BASIC ELECTRICAL ENGG.

Classification of source

i) Based on

Unit I → Review of basic concept & network theories

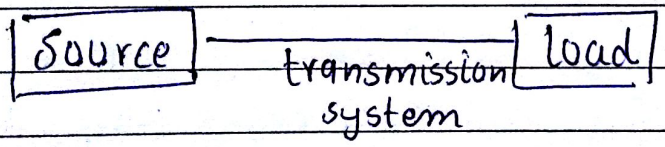
Unit II → Single phase AC circuits

Unit III → Three phase AC circuits

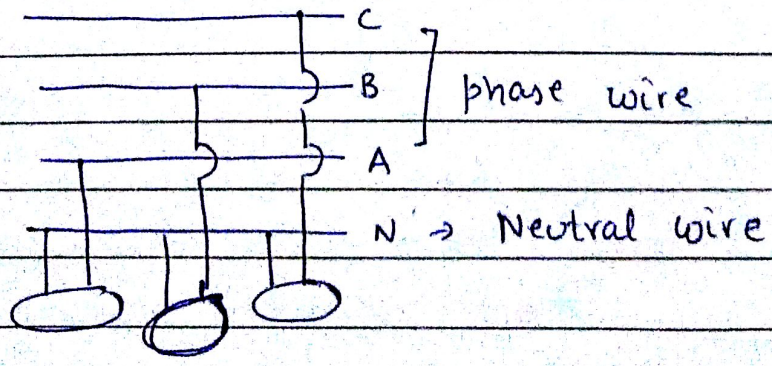
Unit IV → Magnetic circuits are transformer

Unit V → Measuring instruments.

The medium used for transmitting electrical energy is transmission system.



nature of first transmission system
→ Thomas elva eddison



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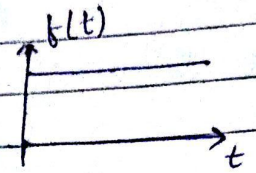
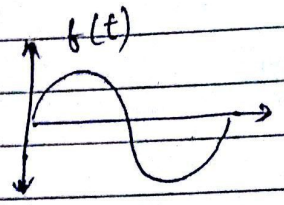
Classification of sources

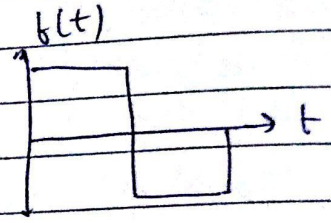
i) Based on dependence on time

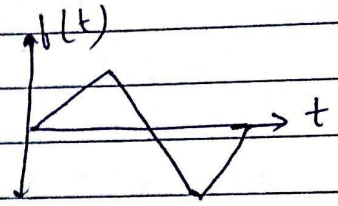
(a) DC sources (fixed with change of time)



(b) AC source (changes with change of time)







ii) Based on voltage or current

(a) Voltage sources (voltage remain fixed with the change of load wires)

The voltage sources are those sources whose terminal voltage remains constant or range in a limited range with a changed load current

(b) Current sources (current remains fixed)

Current sources are those source whose current magnitude remains constant or vary in a limited range with the change in load voltage

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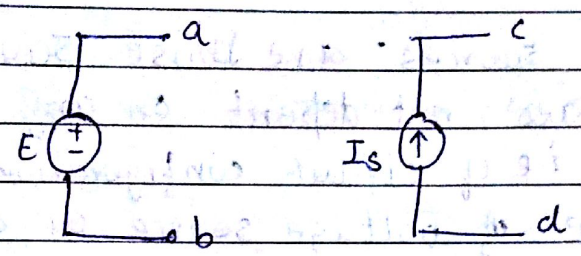
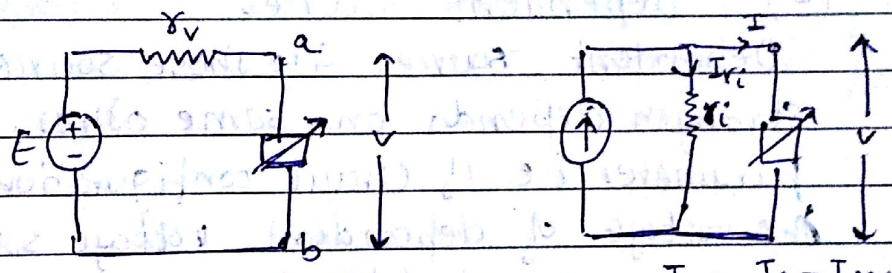
iii) Based on practicability of sources

(a) Ideal Sources : Ideal sources are those sources whose strength remains fixed with the change in load for voltage sources, terminal voltage remains fixed. for current source output current remains fixed.



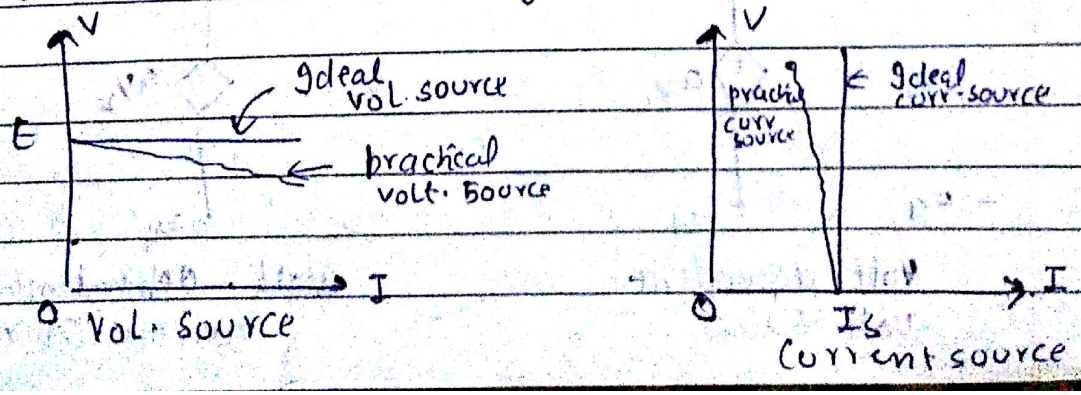
(b) Practical Sources



$V = E - Ir_v$ $\qquad$ $I = I_s - Ir_i$

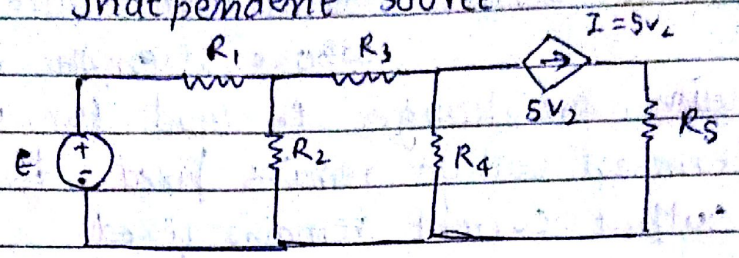
$= I_s - V/r_i$

The practical sources are those sources whose strength diminishes with increase in load. For practical voltage source, voltage across the load decrease with increase in current to the load and for practical current sources, the current through the load decreases with the increase in voltage across the load.



