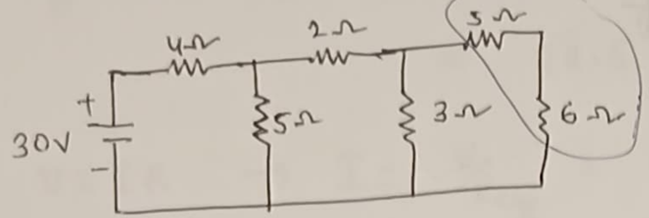
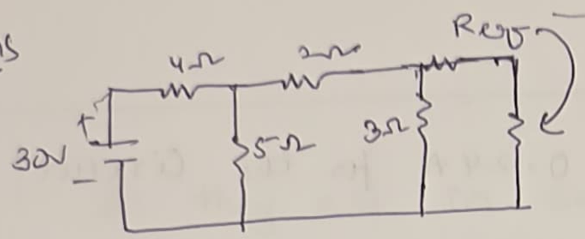
PART A

① Determine the equivalent resistance and Source current.



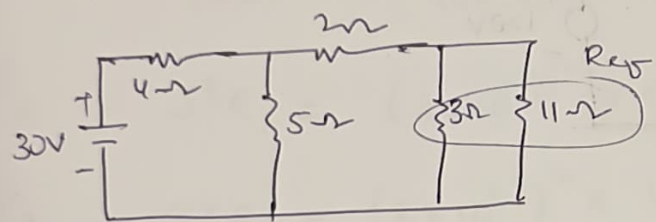
Ans



Req = (5 + 6) series

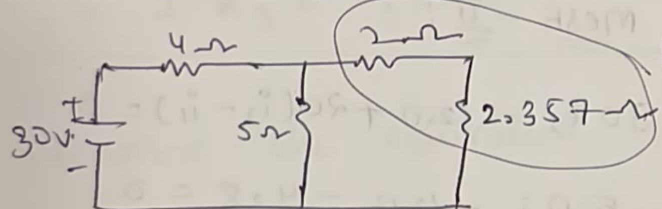
Req = 11Ω

11Ω and 3Ω are in parallel



$$R_{eq} = \frac{3 \times 11}{3 + 11} = 2.357\ \Omega$$

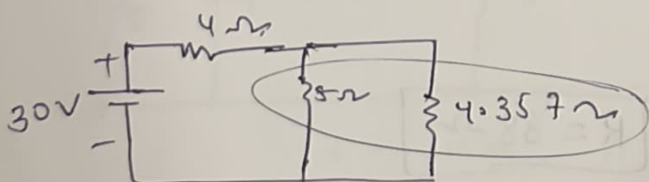
2.357 Ω and 2Ω are in series



Req = 2 + 2.357

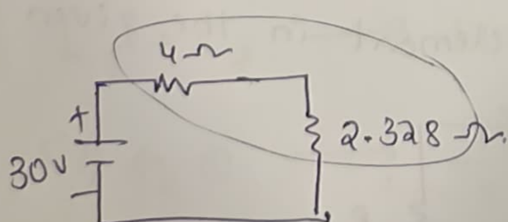
Req = 4.357 Ω

4.357 Ω and 5 Ω are parallel



$$R_{eq} = \frac{5 \times 4.357}{5 + 4.357} = 2.328\ \Omega$$

4Ω & 2.328 Ω are in Series



Req = 4 + 2.328 Ω

$$\boxed{R_{eq} = 6.328\ \Omega}$$

Source current $(I) = V/R_{eq}$

$$I = \frac{30}{6.328}$$

$$\boxed{I = 4.74\,A}$$

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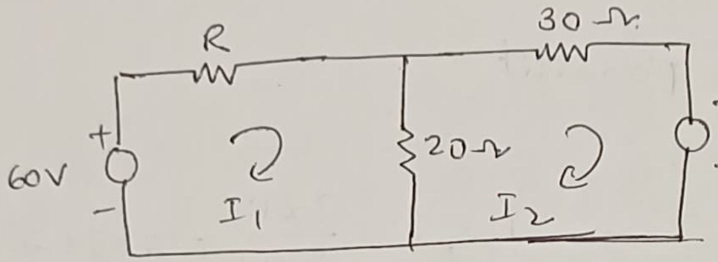
(2) Find the value of R if $i_1 = 0.24\,A$ for the circuit shown in below figure.



Given; $I_1 = 0.24\,A$

Mesh - I :

$60 - i_1 R - 20(i_1 - i_2) = 0$

$55.2 - 0.24R + 20 i_2 = 0$

Substitute 'i_2'

$55.2 - 0.24R + 20(-2.304) = 0$

$0.24R = 9.12 \Rightarrow \boxed{R = 38\,\Omega}$

Mesh - II :

$30 i_2 + 120 + 20(i_2 - i_1) = 0$

$50 i_2 + 120 - 4.8 = 0$

$i_2 = -2.304\,A$

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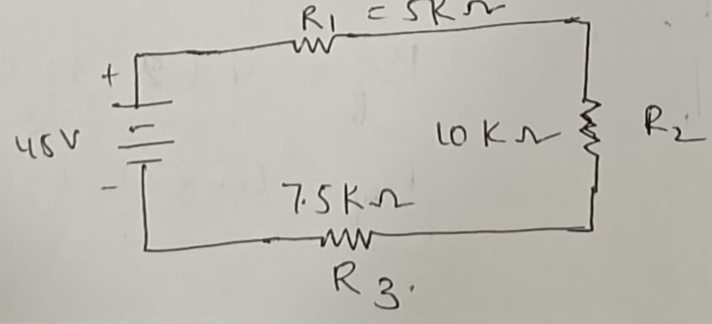
(3) Determine power across each element in the given circuit.



