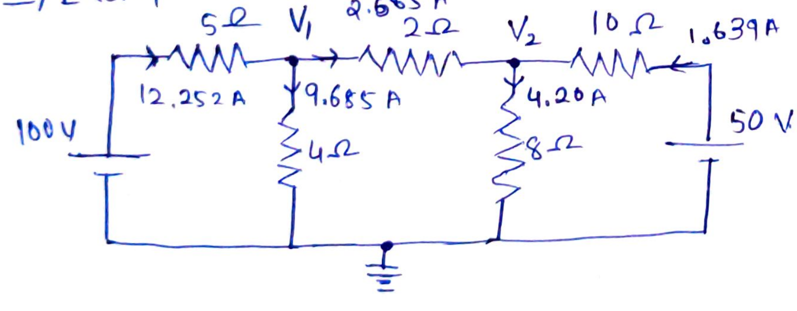
=) Nodal voltage analysis

1) Junction : It is point in a network where three or more branches are ~~there~~ meeting.

- i) identify no. of junctions.
- ii) consider one of the junction as reference, (so we can say its potential is zero. & Assume the load voltage for remaining junctions).
- iv) Current flows from higher to lower potential.
- v) While applying KCL to write node eqn, assume that all ~~a~~ branch currents are leaving the node.

* vi no. of eqn = no. of junctions − 1.

=) Example :



Now, At Node - 1.

$$\frac{V_1 - 100}{5} + \frac{V_1 - 0}{4} + \frac{V_1 - V_2}{2} = 0 \Rightarrow 4V_1 - 400 + 5V_1 + 10V_1 - 10V_2 = 0$$

$$\Rightarrow 19V_1 - 10V_2 = 400$$

$$\frac{V_2 - 50}{10} + \frac{V_2 - 0}{8} + \frac{V_2 - V_1}{2} = 0 \Rightarrow 4V_2 - 200 + 5V_2 + 20V_2 - 20V_1 = 0$$

$$29V_2 - 20V_1 = 200.$$

$\therefore V_2 = 33.61$

$V_1 = 88.74$

$$Y = \begin{bmatrix} Y_{11} & Y_{12} & Y_{13} \\ Y_{21} & Y_{22} & Y_{23} \\ Y_{31} & Y_{32} & Y_{33} \end{bmatrix}$$

$\boxed{Y . V = I}$

Y_{11} = SUM OF all branch admitance connected to Junction 1. (Always +ve)

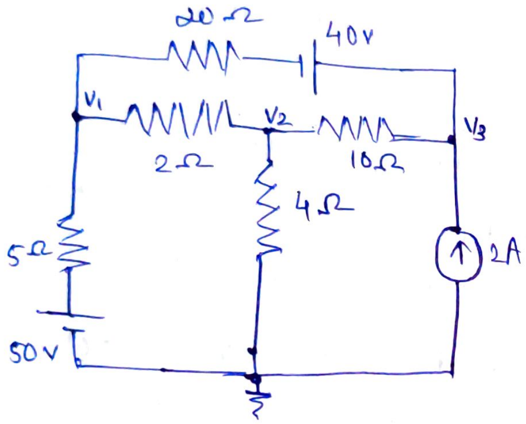
Y_{12} = SUM OF all branch admitances connected b/w. Junction or node 1 & node 2. (Always -ve).

$$I = \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix}$$

I_1 = Sum all source current connect to Juction 1

= current toward junction, cosider it with +ve sign.