(iv) Based on dependency upon circuit parameter

(a) Independent source

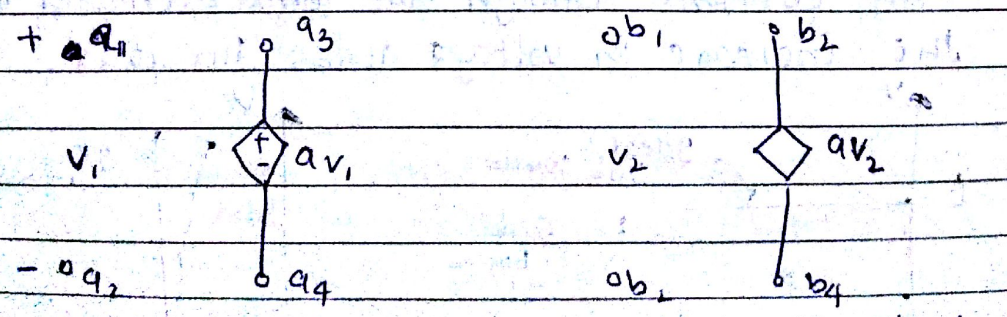


Independent sources are those sources whose strength does not depent on any other circuit parameter i.e if circuit configuration is changed the voltage of voltage source or current of current source remain unchanged.

(b) Dependent Sources

Dependent sources are those sources whose strength depends on some other circuit parameter i.e if circuit configuration is changed the voltage of dependent voltage source and the current of dependent current source will be change

For the given above circuit for current of dependent current source is $5V_2$ which is dependent upon voltage across resistance (R_3)



Volt. dependent Volt. source

Volt. dependent current source

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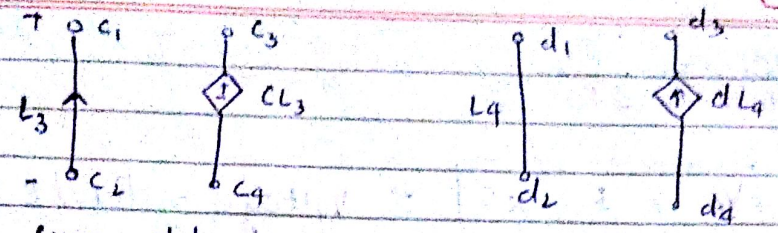
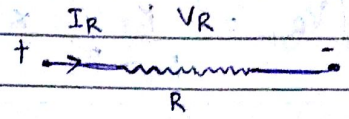


curr. dependent vol-source

curr. dependent curr. source

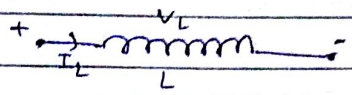
LOADS

→ Resistor



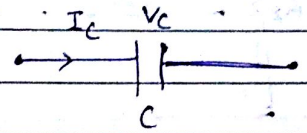
⇒ $V_R = I_R R(\Omega)$ (Amp) (volt) Ohm's law

→ Inductor



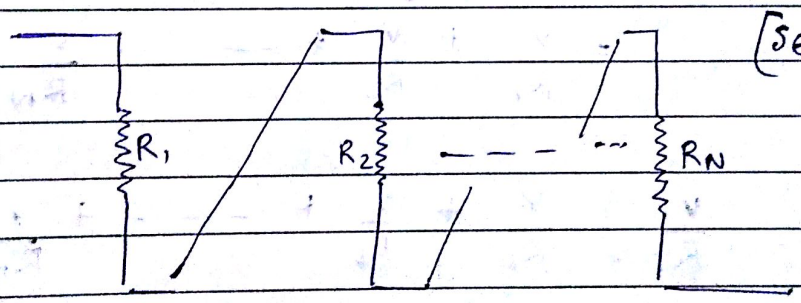
⇒ $V_L = L \frac{dI_L}{dt}$ (Henry, H)

→ Capacitor

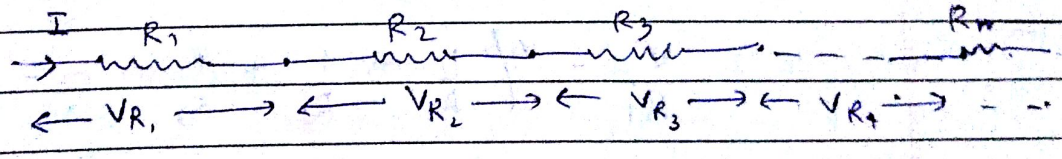


⇒ $V_C = \frac{1}{C}\int I\,dt$ (farad, F)

RESISTORS



[Serial combination]



$$V = V_{R_1} + V_{R_2} + V_{R_3} + V_{R_4} \cdots V_{R_N}$$

$$= IR_1 + IR_2 + IR_3 \cdots IR_N$$

$$V = I(R_1 + R_2 + R_3 + \cdots R_N)$$

$$\frac{V}{I} = R_T \Rightarrow \boxed{V = IR_T}$$

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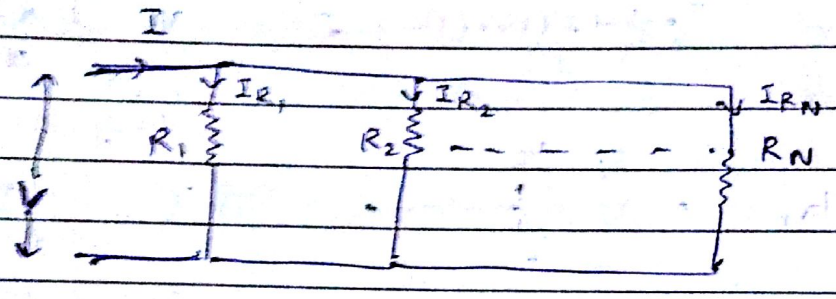
$$\frac{V_{R_1}}{V} = \frac{IR_1}{IR_T}$$

$$\boxed{V_{R_1} = \frac{R_1}{R_T} \times V}$$ → Voltage - divide Rule

For two resis R_1 & R_2 in series

$$\boxed{V_{R_1} = \frac{R_1}{R_1 + R_2} \times V}$$



$$I = I_{R_1} + I_{R_2} + \cdots + I_{R_N}$$

$$= \frac{V}{R_1} + \frac{V}{R_2} + \cdots \frac{V}{R_N}$$

$$\frac{V}{R_T} = \frac{V}{R_1} + \frac{V}{R_2} + \cdots + \frac{V}{R_N}$$

$$\frac{V}{R_T} = V\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots \frac{1}{R_N}\right)$$

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots \frac{1}{R_N}$$

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$$I_{R_1} = \frac{V}{R_1}$$

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

$$\frac{I_{R_1}}{I} = \frac{1/R_1}{1/R_T} = \frac{R_T}{R_T}$$

$$\boxed{I_{R_1} = \frac{R_T}{R_1} \times I}$$ current-divide rule

For R_1 & R_2 connected in //

$$I_{R_1} = \frac{1}{R_1} \times \frac{1}{1/R_T} \times I$$

$$= \frac{1}{R_1} \times \frac{1}{1/R_1 + 1/R_2} \times I$$

$$= \frac{1}{R_1} \times \frac{R_1 \times R_2}{R_1 + R_2} \times I$$

$$\boxed{I_{R_1} = \frac{I R_2}{R_1 + R_2}}$$

INDUCTOR $L_1, L_2 \ldots L_N$

Series $L_T = L_1 + L_2 + L_3 + \ldots L_N$

// Combi $= \frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \ldots \frac{1}{L_N}$