Sol $R_{eq} = R_1 + R_2 + R_3 = (5 + 10 + 7.5)\,k\Omega$

$= 22.5 \times 10^3\,\Omega$

$V = IR \rightarrow I = V/R_{eq} = \dfrac{45}{22.5 \times 10^3}$

$I = 2 \times 10^{-3}$

$I = 2mA.$

As they are in series, current flowing through each resistor is same i.e

$I_{5k\Omega} = I_{10k\Omega} = I_{7.5k\Omega} = 2mA.$

$P_{R_1} = I^2 R_1 = (2\times10^{-3})^2 \times 5 \times 10^3 = 20\,mW.$

$P_{R_2} = I^2 R_2 = (2 \times 10^{-3})^2 \times 10 \times 10^3 = 40\,mW.$

$P_{R_3} = I^2 R_3 = (2 \times 10^{-3})^2 \times 7.5 \times 10^3 = 30\,mW.$

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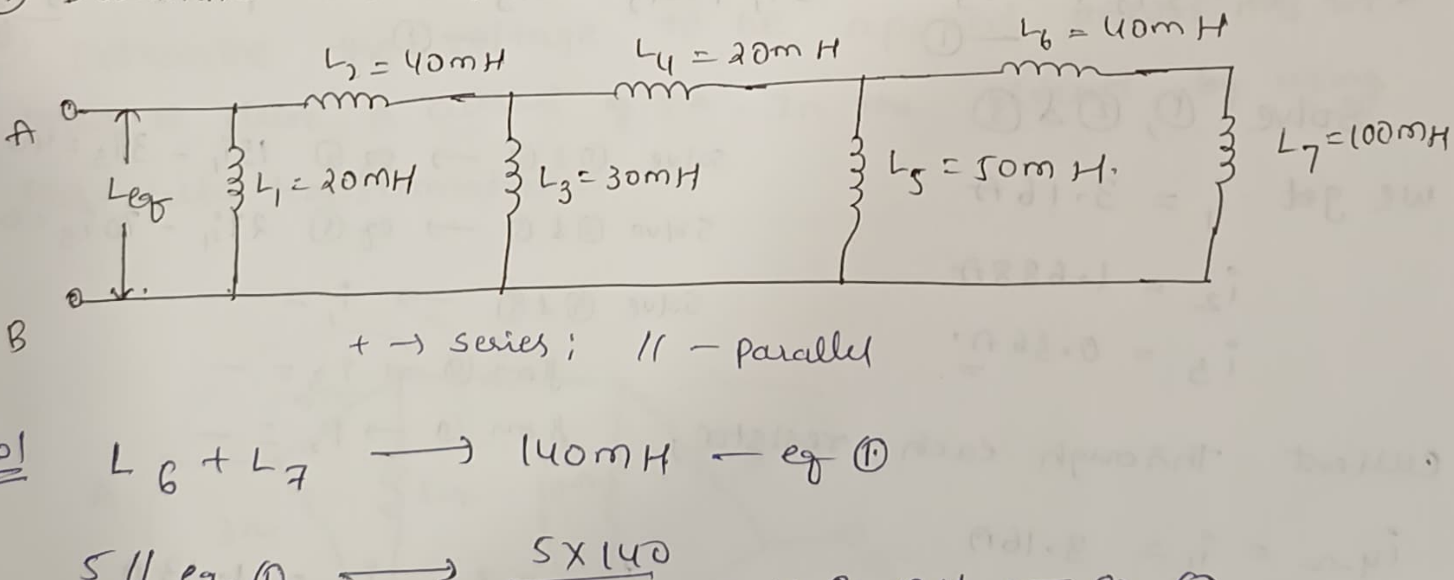
(4) Determine the equivalent inductance in the given circuit



$+ \rightarrow$ series ; $//$ – parallel

Sol $L_6 + L_7 \longrightarrow 140mH$ – eq (1)

$5 //$ eq (1) $\longrightarrow \dfrac{5 \times 140}{5 + 140} = 4.82\,mH$ – eq (2)

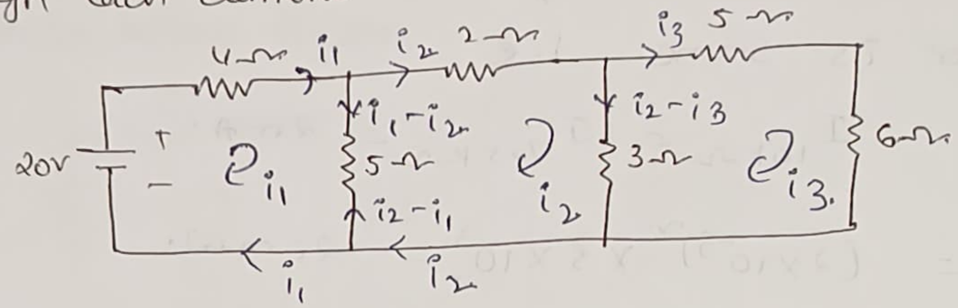
eq (2) + 20mH $\longrightarrow 4.82 + 20 = 24.82\,mH$ – eq (3)

eq (3) // 30mH $\longrightarrow \dfrac{24.82 \times 30}{24.82 + 30} = 13.58\,mH$ – eq (4) eq ④ + 40 mH → 40 + 13.58 = 53.58 mH → eq ⑤

eq ⑤ // 20 → $\frac{20 \times 53.58}{20 + 53.58} = 14.5\ mH$ → eq ⑥

eq ⑥ = $R_{eq} = 14.5\ mH$.

⑤ Apply Mesh analysis and calculate the current above through each element.



Sol By Mesh Analysis

Mesh - 1 :

$20 - 4i_1 - 5(i_1 - i_2) = 0$

$20 = 9i_1 - 5i_2 + 0 \cdot i_3$ — ①

Mesh - 2 :

$2i_2 + 3(i_2 - i_3) + 5(i_2 - i_1) = 0$

$-5i_1 + 10i_2 - 3i_3 = 0$ — ②

Mesh - 3

$5i_3 + 6i_3 + 3(i_3 - i_2) = 0$

$0 \cdot i_1 - 3i_2 + 14i_3 = 0$ — ③

Solve ①, ② & ③

we get $i_1 = 3.16A$

$i_2 = 1.688A$

$i_3 = 0.36A$.

solve ① & ② → eq ④ $13i_1 - 3i_3 = 40$

Solve ① & ③ → eq ⑤ $27i_1 - 70i_3 = 60$

Solve ④ & ⑤ → $i_1 = -$

from ④ → $i_3 = -$

from ① → $i_2 = -$

current through each resistor,

$i_{4\Omega} = i_1 = 3.16A$

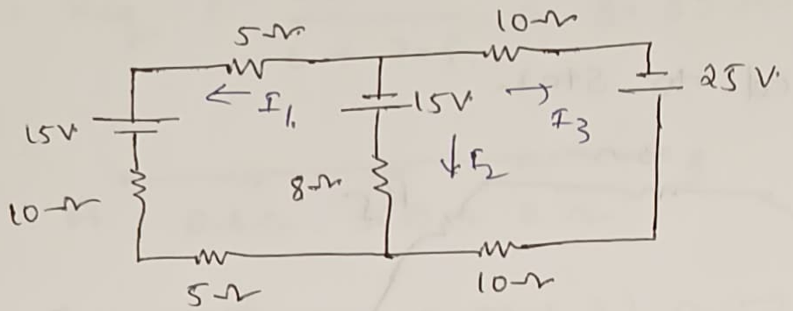
$i_{2\Omega} = i_2 = 1.688A$

$i_{5\Omega} = i_{6\Omega} = i_3 = 0.36A$

$i_{3\Omega} = i_2 - i_3 = 1.33\ A$

$i_{5\Omega} = i_1 - i_2 = 1.47A$

⑥ Find the current in the 8 ohm resistor in the following circuit shown in figure using Kirchhoff's laws.



Sol $I_{8\Omega} = I_2 = ?$

By KCL, $I_1 + I_2 + I_3 = 0$

$$I_2 = -I_1 - I_3$$

$$I_2 = -\left(\frac{15-15}{5+10+5}\right) - \left(\frac{15-(-25)}{10+10}\right)$$

$$\boxed{I_2 = -2A}$$

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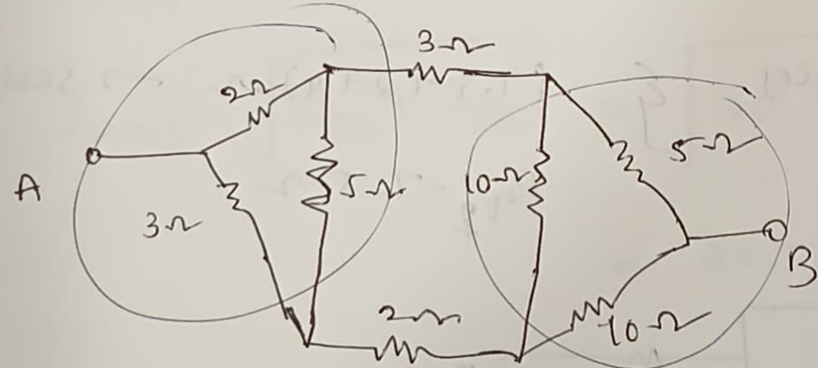
⑦ Determine the voltage to be applied across AB in order to drive a current of 5A. In the circuit by using star-delta transformation.