(2)



Find power supplied by 50V source.

$$\frac{V_1-50}{5} + \frac{V_1-V_2}{2} + \frac{V_1+40-V_3}{20} = 0$$

$$\left(\frac{1}{5}+\frac{1}{2}+\frac{1}{20}\right)V_1 - \frac{1}{2}V_2 - \frac{1}{20}V_3 = 10-2 = 8$$

$$\frac{3V_1}{4} - \frac{1}{2}V_2 - \frac{1}{20}V_3 = 8$$

$$\frac{V_2-V_1}{2} + \frac{V_2-V_3}{10} + \frac{V_2}{4} = 0 \Rightarrow \left(\frac{1}{2}+\frac{1}{10}+\frac{1}{4}\right)V_2 - \frac{V_1}{2} - \frac{V_3}{10} = 0$$

$$= \frac{17}{20}V_2 - \frac{V_1}{2} - V_3/10 = 0$$

$$\frac{V_3-V_2}{10} + \frac{V_3-40-V_1}{20} - 2 = 0 \Rightarrow \left(\frac{1}{10}+\frac{1}{20}\right)V_3 - \frac{V_2}{10} - \frac{V_1}{20} = 4$$

$$\Rightarrow \frac{3}{20}V_3 - \frac{V_2}{10} - \frac{V_1}{20} = 4$$

find only V_1 & than $\frac{50-V_1}{5} = I_1$

& power is VI_1

Now.

$$\begin{bmatrix} 0.75 & -0.5 & -0.05 \\ -0.5 & 0.85 & -0.1 \\ -0.05 & -0.1 & 0.15 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 8 \\ 0 \\ 4 \end{bmatrix}$$

Now, $V_1 = \dfrac{\begin{bmatrix} 8 & -0.5 & 0.05 \\ 0 & 0.85 & -0.1 \\ 4 & -0.1 & 0.15 \end{bmatrix}}{\Delta} = \dfrac{0.94 + 0.03}{0.08 + 0.2 - 0.17} = \dfrac{0.97}{0.11} = 8.81$

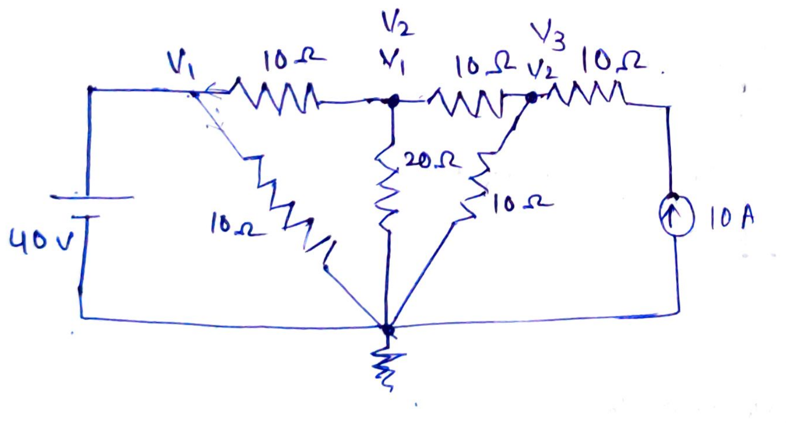
$V_1 = 8.81\ V$

$\Rightarrow$ $I_1 = \dfrac{50 - 8.81}{5} = 8.236\ A$

$\therefore$ $P = 50 \times 8.236$

$P = 411.81\ W$. is power supplied by 50 V supply.

3)



Find out power supplied by 40V ~~supply~~, source.

Now, $\dfrac{V_1 - 40}{10} + \dfrac{V_1}{20} + \dfrac{V_1 - V_2}{10} = 0 \Rightarrow \left(\frac{1}{10} + \frac{1}{10} + \frac{1}{20}\right) V_1 - \frac{V_2}{10} = 4$

$\dfrac{V_2 - V_1}{10} + \dfrac{V_2}{10} + \cancel{\dfrac{V_2}{10}} - 10 = 0 \Rightarrow \left(\frac{1}{10} + \frac{1}{10} + \cancel{\frac{1}{10}}\right) V_2 - \frac{V_1}{10} = 10.$

$$\begin{bmatrix}0.25 & -0.1\\ -0.1 & 0.2\end{bmatrix}\begin{bmatrix}V_1\\ V_2\end{bmatrix} = \begin{bmatrix}4\\ 10\end{bmatrix}$$