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CAPACITOR

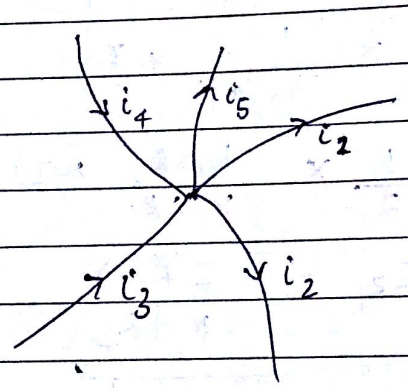
series $= \frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \text{---} \frac{1}{C_N}$

//Combi $C_T = C_1 + C_2 + \text{———} C_N$

KIRCHOFF'S LAW

KCL ↓ Kirchoff current law

KVL ↓ Kirchoff Voltage Law

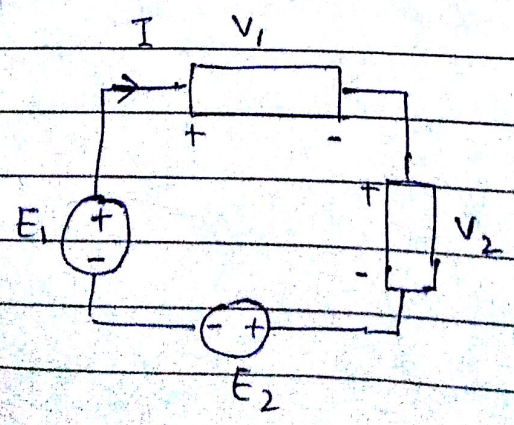


[KCL]

for outgoing current as +ve

$$i_1 + i_2 + i_5 - i_3 - i_4 = 0$$

$$i_1 + i_2 + i_5 = i_3 + i_4$$



[KVL]

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Taking voltage rise as +ve

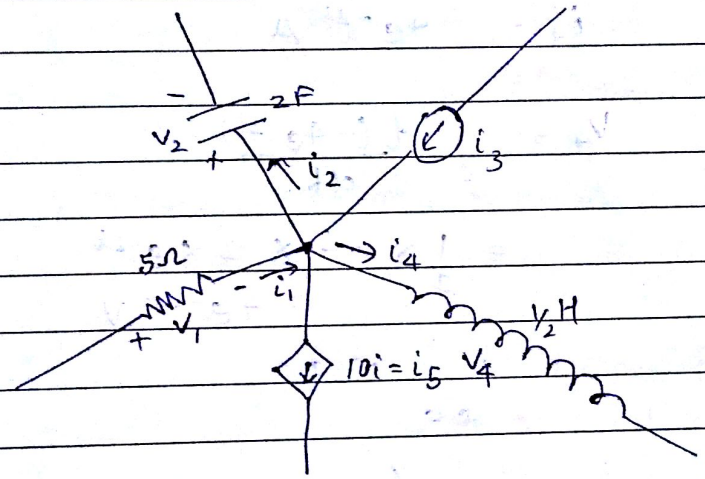
$$E_1 - V_1 - V_2 - E_2 = 0$$

$$E_1 = V_1 + V_2 + E_2$$

$$IE_1 = IV_1 + IV_2 + IE_2$$

Power supplied by E_1 — Power consumed by V_1 — Power consumed by V_2 — Power consumed by E_2