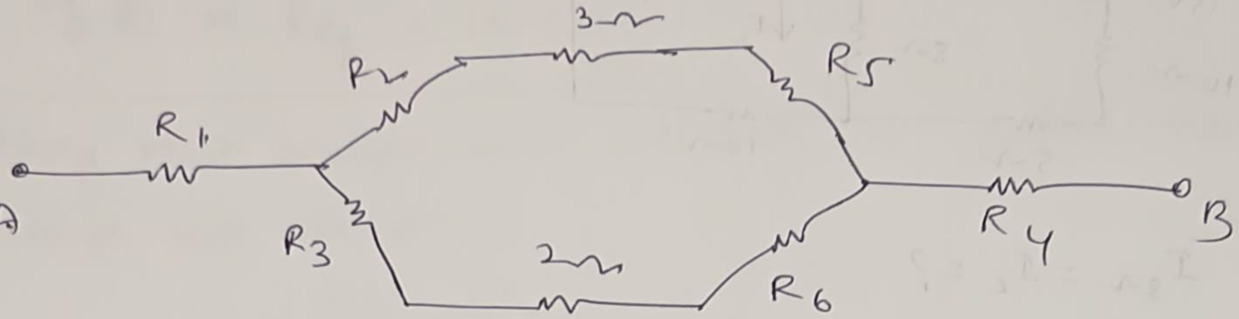


Sol $I_{AB} = 5A$; $V_{AB} = ?$

Star delta transformation.

* Delta is converted to star

like:

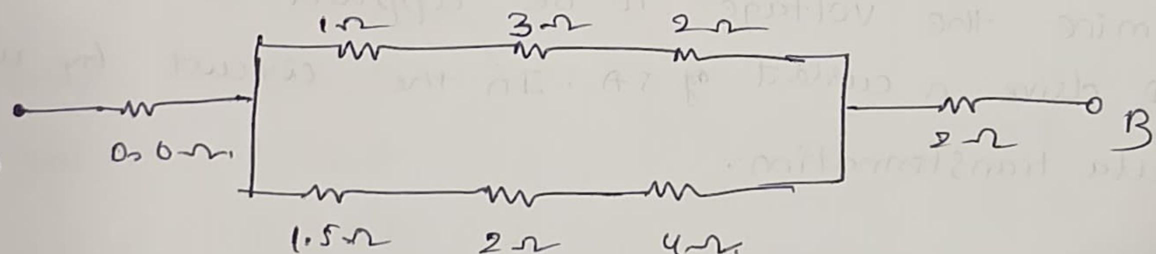


$$R_1 = \frac{2\times3}{2+3+5} = 0.6\Omega \;;\quad R_2 = \frac{2\times5}{2+3+5} = 1\Omega$$

$$R_3 = \frac{5\times3}{2+3+5} = 1.5\Omega \;;\quad R_4 = \frac{5\times10}{5+10+10} = 2\Omega$$

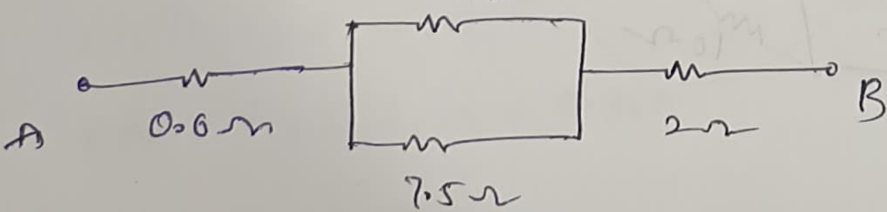
$$R_5 = \frac{10\times5}{5+10+10} = 2\Omega \;;\quad R_6 = \frac{10\times10}{5+10+10} = 4\Omega$$

Now, the circuit be like.



$(1+3+2)\Omega \rightarrow$ series & $(1.5+2+4)\Omega \rightarrow$ series

$R_{eq_1} = 6\Omega$ $\quad$ $R_{eq_2} = 7.5\Omega$

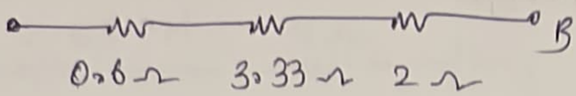


A 240 volts, 50 Hz, AC supply is applied a coil of.

$6\,\Omega$ & $7.5\,\Omega$ are parallel

$$\therefore R_{eq} = \frac{6 \times 7.5}{6 + 7.5} = 3.33\,\Omega$$

Now;



$$R_{eq} = (0.6 + 3.33 + 2)\,\Omega \rightarrow \text{series}$$

$$R_{eq} = 5.9\,\Omega = R_{AB}$$

Now; $V = IR \Rightarrow V_{AB} = I_{AB} R_{AB}$

$$V_{AB} = 5 \times 5.9$$

$$\boxed{V_{AB} = 29.5\,V}$$

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(8) A wire is carrying a direct current of 20 A and a Sinusoidal alternating current of peak value 20 A. Find the Rms value of the resultant current in the wire.

Sol

$I_{DC} = 20A$; $(I_{max})_{A\text{-}C} = 20A$; $\longrightarrow I_{AC} = \frac{I_m}{\sqrt{2}} = \frac{20}{\sqrt{2}}$

$I_{Rms} = ?$

$$I_{Rms} = \sqrt{I_{DC}^2 + I_{AC}^2} = \sqrt{20^2 + \left(\frac{20}{\sqrt{2}}\right)^2}$$

$$= 24.5\,A$$

(9) A sine wave has a peak value of 25 V. State the following values a) RMS

b) peak to peak

c) average.

Sol

$V_p = 25V = V_m$

a) $V_{rms} = \frac{V_m}{\sqrt{2}} = \frac{25}{\sqrt{2}} = 17.675\ V$

b) $V_{p-p} = 2 \times V_m = 2 \times 25 V = 50 V$

c) $V_{avg} = \frac{2V_m}{\pi} = \frac{50 V}{\pi} = 15.9 V$

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(10) Coil of inductance 400 MH, and of negligable resistance, is connected to a 5 KHz supply. If the current flow is 15 mA, determine the supply voltage.

Ans

$L = 400 \cancel{\mu}H = 400 \times 10^{-6}$ H.

$f = 5 KHz = 5 \times 10^3$ Hz.

$I = 15 \cancel{m}A = 15 \times 10^{-3}$ A

$X_L = (2\pi f_L)\ \Omega = 2 \times \pi \times 5 \times 10^3 \times 400 \times 10^{-6}$

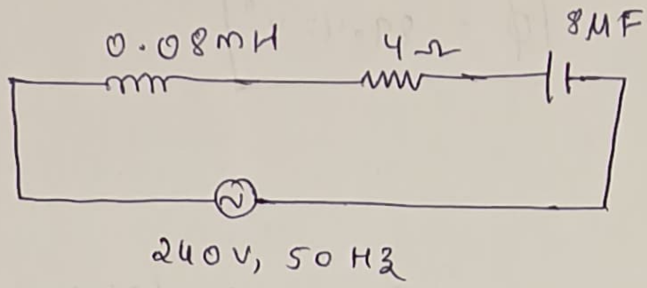
$X_L = 12.57\ \Omega$

$V = (I X_L)\ V = 15 \times 10^{-3} \times 12.57$

$V = 188.5\ mV$

(1) A 240 volts, 50 Hz, AC supply is applied a coil of 0.08H inductance and 4Ω resistance connected in series with a capacitor of 8μF. Calculate the following (i) Impedance (ii) current (iii) phase angle (iv) Active power.

Sol



(i) $X_C = \frac{1}{2\pi f C} = \frac{1}{2 \times 3.14 \times 50 \times 8 \times 10^{-6}} = 398.08\,\Omega$

$X_L = 2\pi f L = 2 \times 3.14 \times 50 \times 8 \times 10^{-5} = 0.02512\,\Omega$

$Z = R + j(X_L - X_C)$.