$$V_1 = \frac{\begin{bmatrix}4 & -0.1\\ 10 & 0.2\end{bmatrix}}{0.065} = \cancel{0,}\ \frac{2.4}{0.065} = \cancel{36.84}\ V \quad \frac{1.8}{0.04} = 45$$

$$V_2 = \frac{\begin{bmatrix}0.25 & 4\\ -0.1 & 10\end{bmatrix}}{0.065} = \frac{2.9}{0.065} = \cancel{44.61}\ V. \quad \frac{2.9}{0.04} = 72.5$$

$$I_1 = \frac{V_1 - 40}{10} = 0.616\ A \qquad I_1 = \frac{5}{10} = 0.5$$

$$\therefore I_{40} = 4 + 0.616 = 4.616 \qquad I = 4 - 0.5 = 3.5$$

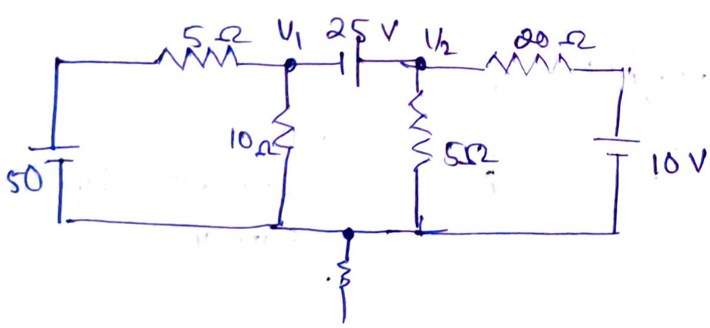
$$\therefore P = 40 \times \cancel{4.616}\ 3.5$$

~~whole wrong solution~~

$\boxed{\cancel{P = 184.64\ Watt}}$ $\boxed{P = 140\ Watt}$

$\cancel{V_1 = 40\ V.}$ $\cancel{I_1 = 40}$

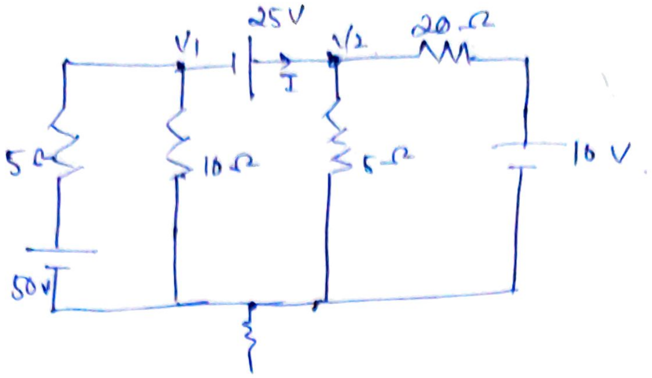
4)



$$\frac{V_1 - 50}{5} + \frac{V_1}{10} + \cancel{V_1 + 25 - V_2} =$$

$$\frac{V_2 - 10}{20} + \frac{V_2}{5}$$

4)



ASSUM I in 25 V branch.

$$\frac{V_1 - 50}{5} + \frac{V_1}{10} - I = 0 \quad \text{— (1)}$$

$$\frac{V_2 - 10}{20} + \frac{V_2}{5} - I = 0. \quad \text{— (2)}$$

$$V_2 - V_1 = 25 \quad \text{— (5)}$$

$\Rightarrow$ $0.2V_1 - 10 + 0.1V_1 - I = 0 \Rightarrow 0.3V_1 - I = 10$ — (3)

$0.05V_2 + 0.2V_2 - I - 0.5 = 0 \Rightarrow 0.25V_2 - I = 0.5$ — (4)

Now, (3) - (4), we get.

$\cancel{0.3V_1 - 0.25V_2 = 9.5}$ — (6)

Now, (6) × 4 + (5), we get.

$\cancel{V_2 - V_1 = 25}$

$+ 1.2V_1 - V_2 = 38.0$ $\Rightarrow 0.2V_1 = 38$

$\Rightarrow V_1 = 38 \times 5$.