Ques



$V_1 = 10e^{-2t}$

$V_2 = 2e^{-2t}$

$i_3 = 6e^{-2t}$

Find V_4

$$V = L\frac{dI}{dt}$$

$$V_4 = \frac{1}{2}\frac{di_4}{dt}$$

$$i_4 = ??$$

$$i_1 = \frac{V_1}{R_1} = \frac{10e^{-2t}}{5} = 2e^{-2t}\ A$$

$$i_2 = C\frac{dV_2}{dt} = \frac{2\,d(2e^{-2t})}{dt}$$

$$= -8e^{-2t}\ A$$

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$i_3 = 6e^{-2t}$

$i_5 = 10 \times i_1 = 20e^{-2t}$ A

input current are assumed as +ve

$i_1 - i_2 + i_3 - i_4 - i_5 = 0$

$i_1 + i_3 = i_2 + i_4 + i_5$

$i_4 = 2e^{-2t} + 6e^{-2t} + 8e^{-2t} + 20e^{-2t}$

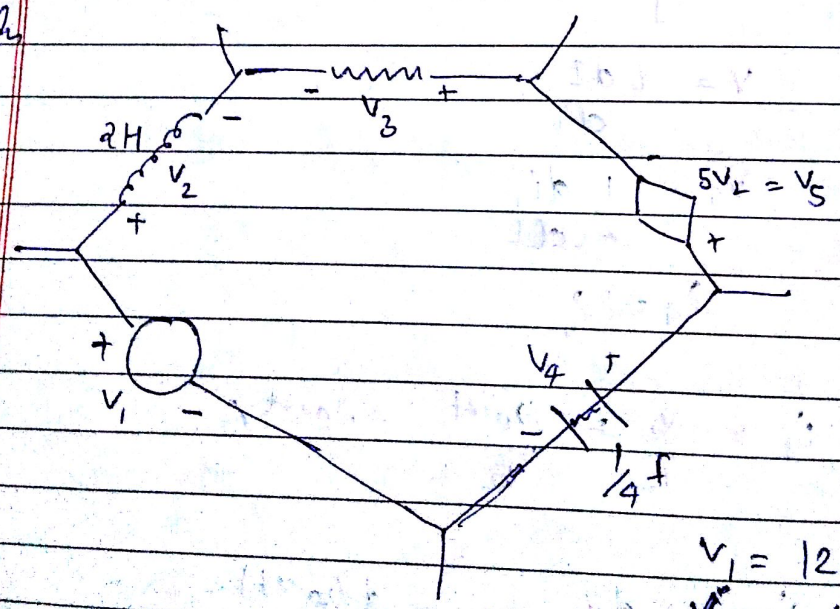
$i_4 = -4e^{-2t}$ A

$V_4 = \frac{1}{2} \frac{d(-4e^{-2t})}{dt}$

$= \frac{1}{2} \times -4 \times -2 \times e^{-2t}$

$= 4e^{-2t}$ V

Q



$V_1 = 12\sin 2t$

$V_2 = 4\sin 2t$

$i_3 = 2\sin 2t - 4\cos 2t$

$V_4 = ?$

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$$i = C\frac{dv}{dt}$$

$$i_4 = C\frac{dv_4}{dt}$$

$$v_2 = L\frac{di_2}{dt} = 2\frac{d}{dt}(4\sin 2t)$$

$$= 16\cos 2t \text{ V}$$

$$v_3 = Ri_3 = 5(2\sin 2t - 4\cos 2t)$$

$$= 10\sin 2t - 20\cos 2t \text{ V}$$

$$v_5 = 5v_2 = 5 \times 16\cos 2t$$

$$= 80\cos 2t \text{ V}$$

Taking voltage rise as +ve

$$v_1 - v_2 + v_3 + v_5 - v_4$$

$$12\sin 2t - 16\cos 2t + 10\sin 2t - 20\cos 2t + 80\cos 2t - v_4 = 0$$

$$v_4 = (22\sin 2t + 44\cos 2t) \text{ V}$$

$$i_4 = C\frac{dv_4}{dt}$$

$$= \frac{1}{4}\frac{d}{dt}(22\sin 2t + 44\cos 2t)$$

$$= \frac{1}{4}(44\cos 2t - 88\cos 2t)$$

$$= (11\cos 2t - 22\cos 2t) \text{ A}$$

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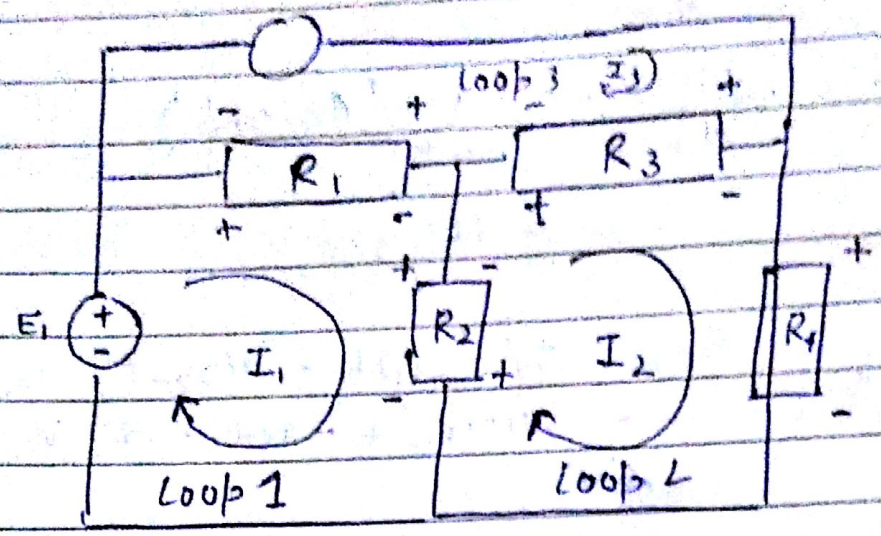
MESH ANALYSIS



For loop 1

$$E_1 - R_1(I_1 - I_3) - R_2(I_1 - I_2) = 0$$

$$E_1 - (R_1 + R_2)I_1 + R_2 I_2 + R_1 I_3 = 0 \quad -(1)$$

For loop 2

$$-R_2(I_2 - I_1) - R_3(I_2 - I_3) - R_4 I_2 = 0$$

$$R_2 I_1 - (R_2 + R_3 + R_4)I_2 + R_3 I_3 = 0 \quad -(2)$$

For loop 3

$$E_2 - R_3(I_3 - I_2) - R_1(I_3 - I_1) = 0$$

$$E_2 + R_1 I_1 + R_3 I_2 - (R_1 + R_3)I_3 = 0 \quad -(3)$$

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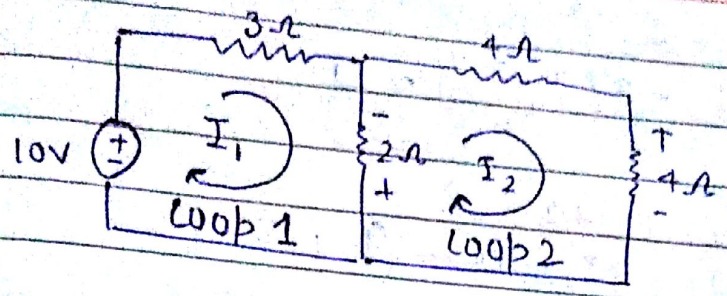
Qus



For I in each branch

Loop 1

$$10 - 3I_1 - 2(I_1 - I_2) = 0$$
$$10 - 5I_1 + 2I_2 = 0$$
$$5I_1 - 2I_2 = 0 \quad - (1)$$

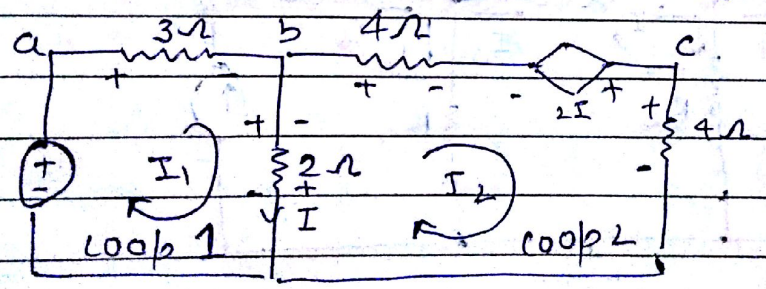
Loop 2

$$-2(I_2 - I_1) - 4I_2 - 4I_2 = 0$$
$$-2I_2 + 2I_1 - 8I_2 = 0$$
$$2I_1 = 10I_2$$
$$I_1 = 5I_2$$
$$5(5I_2) - 2I_2 = 0$$

$$I_2 = \frac{10}{23} A$$

$$I_1 = \frac{50}{23} A$$

Qus



KVL for Loop 1

Take the Voltage rise as +ve

$$10 - 3I_1 - 2(I) = 0$$

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$$I = I_1 - I_2$$

$$\therefore \quad 10 - 3I_1 - 2(I_1 - I_2) = 0$$

$$10 - 5I_1 + 2I_2 = 0$$

$$5I_1 - 2I_2 = 10 \quad - (1)$$

KVL for loop 2

$$-2(I_2 - I_1) - 4I_2 + 2I - 4I_2 = 0$$

$$I = I_1 - I_2$$

$$-2I_2 + 2I_1 - 4I_2 + 2I_1 - 2I_2 - 4I_2 = 0$$

$$4I_1 = 12I_2$$

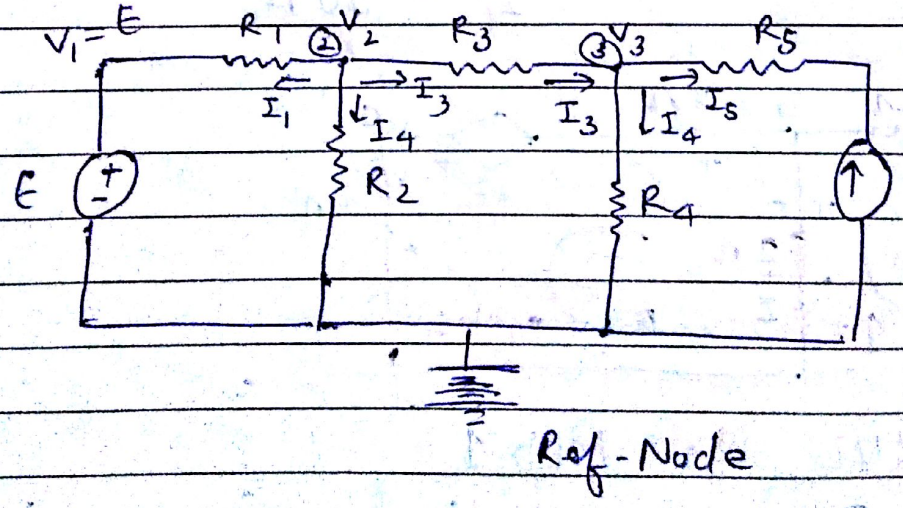
$$\boxed{I_1 = 3I_2} \quad - (2)$$

$$I_2 = \frac{10}{13} \text{ A}$$

$$I_1 = \frac{30}{13} \text{ A}$$

$$I = \frac{20}{13} \text{ A}$$

NODAL ANALYSIS



Ref-Node

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KCL eq. at node (2)

$$I_1 + I_2 + I_3 = 0$$

$$\frac{V_2 - E_1}{R_1} + \frac{V_2}{R_2} + \frac{V_2 - V_3}{R_3} = 0$$

$$\boxed{V_2\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right) - \frac{V_3}{R_3} - \frac{E}{R_1} = 0}$$