$|Z| = \sqrt{4^2 + (0.02512 - 398.08)^2}$

$|Z| = \sqrt{158459.80}$

$\boxed{|Z| = 398.07}$

(ii) $I = ?$; $V = IZ$

$I = V/Z = \frac{240}{398.07}$

$\boxed{I = 0.6029\,A}$

(iii) phase angle (ϕ) = ?

$$\tan\phi = \frac{X}{R} \Rightarrow \phi = \tan^{-1}\left(\frac{X}{R}\right)$$

$$\phi = \tan^{-1}\left(\frac{398.05}{4}\right)$$

$$\boxed{\phi = 89.424^\circ}$$

(iv) Active power (?)

$$P_{act} = VI\cos\phi = 240 \times 0.6029 \times \cos(89.424)$$

$$\boxed{P_{act} = 1.45\,W}$$

Extra

(v) Quality factor (?)

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

$$Q = \frac{1}{4}\sqrt{\frac{0.08 \times 10^{-3}}{8 \times 10^{-6}}}$$

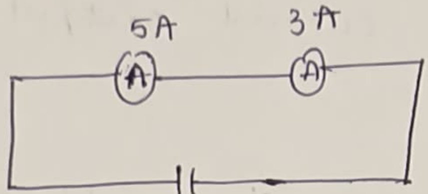
$$Q = 0.79 \text{ NO UNITS}$$

PART- B

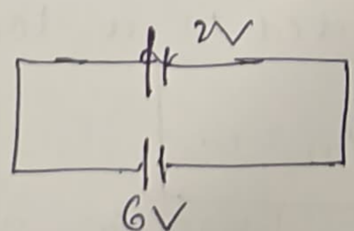
M - I

(1) Is it possible to connect directly two current sources 5A and 3A in series? And similarly can we connect directly two voltage sources 2v and 6v in parallel? Justify your answer.

Ans



If two current sources are connected in series aiding direction and they have exactly the same rated current, they can take on any voltage they like, the same or different -- it is undefined, since each can force its rated current regardless of the voltage either of them make. But if the rated current of one source is the tiniest bit larger than the other, the one which is with the larger rated current will start to increase its terminal voltage to try to achieve its rated current, and the other source will start to decrease its voltage to keep its current at its ~~and~~ rated value. The end point is that the one with the larger rated current will raise its terminal voltage to plus infinity and the one with the smaller rated current will decrease its terminal voltage to zero and then on to minus infinity.



You can only place voltage sources in parallel if they have the same voltage. This would be impossible to achieve with each source trying to maintain a different voltage across the same two nodes. This may result in damage to the sources like exploding batteries. The primary advantage for combining voltage sources in parallel is to increase the current output above that of any single source.

2&3Q) State and Explain Kirchhoff's voltage law and
4Q) Kirchhoff's current law with suitable diagrams.

3) Explain ohm's law with suitable example.

4) Make short notes on: practical sources and ideal sources.

Ans 2) Kirchhoff's law: It is related to the study of flow of current in the whole circuit. Mainly it is classified into two types.

a) Kirchhoff's voltage law: It states that, "The sum of the ~~currents~~ voltages ~~coming~~ around a loop or mesh is equal to zero."

→ based on law of conservation of Energy.

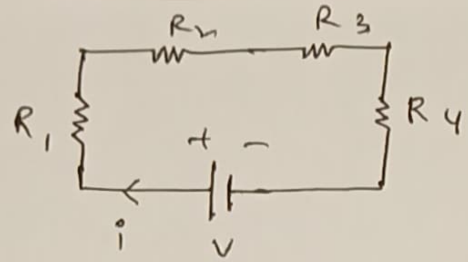
→ Also called as "Kirchhoff's second law."

→ It is independent of the nature of the network of elements that are connected to a loop or mesh.

→ mathematically; $\boxed{\sum_{n=1}^{N} V_n = 0.}$

V_n → n^{th} element Voltage in a loop.

N → No. of network elements in a loop.



Consider the above circuit with four resistances. Let the resistances be R_1, R_2, R_3 and R_4. Let 'v' is the voltage source across the loop and 'i' be the total current flowing across the loop. Then according to the KVL statement,

$$-iR_1 - iR_2 - iR_3 - iR_4 + V = 0$$

$$V = iR_1 + iR_2 + iR_3 + iR_4$$

$$V = V_1 + V_2 + V_3 + V_4.$$

(or)

simply; $\boxed{\sum_{n=1}^{N} V_n = 0.}$

b) <u>Kirchhoff's</u> <u>current law</u>: It states that, " the sum of the currents entering into node is equal to the sum of the currents leaving the node." simply, the Algebraic sum of currents in the circuit is zero.

→ based on law of conservation of charge

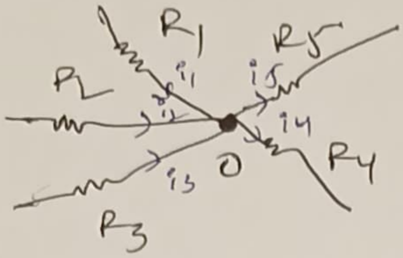
→ Also called as Kirchhoff's first law.

→ It is independent of the nature of network elements that are connected to a node.

→ mathematically; $\sum_{m=1}^{M} I_m = 0$

I_m → m^{th} branch current leaving the node.

M → No. of branches that are connected to the node.



Consider five resistors connected to the node named 'O'. Let the resistors be R_1, R_2, R_3, R_4 and R_5 and let the current flowing through the corresponding resistors be i_1, i_2, i_3, i_4, i_5. According to the KCL statement;

$$i_1 + i_2 + i_3 = -i_4 \mp i_5$$

$$\Rightarrow i_1 + i_2 + i_3 + i_4 + i_5 = 0 \quad \text{(or) simply}$$

$$\Rightarrow \boxed{\sum_{m=1}^{M} I_m = 0}$$

③ **OHM's LAW**: It states that 'at constant temperature, potential difference 'V' across the ends of a conductor is directly proportional to the current 'I' flowing through the conductor.

$$V \propto I$$

$$V = IR$$

where;

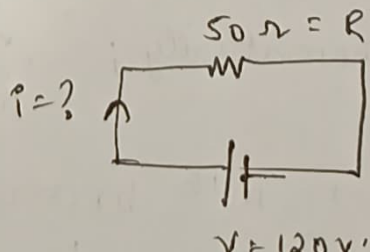
R → proportionality constant → Resistance.

Ex: To determine the amount of current flowing through a 50Ω resistor which is connected to a voltage source of 120V, then we use Ohm's law.

$I = ?$; $R = 50\Omega$; $V = 120V$

$V = IR \Rightarrow I = V/R = \frac{120}{50}$

$$\boxed{I = 2.4A}$$



(4) Ideal Sources : → An imaginary source.

→ No source internal resistance.

→ provide constant voltage / current.

→ Not available in market

Practical Sources : → Practically possible.

→ Source internal resistance.

→ Provide variable current / voltage.

→ Available in market.

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(6) List out the expressions of star to delta and delta to star transformation.

Sol Star to delta transformation :

$$R_1 = R_A + R_C + \frac{R_A R_C}{R_B}$$

$$R_2 = R_B + R_A + \frac{R_A R_B}{R_C}$$

$$R_3 = R_C + R_B + \frac{R_B R_C}{R_A}.$$

Delta to star transformation :

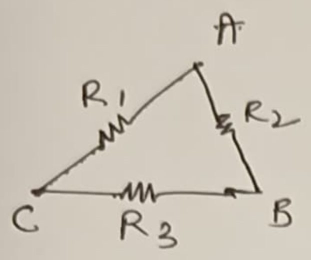
$$R_A = \frac{R_1 R_2}{R_1 + R_2 + R_3}.$$

$$R_B = \frac{R_2 R_3}{R_1 + R_2 + R_3}.$$

$$R_C = \frac{R_1 R_3}{R_1 + R_2 + R_3}.$$

(14) Derive the equivalent expressions for equivalent resistance while transforming from star to delta and delta to star.