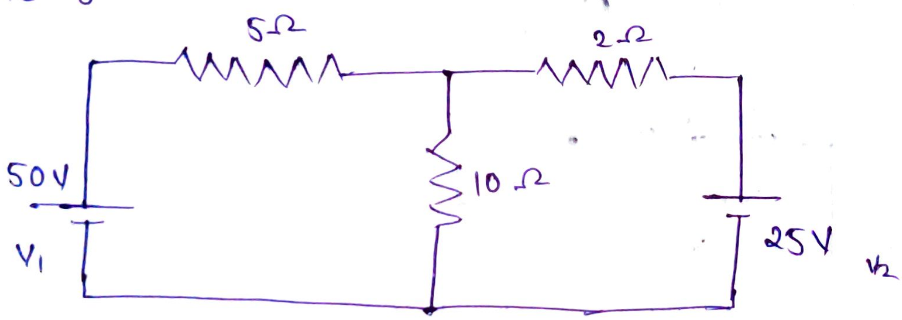
⇒ Superposition theorem.

→ In a linear, bilateral network containing more then one energy sources, the resultant current in any branch of the network is the algebraic sum of the currents that would be produced by each energy source taken separatly, with all the other energy sources being replaced by their respective internal resistances.

→ If internal resistances are not given, consider sources as ideal sources & replace voltage source by short circuit & current source by open circuit.

Example :

1)



· Find out current passing through 10Ω.

$I_1 = 7.5\ A$ $\quad I_2 = 4.6875\ A$

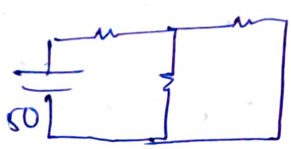
$I_1 = 1.25$ $\quad I_2 = 1.5625$

$\frac{V_1 - 50}{5} + \frac{V_1}{10} + \frac{V_1 - 25}{2} = 0.$ $\quad ⇒ 0.8 V_1 = 22.5$

$V_1 = 28.125$

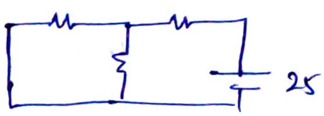
$I = 2.8125$

Fig ① →



→ to get I_1 through 10Ω

→



→ to get I_2 throu 10Ω

$I_1 + I_2 =$ I through 10.

5)

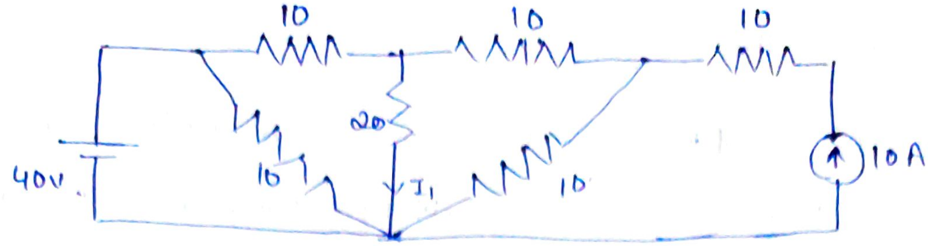
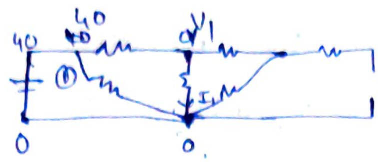


Fig. ⟶



$\cancel{\frac{V}{20} + \frac{V-40}{10} +}$ ~~At Junc (1)~~

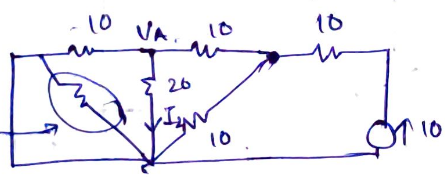
$$\frac{V}{20} + \frac{V-40}{10} + \frac{V}{20} = 0$$

$$\frac{40-V_1}{10} + \frac{40}{40}$$

$$\Rightarrow \quad \frac{4V}{20} - 4 = 0 \qquad V = 20\,V$$

$$\therefore \quad \boxed{I_1 = 1A}$$

Fig ⟶



short circuit

$$\frac{2VA}{20} + \frac{VA}{20} + \frac{2VA - 2VB}{20} = 0 \Rightarrow \frac{10VA}{4} - \frac{4VB}{10} = 0$$

$$\frac{VB}{10} + \frac{VB - VA}{10} + \frac{VB}{10} = 10 \Rightarrow \frac{3VB}{10} - \frac{VA}{10} = 100$$