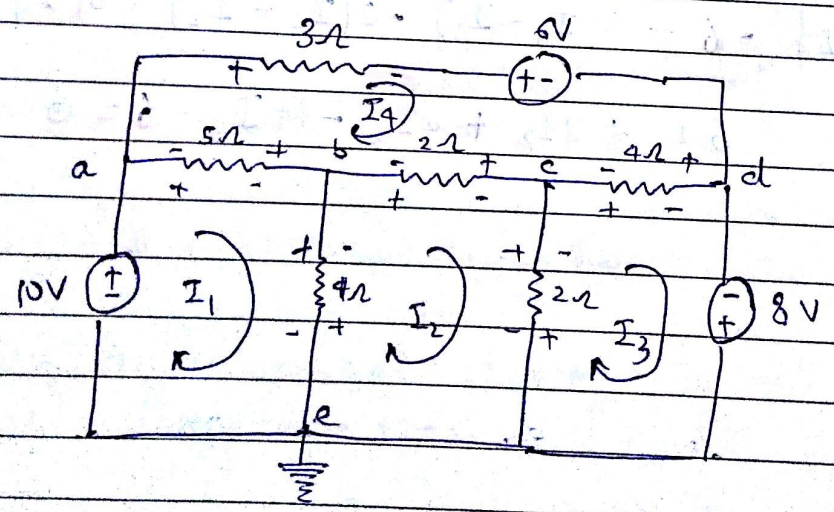
KCL eq for node (3)

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

$$-\frac{(V_2 - V_3)}{R_3} + \frac{V_3}{R_4} - I = 0$$

$$\boxed{-\frac{V_2}{R_3} + V_3\left(\frac{1}{R_3} + \frac{1}{R_4}\right) - I = 0}$$

Que



(a) Find the voltage at node 'b' and 'c' using mesh analysis

(b) Find current through 3Ω resistance using nodal analysis

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KVL equation

(a) For Loop 1

$$10 - 5(I_1 - I_4) - 4(I_1 - I_2) = 0$$

$$10 - 9I_1 + 5I_4 + 4I_2 = 0 \quad - (1)$$

For Loop 2

$$-4(I_2 - I_1) - 2(I_2 - I_4) - 2(I_2 - I_3) = 0$$

$$4I_1 - 8I_2 + 2I_3 + 2I_4 = 0 \quad - (2)$$

For loop 3

$$-2(I_3 - I_2) - 4(I_3 - I_4) + 8 = 0$$

$$2I_1 - 6I_3 + 4I_4 + 8 = 0$$

For loop 4

$$-3I_4 - 6 - 4(I_4 - I_3) - 2(I_4 - I_2) - 5(I_4 - I_1) = 0$$

$$5I_1 + 2I_2 + 4I_3 - 14I_4 - 6 = 0 \quad - (4)$$

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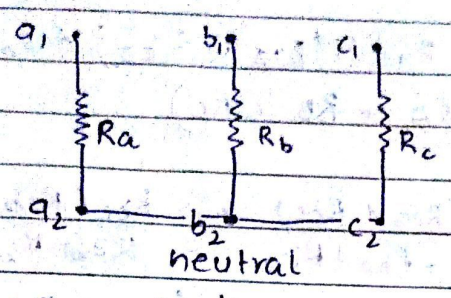
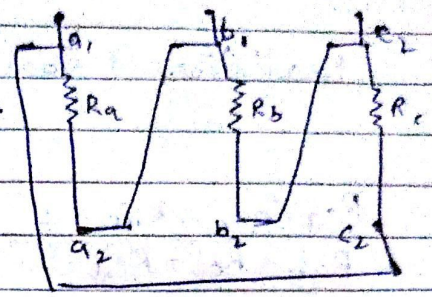
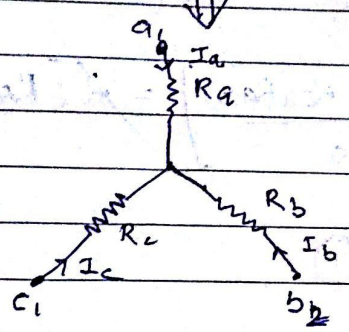
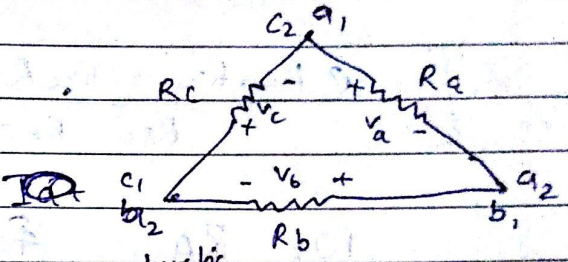
STAR & DELTA CONNECTION





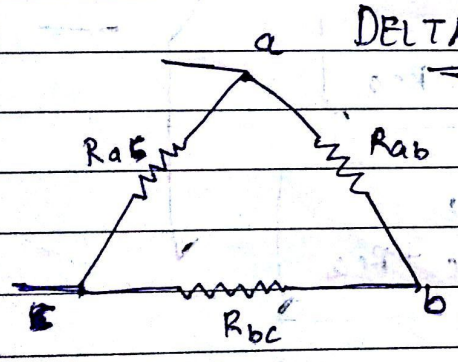


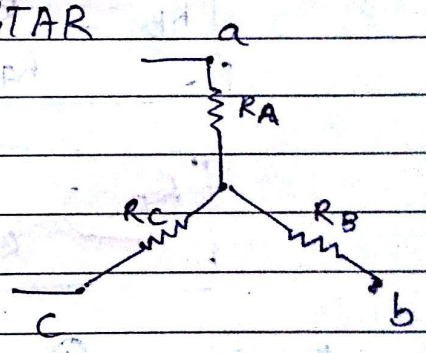


characterstics eq of star connection $\boxed{I_a + I_b + I_c = 0}$

characteristic eq of delta connection $\boxed{V_a + V_c + V_b = 0}$

DELTA TO STAR





b/w terminal a & c

$$R_{ca} \parallel (R_{ab} + R_{bc}) = R_A + R_C \quad - (1)$$

b/w terminal a & b

$$R_{ab} \parallel (R_{ca} + R_{bc}) = R_A + R_B \quad - (2)$$

b/w terminal b & c

$$R_{bc} \parallel (R_{ab} + R_{ca}) = R_B + R_C \quad - (3)$$

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① + ② + ③

$$R_{ca} \| (R_{ab} + R_{bc}) + R_{ab} \| (R_{ca} + R_{bc}) + R_{bc} \| (R_{ab} + R_{ca})$$
$$= 2(R_A + R_B + R_C)$$

$$\frac{R_{ca}(R_{ab} + R_{bc})}{R_{ab} + R_{bc} + R_{ca}} + \frac{R_{ab}(R_{ca} + R_{bc})}{R_{ab} + R_{bc} + R_{ca}} + \frac{R_{bc}(R_{ab} + R_{ca})}{R_{ab} + R_{bc} + R_{ca}}$$
$$= 2(R_A + R_B + R_C)$$

$$\cancel{2}\left[\frac{R_{ab}R_{bc} + R_{bc}R_{ca} + R_{ca}R_{ab}}{R_{ab} + R_{bc} + R_{ca}}\right] = \cancel{2}[R_A + R_B + R_C] \quad \text{— ④}$$