Sol **Delta Network**: If three elements are connected in a closed path, then it is connected in delta.

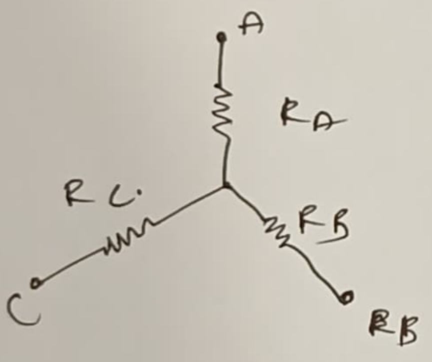


$$R_{AB} = \frac{(R_1+R_3)R_2}{R_1+R_2+R_3}$$

$$R_{BC} = \frac{(R_1+R_2)R_3}{R_1+R_2+R_3}$$

$$R_{CA} = \frac{(R_2+R_3)R_1}{R_1+R_2+R_3}.$$

Star Network: If three elements are meeting at node, then it is said to be connected in star network.



$$R_{AB} = R_A + R_B$$

$$R_{BC} = R_B + R_C$$

$$R_{CA} = R_C + R_A$$

Delta to star: Now;

$$R_A + R_B = \frac{(R_1+R_3)R_2}{R_1+R_2+R_3} \quad \text{--- (1)}$$

$$R_B + R_C = \frac{(R_1+R_2)R_3}{R_1+R_2+R_3} \quad \text{--- (2)}$$

$$R_C + R_A = \frac{(R_2+R_3)R_1}{R_1+R_2+R_3} \quad \text{--- (3)}$$

① + ② + ③

$$2(R_A + R_B + R_C) = \frac{2(R_1R_2 + R_2R_3 + R_3R_1)}{R_1 + R_2 + R_3}$$

$$R_A + R_B + R_C = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_1 + R_2 + R_3} \quad \text{— ④}$$

④ − ②

$$R_A + R_B + R_C - R_B - R_C = \frac{R_1R_2 + R_2R_3 + R_3R_1 - R_1R_3 - R_2R_3}{R_1 + R_2 + R_3}$$

$$\boxed{R_A = \frac{R_1R_2}{R_1 + R_2 + R_3}} \quad \text{— ⑤}$$

Similarly ④ − ③

$$\boxed{R_B = \frac{R_2R_3}{R_1 + R_2 + R_3}} \quad \text{— ⑥}$$

④ − ①

$$\boxed{R_C = \frac{R_3R_1}{R_1 + R_2 + R_3}} \quad \text{— ⑦}$$

<u>star to delta</u>

⑤ × ⑥ + ⑥ × ⑦ + ⑦ × ⑤

$$\Rightarrow R_AR_B + R_BR_C + R_CR_A = \frac{R_1R_2^2R_3 + R_1R_2R_3^2 + R_1^2R_2R_3}{(R_1 + R_2 + R_3)^2}$$

$$\Rightarrow R_AR_B + R_BR_C + R_CR_A = \frac{R_1R_2R_3\cancel{(R_2 + R_3 + R_1)}}{(R_1 + R_2 + R_3)^{\cancel{2}}}$$

$$R_A R_B + R_B R_C + R_C R_A = \frac{R_1 R_2 R_3}{R_1 + R_2 + R_3} \quad \text{--- (8)}$$

(8)/(5) $\rightarrow$ $$\frac{R_A R_B + R_B R_C + R_C R_A}{R_A} = \frac{R_1 R_2 R_3}{R_1 R_2}$$

$$\boxed{R_B + R_C + \frac{R_B R_C}{R_A} = R_3.}$$

Similarly

(8)/(6) $\rightarrow$ $$\boxed{R_A + R_C + \frac{R_A R_C}{R_B} = R_1}$$

(8)/(9) $\rightarrow$ $$\boxed{R_A + R_B + \frac{R_A R_B}{R_C} = R_2}$$

Hence derived

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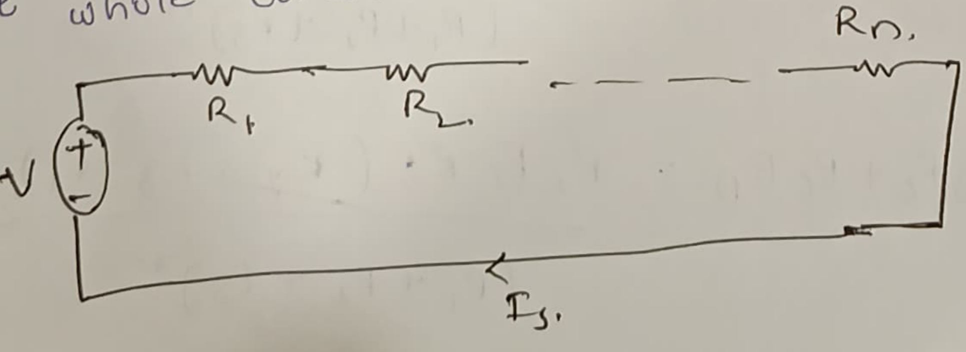
(12) & (13) Derive the equivalent resistance equations when they are connected in series and parallel.

Ans **Series:** Consider 'n' resistances named $R_1, R_2, R_3, \ldots, R_n$ which are connected in series and a battery of 'v' volts is connected and I_s be the current in the whole circuit.



We know that, in series circuit, current is same and voltage divides. Accd. to KVL;

$$V = V_1 + V_2 + \text{———} + V_n$$

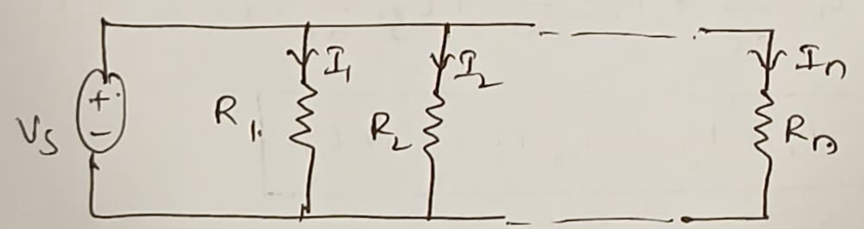
but; $V_1 = I_s R_1$; $V_2 = I_s R_2$, ——— $V_n = I_s R_n$

$$V = I_s R_{eq}$$

$$I_s R_{eq} = I_s R_1 + I_s R_2 + \text{———} + I_s R_n$$

$$\boxed{R_{eq} = R_1 + R_2 + \text{---} + R_n}$$

Parallel: Consider 'n' resistors named $R_1, R_2, — R_n$ which are connected in parallel and a battery of 'v' volts is connected and I_s be the current flowing at battery. I_s



We know that, in parallel circuit; voltage is same and the current divides. Accd to KCL

$$I_s = I_1 + I_2 + \text{———} + I_n$$

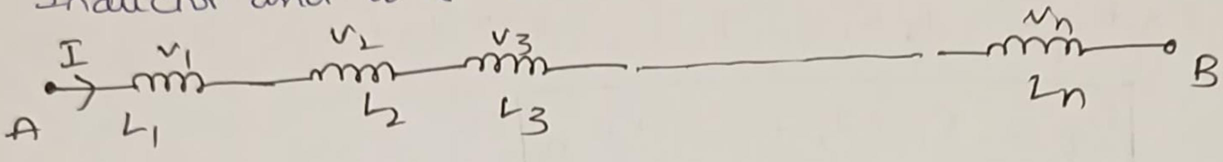
$$\frac{V_s}{R_{eq}} = \frac{V_s}{R_1} + \frac{V_s}{R_2} + \text{———} + \frac{V_s}{R_n}$$

$$\boxed{\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \text{———} + \frac{1}{R_n}}$$

(15) Desire the equivalent Inductance equations, when they
& are connected in series and parallel.
(20)

Sol

Series: Consider 'n' Inductors connected in series. let they be named as $L_1, L_2, L_3, \text{——} L_n$. The voltages across the inductors be as $V_1, V_2, V_3, \text{——} V_n$ respectively. The current 'I' is passes through the Inductor and it is same in the whole circuit below.