$30VA - 12VB = 0$

$12VB - 4VA = 100$ $\qquad \frac{2VB - VA}{10}$

$26VA = 100 \qquad VA = 3.846\ 25$

$2VB - VA = 100$

$$\frac{5VA}{20} - \frac{2VB}{20} = 0 \Rightarrow 5VA - 2VB = 0$$

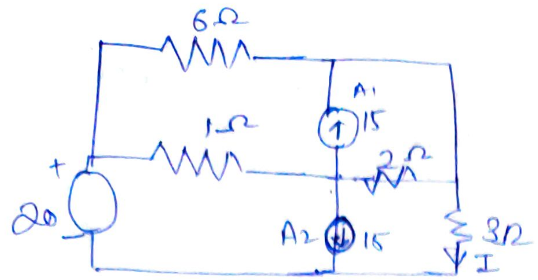
$3VB - 6VA = 500 \qquad 4VA$

$VA = 25$

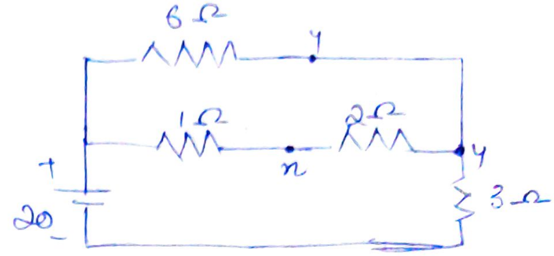
$VB = 500 \qquad \frac{1000}{7}$

$5VA = 1500 - 500$

6)

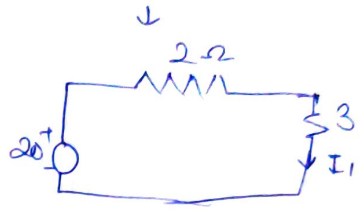


Find current through 3Ω.



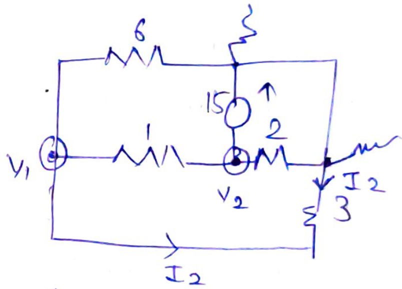
Now, for 20V source

Now, $I_1 = \frac{20}{5} = 4A.$



Now, for A_1 ⓘ15 source.

$$\frac{V_1}{6} + \frac{V_1 - V_2}{1} + \frac{V_1}{3} = 0$$



$$\frac{V_1}{2} + V_1 - V_2 = 0.$$

$$\Rightarrow 3V_1 - 2V_2 = 0.$$

$$\frac{V_2 - V_1}{1} + 15 + \frac{V_2}{2} = 0$$

$$\Rightarrow 3V_2 - 2V_1 + 30 = 0.$$

$9V_1 - 6V_2 = 0$

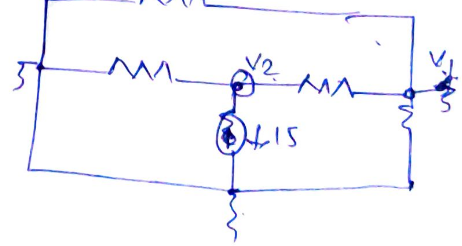
$6V_2 - 4V_1 + 60 = 0$

$5V_1 = -60$

$\Rightarrow V_1 = -12.$

$\therefore I_2 = \frac{\cancel{0 - (-12)} - V_1}{3} = 4A$

Now, for A_2 ⓘ15 source.