For R_A ④ − ①

$$\left.\begin{aligned} R_A &= \frac{R_{ca}R_{ab}}{R_{ab} + R_{bc} + R_{ca}} \\ R_B &= \frac{R_{ab}R_{bc}}{R_{ab} + R_{bc} + R_{ca}} \\ R_C &= \frac{R_{ca}R_{bc}}{R_{ab} + R_{bc} + R_{ca}} \end{aligned}\right\} \quad \text{— ⑤}$$

Equation no ⑤ shows the relationship b/w resistances ~~and~~ in star connection and delta connection

If delta connected resistances are given, the equivalent star resistance can be found with help of eq. no ⑤

Page No.

STAR to DELTA

$$\frac{R_B}{R_A} = \frac{R_{bc}}{R_{ca}} \Rightarrow R_{ca} = \frac{R_A}{R_B} \times R_{bc}$$

$$\frac{R_C}{R_A} = \frac{R_{bc}}{R_{ab}} \Rightarrow R_{ab} = \frac{R_A}{R_B} \times R_{bc}$$

$$R_A = \frac{\left(\frac{R_A}{R_C} \times R_{bc}\right)\left(\frac{R_A}{R_B} \times R_{bc}\right)}{\frac{R_A}{R_C} \times R_{bc} + R_{bc} + \frac{R_A}{R_B} \times R_{bc}}$$

By solving it

$$R_{bc} = \frac{R_A R_B + R_B R_C + R_C R_A}{R_A}$$

$$R_{ca} = \frac{R_A R_B + R_B R_C + R_C R_A}{R_B} \quad -(6)$$

$$R_{ab} = \frac{R_A R_B + R_B R_C + R_C R_A}{R_C}$$

With the help of equation (6) the equivalent resistances in ~~star~~ delta connection can be found out in terms of star connected resistances.

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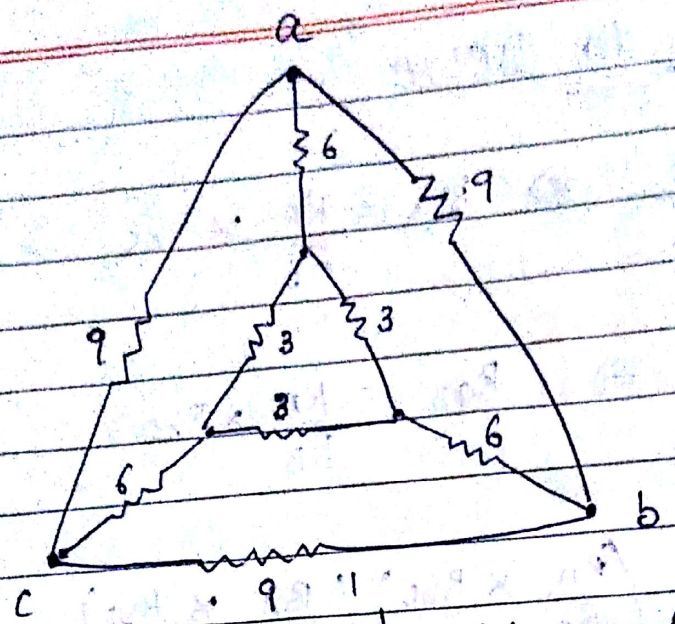
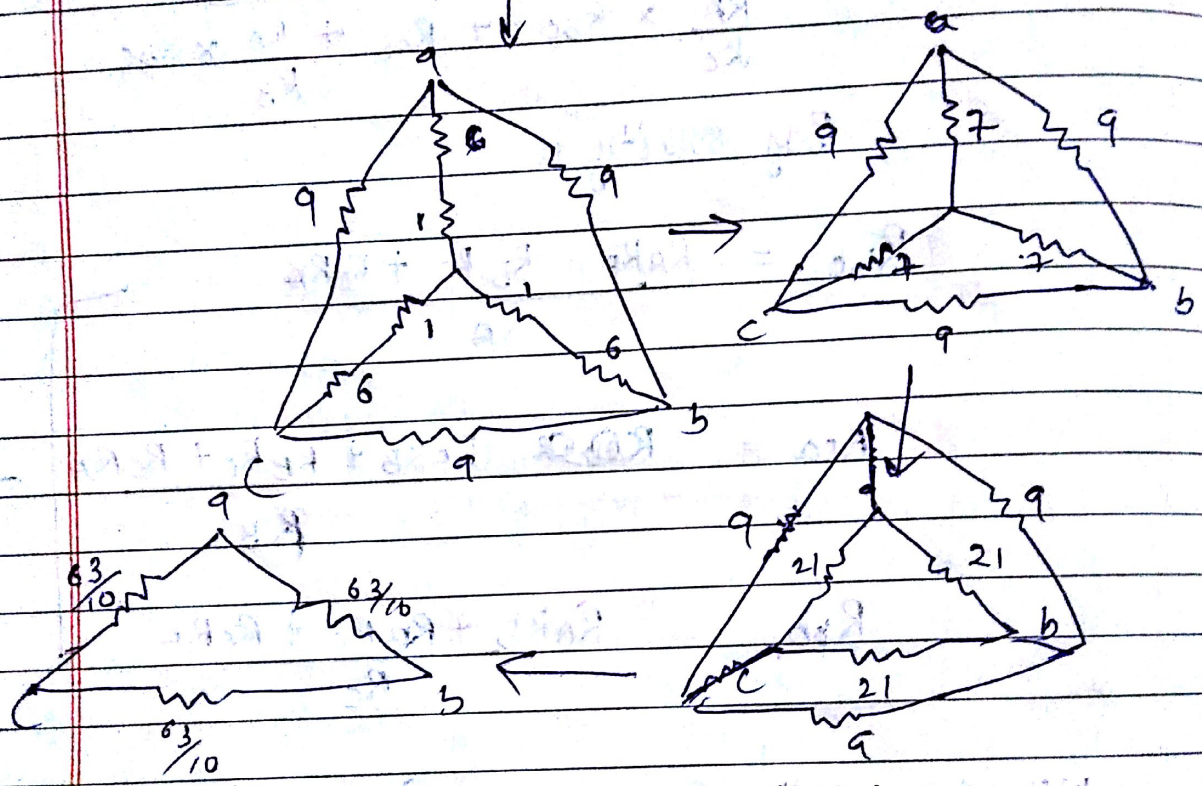