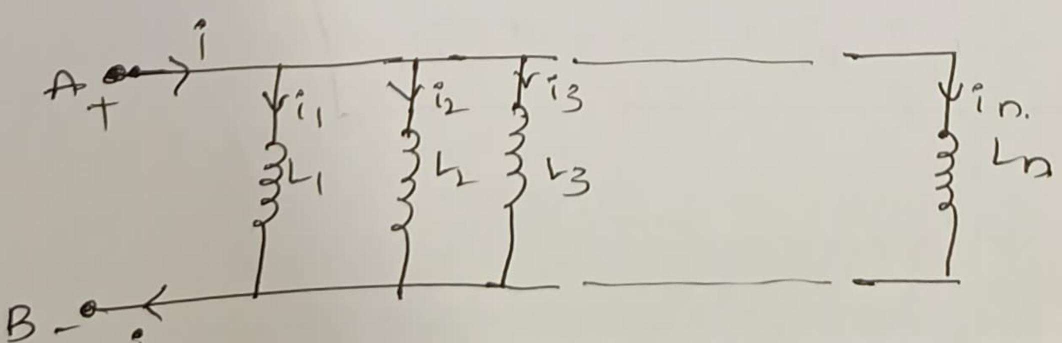
Accd. to KVL; $V = V_1 + V_2 + V_3 + \text{——} + V_n.$

But we know that ; $V = L \cdot \frac{di}{dt}$

$$L_{eq} \frac{di}{dt} = L_1 \cdot \frac{di}{dt} + L_2 \cdot \frac{di}{dt} + L_3 \cdot \frac{di}{dt} + \text{——} + L_n \frac{di}{dt}$$

$$\boxed{L_{eq} = L_1 + L_2 + L_3 + \text{——} + L_n}$$

Parallel: Consider 'n' Inductors connected in parallel. let $L_1, L_2, L_3, \text{——} L_n$ be named as Inductors having $i_1, i_2, i_3, \text{——} i_n$ as their corresponding currents. The potential difference across them is same and we know that in parallel circuit the current divides which is shown below



Accd. to KCL; $i = i_1 + i_2 + i_3 + \text{---} + i_n$.

we know that; $i = \frac{1}{L}\int v\,dt$

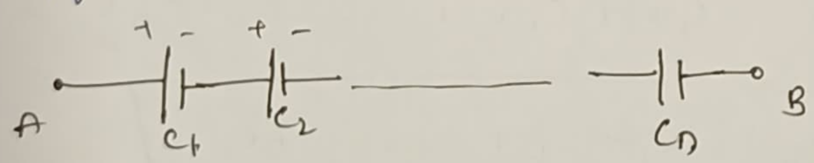
$$\frac{1}{L_{eq}}\int v\,dt = \frac{1}{L_1}\int v\,dt + \frac{1}{L_2}\int v\,dt + \frac{1}{L_3}\int v\,dt + \text{---} + \frac{1}{L_n}\int v\,dt$$

$$\boxed{\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \text{---} + \frac{1}{L_n}}$$

---

(5), (18) Derive the equivalent Capacitence equations, when they are connected in series and parallel.

Ans **Series:** Consider 'n' Capacitors which are connected in series and each capacitor has its respective voltage/potential differences. let the 'n' capacitors be $C_1, C_2, \text{---}\ C_n$ with 'n' corresponding voltages $V_1, V_2, \text{---}, V_n$ as shown in below figure.



When capacitors are connected in series, the magnitude of charge 'Q' on each capacitor is same i.e

$Q = C_1V_1 = C_2V_2 = \text{---} = C_nV_n$.

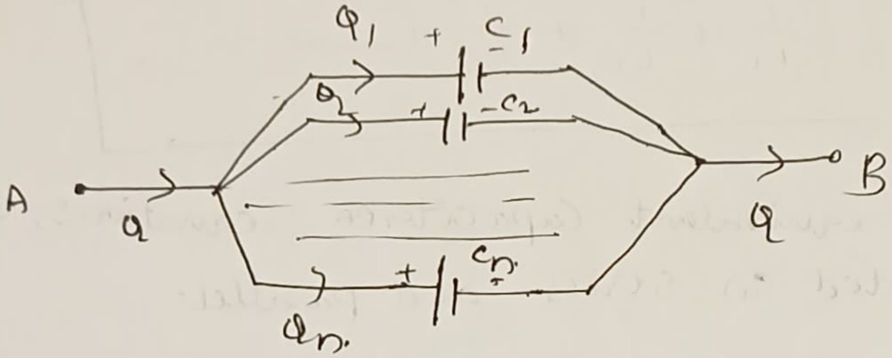
The potential difference across the combination is,

$$V = V_1 + V_2 + \text{---} + V_n$$

$$\frac{Q}{C_{eq}} = \frac{Q}{C_1} + \frac{Q}{C_2} + \text{---} + \frac{Q}{C_n}$$

$$\boxed{\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \text{———} + \frac{1}{C_n}}.$$

Parallel: Consider 'n' capacitors which are connected in parallel in between two point a & b as shown in below figure. let the 'n' capacitors be $C_1, C_2, \text{—} C_n$ with their corresponding charges $Q_1, Q_2, \text{—}, Q_n$.



When capacitors are connected in parallel, the potential difference 'V' across each capacitor is same

we know that; $Q = CV$.

But $Q = Q_1 + Q_2 + \text{———} + Q_n$

$$C_{eq} V = C_1 V + C_2 V + \text{———} + C_n V$$

$$\boxed{C_{eq} = C_1 + C_2 + \text{———} + C_n}.$$

---

(7) Describe the method used to determine loop currents for multiple loop network with an neat example.

Ans Mesh is a loop that doesn't contain any other loops inside it. Loop is a path that terminates at the same node where it started from.

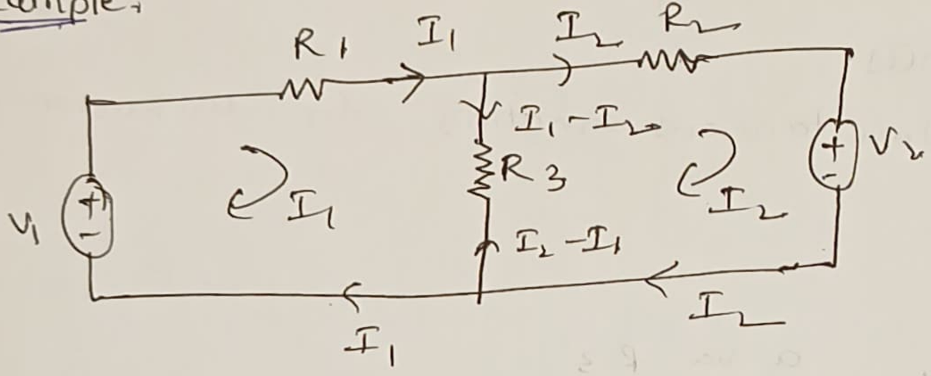
Steps: ① Identify all the loops in network and select a loop/mesh currents.