$$\frac{V_1}{6} + \frac{V_1}{3} + \frac{V_1 - V_2}{2} = 0 \quad 6V_1 - 3V_2 = 0$$

$\Rightarrow 3V_1 - 2V_2 = 0.$

$$\frac{V_2}{1} + \frac{V_2 - V_1}{2} + 15 = 0$$

$\Rightarrow 3V_2 - 2V_1 + 30 = 0 \quad \Rightarrow \quad V_1 = -6$

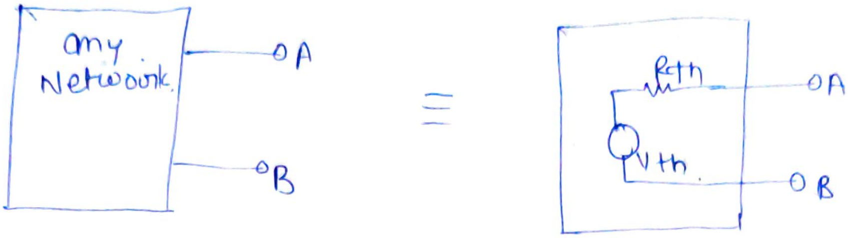
$I_3 = \frac{V_B}{2} = -2A$

$I_B = \frac{-6}{3} = -2.$

$\therefore I = 4 + 4 - 2 = 6A.$

⇒ Thevenin's theorem.

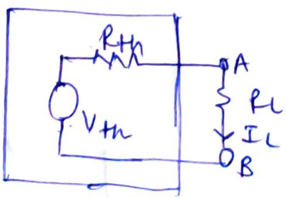
→ Any two terminals linear, bilateral, active networks can be replaced by single voltage source V_{Th} in series with single resistance R_{th}.



→ The thevenin's equivalant voltage V_{th} is the open circuit voltage measured between terminals A & B.

→ The thevenin's equivalant Resistance R_{th} is the resistance of the network as seen from output termins A & B with all energy sources being replaced by their internal resistances.

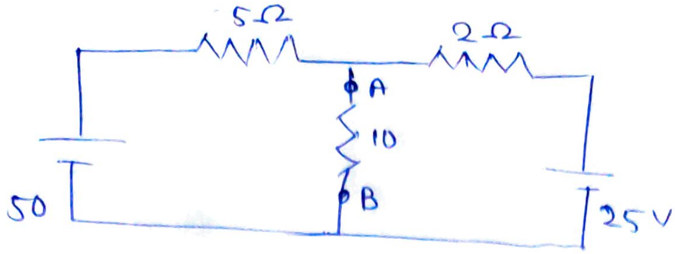
→ If internal resistances are not given then consider the sources as ideal sources and replace voltage source by short-circuit & current source by open circuit.



$$I_L = \frac{V_{th}}{R_L + R_{th}}$$

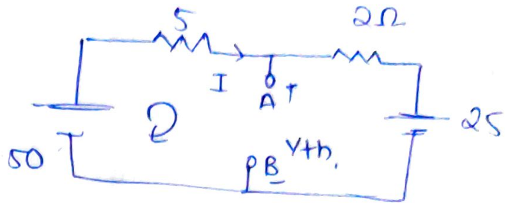
Numericals :

1) NU



Find current through 10.

Now, for V_{th}.



$50 - 5 \times \frac{25}{7} - V_{th} = 0.$

$I = \frac{50-25}{7} = 25/7 = 3.571 A.$

$V_{th} = 50 - \frac{125}{7} = 0$

$V_{th} = \frac{225}{7} = 32.145$

$R_{th} = 10/7$

$\therefore I_L = \frac{V_{th}}{R_L + R_{th}} = \frac{32.145}{1.428+10} = 2.81 A.$

$\therefore I_{10} = 2.81 A.$