Find equ. resistance b/w terminal a & b



$$= \frac{1}{21} + \frac{1}{42}$$

$$= \frac{5}{63} + \frac{10}{63}$$

$$= \frac{63}{15} \quad \frac{21}{5} = 4.2\,\Omega$$

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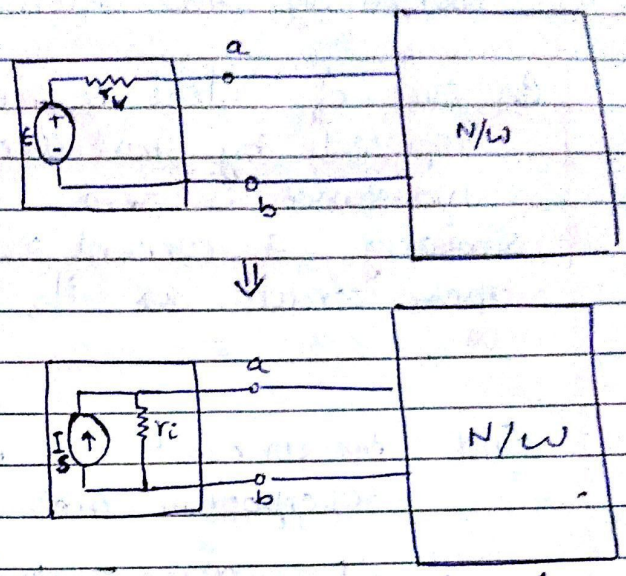
SOURCE TRANSFORMATION



$I_s = \frac{E}{r_v}$; $r_i = r_v$ (volt to curr. transf)

$E = I_s r_i$; $r_v = r_i$ (curr to volt. transf)

NETWORK THEOREMS [set of rules given to make the analyses of circuit easy]

- → Superposition Theorem
- → Thevenin's Theorem
- → Norton's Theorem
- → Maximum Power transfer Theorem
- → Tellengen's Theorem

SUPERPOSITION THEOREM

In a linear bilateral network ~~the response~~ containing multiple source and resistances the response accross any element can be given by algebric sum of individual responses due to

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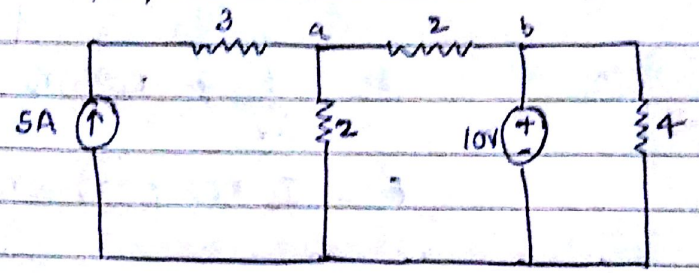
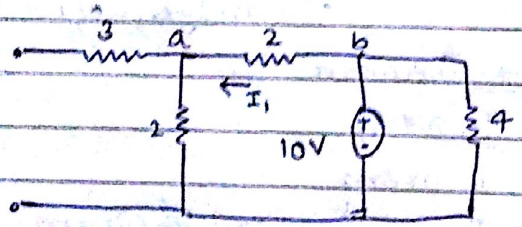
all the sources in the circuit taking one source at a time and replacing all other independent sources by their internal resistance

In case of ideal sources, voltage sources are replaced by short circuits as their internal resistance is zero.
Similarly a current source is replaced by an open circuit as its internal resistance is ∞.

Ans Find the current in branch ab using superposition theorem



Ans Considering Voltage only ⇓

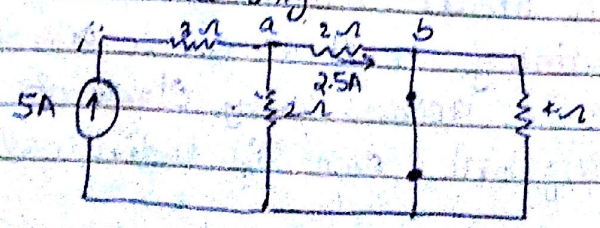


$R_{eq} = 2\Omega$

$I = 5A$

$I_1 = 2.5A$ from b to a

Consider current source only



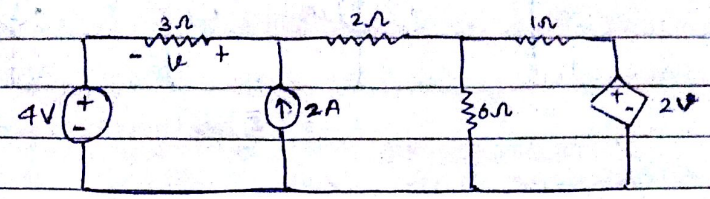
$I_2 = 2.5A$ from a to b

$I = I_1 - I_2$

$= 2.5 - 2.5$

$= 0\ A$

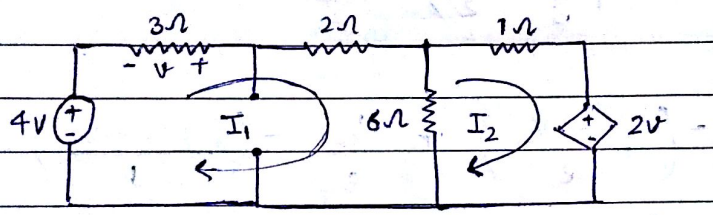
Ques



Find voltage 'v' using superposition theorem

Case I

Ans Consider the voltage source only



$4 + v - 2I_1 - 6(I_1 - I_2) = 0$

$4 + v - 8I_1 + 6I_2 = 0$ — (1)

$-6(I_2 - I_1) - I_2 - 2v = 0$

$6I_1 - 7I_2 - 2v = 0$ — (2)

$v = -3I_1$ — (3)

$12I_1 - 7 \times \frac{48}{5} = 0$

$I_1 = \frac{7 \times 4}{5}$

$4 - 11I_1 + 6I_2 = 0$

$12I_1 - 7I_2 = 0$

$4 - 11 \times \frac{7I_2}{12} + 6I_2 = 0$

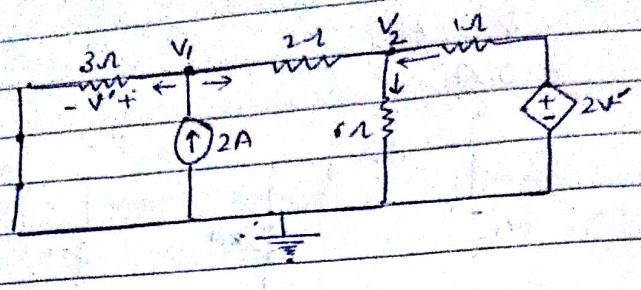
$48 - 77I_2 + 72I_2 = 0$

$5I_2 = 48$

$I_2 = \frac{48}{5}\ A$, $I_1 = \frac{28}{5}\ A$

$v = -16.8\ V$

Case - II



$$V_1 = V' \quad - (3)$$

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

$$V_1\left(\frac{1}{3} + \frac{1}{2}\right) - \frac{V_2}{2} = 2 \quad - (1)$$

$$-\left(\frac{V_1 - V_2}{2}\right) + \frac{V_2}{6} - \left(\frac{2V' - V_2}{1}\right) = 0$$

$$-\frac{V_1}{2} + V_2\left(\frac{1}{2} + \frac{1}{6} + 1\right) - 2V' = 0 \quad - (2)$$

$$\frac{5}{6}V_1 - \frac{V_2}{2} = 2 \quad - (1)$$

$$-\frac{V_1}{2} + \frac{5}{3}V_2 - 2V_1 = 0$$

$$\frac{5}{3}V_2 - \frac{5}{2}V_1 = 0$$

$$\frac{5}{\cancel{6}_3} \times \frac{\cancel{5}}{3}V_2 \times \frac{\cancel{2}}{\cancel{5}} - \frac{V_2}{2} = 2$$