② Sign conventions for the iR drops and currents source/battery Emf's are the same as for KVL.

③ Apply KVL around the mesh and use Ohm's law to express the branch voltage in terms of unknown mesh currents & resistance.

④ Solve the simultaneous equations for the unknown loop currents.

Example:



Find I_1 and I_2?

Mesh - 1: $I_1R_1 + (I_1 - I_2)R_3 - V_1 = 0$

$I_1R_1 + I_1R_3 - I_2R_3 = V_1$ —①

Mesh - 2: $(I_2 - I_1)R_3 + I_2R_2 + V_2 = 0$

$I_1R_3 - I_2(R_2 + R_3) = V_2$ —②

solving ① & ② ; we get the loop currents I_1 & I_2.

⑧ Summarize the procedure to calculate the node voltages of an electrical network using nodal analysis.

Ans **Procedure to follow in Nodal Analysis:**

① Identify all the nodes in network and select node voltages.

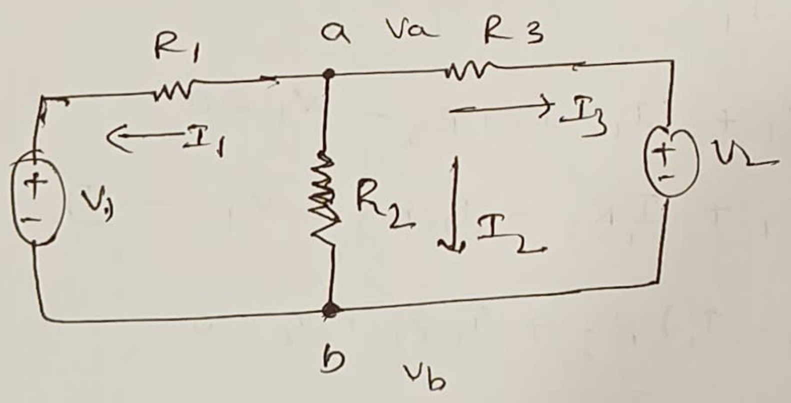
② One of these nodes is taken as reference node, which is at zero potential.

③ Node voltages are measured with respective to the reference node.

④ Apply KCL at each node and use Ohm's Law to express branch current in terms of unknown node voltages & branch resistances.

⑤ Solve the simultaneous equations for unknown node voltages.

Example:



$$\Rightarrow \quad I_1 + I_2 + I_3 = 0$$

$$\Rightarrow \quad \frac{V_a - V_1}{R_1} + \frac{V_a - V_b}{R_2} + \frac{V_a - V_2}{R_3} = 0.$$

---

(16) & Derive the expression for average and RMS values of a sine wave

(17) Mention the process of a sinusoidal voltage waveform (AC) Generation? Also list the expressions of the averaged RMS values of the periodic voltage that are computed?

Sol:

Average value: The average value of voltage is the average of all the instantaneous values during half cycle.

* They are actually DC values.

Mathematically; $V_{avg} = \dfrac{V_1 + V_2 + V_3 + \text{---} + V_n}{n}$

Analytically; $F_{avg} = \dfrac{1}{T}\displaystyle\int_0^T f(t)\,dt$.

Let us consider sinusoidal voltage as $e = E_m \sin\theta$.

a) Avg. value of voltage over complete cycle,

$$E_{avg} = \frac{1}{2\pi}\int_0^{2\pi} E_m \sin\theta \, d\theta$$

$$E_{avg} = \frac{E_m}{2\pi}\int_0^{2\pi} \sin\theta \, d\theta$$

$$\boxed{E_{avg} = 0}$$

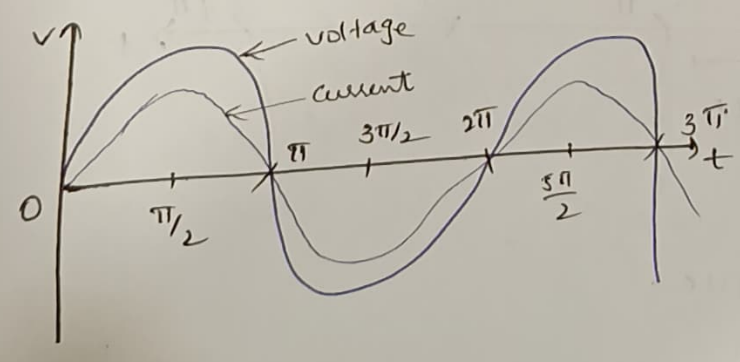
b) Avg. value of voltage over half cycle,

$$E_{avg} = \frac{1}{\pi}\int_0^{\pi} E_m \sin\theta \, d\theta$$

$$E_{avg} = \frac{E_m}{\pi}\int_0^{\pi} \sin\theta \, d\theta$$

$$\boxed{E_{avg} = \frac{2E_m}{\pi}}$$

wave form:



RMS value: Rms value of an AC voltage is defined as that constant voltage which produces the same amount of heat energy as produced by the AC voltage, when both are applied to the same circuit at the same time period.

Mathematically; $V_{rms} = \sqrt{\dfrac{v_1^2 + v_2^2 + v_3^2 + \cdots + v_n^2}{n}}$

Analytically; $F_{rms} = \sqrt{\dfrac{1}{T}\int_0^T f(t)^2\,dt}$.

Let us consider the sinusoidal voltage.

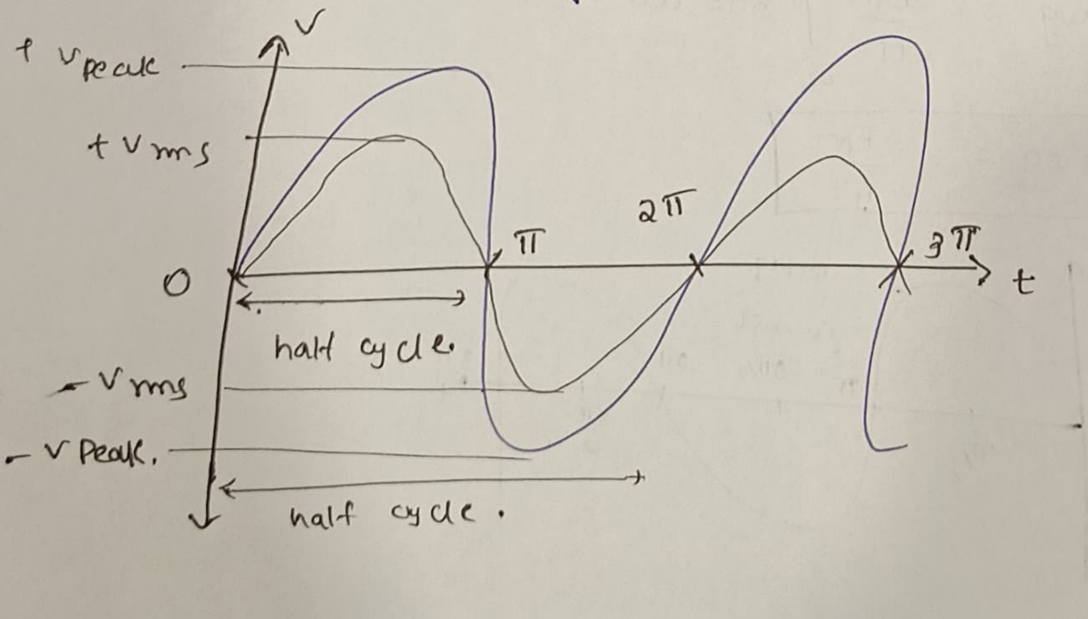
$$e = E_m \sin\theta$$

a) E_{rms} of voltage over complete cycle.

$$E_{rms} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi} (E_m \sin\theta)^2\, d\theta}$$

$$E_{rms} = \frac{E_m}{\sqrt{2}}$$

Similarly $I_{rms} = \dfrac{I_m}{\sqrt{2}}$.



Explain the concept of reactance, Impedance, susceptance and admittance, rectangular and polar forms.

- **Reactance** (X): Opposition of circuit element to an AC signal, due to that element's inductance / capacitance.

→ X_L = Inductive reactance = $2\pi fL$.
X_C = Capacitive reactance = $1/2\pi fC$.

→ measured in ohms (Ω)
→ observed for AC not for DC.

Impedance (Z): The total opposition offered to flow of a sinusoidal current. (or) the ratio of sinusoidal voltage to sinusoidal current.

* $\boxed{Z = \cancel{\ } \ V/I}$. and $\boxed{Z = R + j(X_L - X_C)}$

* Real part of Impedance - resistance.
complex part of Impedance - reactance.
Imaginary

Susceptance (B): The reciprocal of reactance can be termed as the susceptance. (or) the expression of the readiness with which an electric component, circuit or system releases stored energy as the current & voltage fluctuate.

→ measured in mho $(\mho)$ / siemens.

$$\boxed{B = 1/X}$$

→ expressed in imaginary number of siemens.

→ Observed with AC, but not for DC.

Admittance (Y): The reciprocal of Impedance can be termed as Admittance. (or)

* $\boxed{Y = 1/Z = I/V}$

~~Measured in~~ Also; $\boxed{Y = G + jB}$

G → Conductance → $1/R$.

(or)

→ Allowance of circuit elements to the flow of AC or DC.

Rectangular form: It is the form, where the complex number is denoted by its respective horizontal and vertical components i.e y and x axes respectively.

for Ex: $4 + 4j$ * $a + jb$.

polar form: The polar form is where a complex number is denoted by the length and the angle of its vector.

for Ex: $8.49 \angle 45°$. * $\sqrt{a^2+b^2}$ $\tan^{-1}(b/a)$

Remember: Conductance → $G = 1/R$ — resistance.

Suseptance → $B = 1/X$ — reactance

Admittance → $Y = 1/Z$ — Impedance.

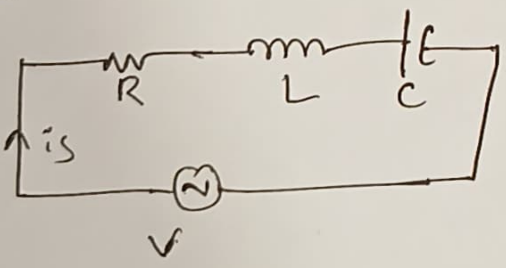
(16) Draw and Explain series RLC circuit in AC circuit Analysis?

Ans

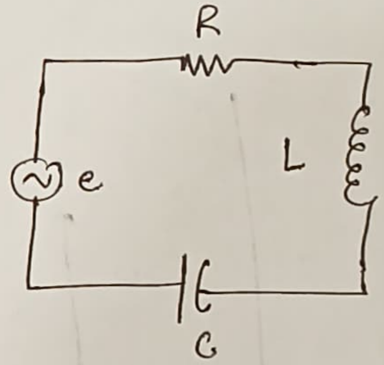
If any AC source is present in any electrical network / circuit. It is known as an AC network / circuit. One of the basic connections is series RLC circuit.

Series RLC circuit:

In the series RLC circuit, we observe that, an AC voltage source is connected to resistor (R); Inductor (L) and Capacitor (C) which are connected in series which is shown in below figures.



(or)



We know that, the current is constant or same in series connections, where as, the supply voltage (AC) gets divided among the passive elements.

Expression for Impedance in the Series RLC circuit:

$$Z = R + j(X_L - X_C).$$

$$\boxed{Z = R^2 + (X_L - X_C)^2.} \rightarrow \text{magnitude of Impedance.}$$

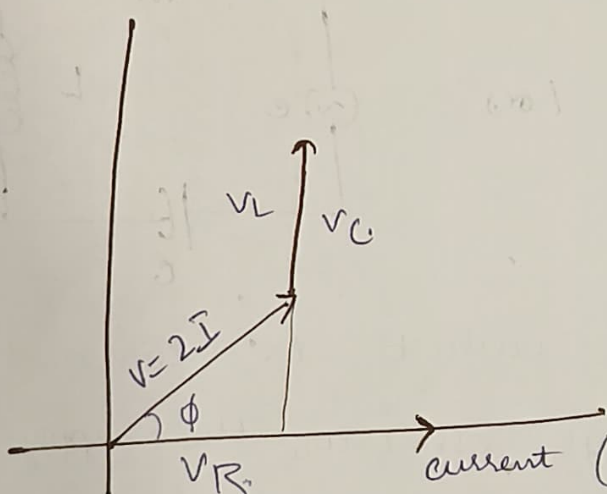
where; $R \rightarrow$ resistance

$X_L \rightarrow$ Inductive reactance.

$X_C \rightarrow$ Capacitive reactance.

* In Series RLC circuit, the current (I) is given by $\boxed{I = V/Z}$

* In rectangular form, the impedance can be written as; $\boxed{Z = R + j(X_L - X_C)}$



* phase angle $\boxed{\phi = \tan^{-1}\left(\frac{X_L - X_C}{R}\right).}$

$X_L = \omega L$

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

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

(9) Define the terms Peak, peak to peak, average, Rms values, peak factor and form factor of sine wave.

Ans **Peak**: The maximum +ve or -ve value attained by an alternating quantity in one complete cycle is called as Peak value.

* It is represented by E_m or V_m for voltages and I_m for current respectively.

Peak to Peak value: The peak to peak value of a sine wave is the value from the positive peak to the negative peak.

* $V_{p-p} = 2V_m / 2V_p$.

Average value: The average value of voltage is the average of all the instantaneous values during half cycle

→ They are actually DC values.

$$* \; V_{avg} = \frac{v_1 + v_2 + \text{---} + v_n}{n}$$

RMS values: The RMS value of a voltage is defined as that constant voltage which produces the same amount of heat energy as produced by the AC voltage, when both are applied to the same circuit at same time period.

$$* \; V_{rms} = \sqrt{\frac{v_1^2 + v_2^2 + \text{---} + v_n^2}{n}}$$

Peak factor: Peak factor of a sinusoidal wave is defined as the ratio of peak value to the rms value of the wave.

* Peak factor = $\frac{V_m}{V_{rms}}$

Form factor: It is defined as the ratio of rms value to the average value of the sine wave.

* Form factor = $\frac{V_{rms}}{V_{avg}}$

---

(19) Define (i) wave form (ii) cycle (iii) frequency and (iv) Time period ? what is frequency in AC and DC.

Ans (i) **wave form**: The shape obtained by plotting the instantaneous values of an alternating quantity such as voltage and current along the Y-axis and time or angle along the X-axis is called a wave form.

(ii) **cycle**: When one set of +ve and -ve values completes by an alternating quantity or it goes through 360° electrical, it is said to have one complete cycle.

(iii) **frequency**: The No. of cycles made per second by an alternating quantity is called frequency (f)

* Measured in Hertz (Hz) (or) cycle per second.

(iv) **Time period**: The time taken in seconds by a voltage or a current to complete one cycle is called Time period.

* Denoted by 'T'

→ The frequency of AC is dependent upon the country. Generally the frequency is 50 Hz or 60 Hz.

→ The DC has no frequency or zero frequency.