$$\frac{5}{\cancel{3}} \times \cancel{36}^{18} - \frac{5}{2}V_1 = 0$$

$$V_2\left[\frac{5}{9} - \frac{1}{2}\right] = 2$$

$$\frac{90 \times 2}{5} -$$

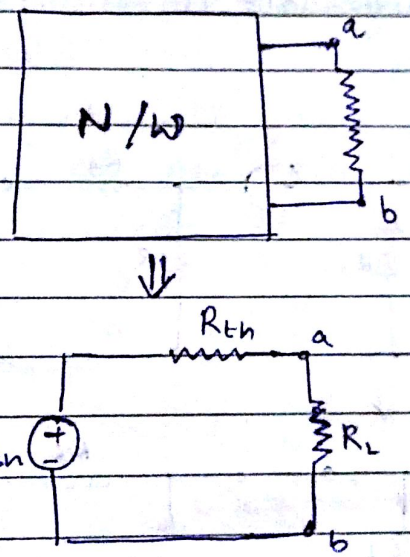
$$V_2 = \frac{2 \times 18}{}$$

$$V_2 = 36\ V$$

$$V_1 = 24V$$

THEVENIN'S THEOREM

In a linear bilateral DC network consisting of multiple sources and resistances, the response across any two terminals can be given by converting rest of the network by an equivalent voltage source and a resistance in series with it. The equivalent voltage source is called thevinin's voltage represented by "V_{th}" and the series resistance is called thevinin's resistance and deboted by "R_{th}"



DETERMINATION OF THEVENIN'S VOLTAGE (V_{th})

→ Remove the element connected across the desired terminals.

→ Calculate the open circuit voltage across the desired terminals if V_{oc} represents the open circuit voltage across terminals ab then thevenin voltage is nothing but the open circuit voltage V_{oc}.

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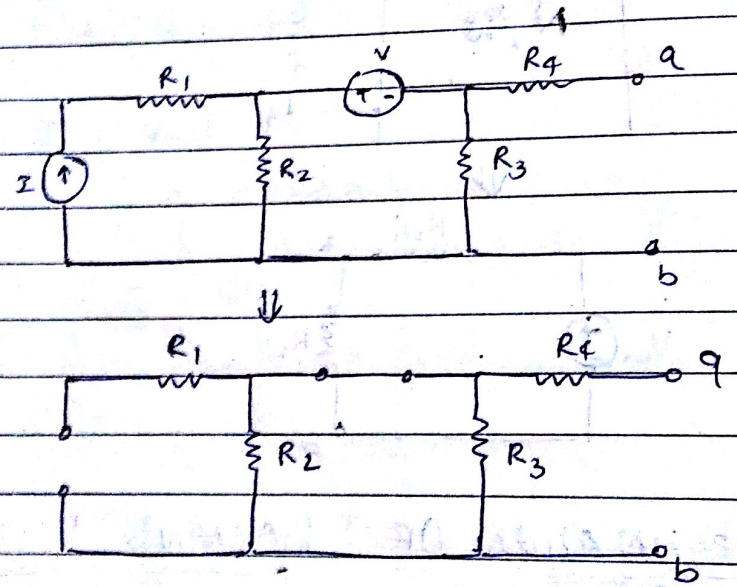
DETERMINATION OF THEVENIN'S RESISTANCE (R_{th})

Method 1

→ remove the element connected across the desired terminals a & b.

→ Replace all the independent source by their internal resistances i.e for ideal voltage source a short circuit is replaced and for ideal current source an open circuit is replaced

→ Find the equivalent resistance across terminal ab by looking into it.



$$R_{th} = R_4 + (R_2 \| R_3)$$

Method 2

→ Calculate open circuit voltage (V_{oc}) across desired terminals a & b.

→ Calculate short circuit current (I_{sc}) through terminals a & b.

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→ Calculate R_{th} given by the ratio of $\frac{V_{oc}}{I_{sc}}$

$$R_{th} = \frac{V_{oc}}{I_{sc}}$$

Method 3

→ Remove the element connected across terminal a b
→ replace all the independent sources within the circuit by their internal resistances
→ Connect a source of known strength across terminals a & b
→ find the response due to the known source at desired terminals a & b.
→ if the connected source is a voltage source of strength V then the responce due to this source will be the current flowing out of this source voltage V.
If strength of current is I

$$R_{th} = \frac{V}{I}$$

//ly if the connected source is a current source with I then the responce will be voltage across the current source if voltage is given by V then $R_{th} = \frac{V}{I}$

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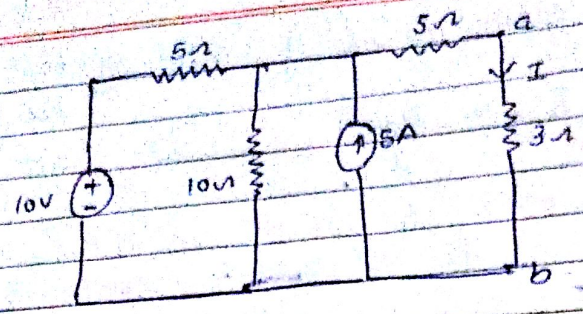
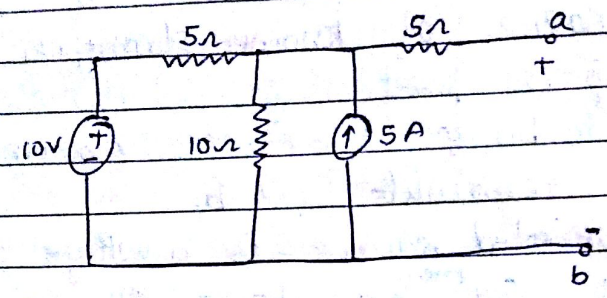
Ques

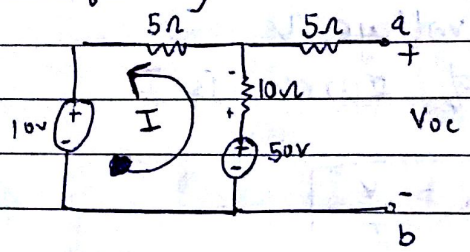


Find current I in 3Ω resistance using thevenin theorem

Ans



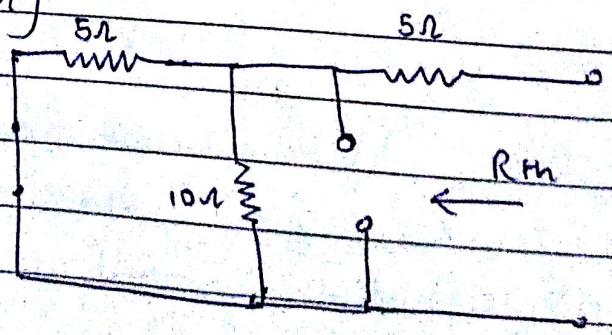
[Calculation of Vth] ⇓



$$I = \frac{50-10}{15} = \frac{40}{15} = \frac{8}{3} \text{ Amp}$$

$$V_{oc} = 50 - 10 \times \frac{8}{3} = \frac{150-80}{3} = \frac{70}{3} \text{ V}$$

[Calculation of Rth]



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$R_{th} = 5 + 5 // 10$

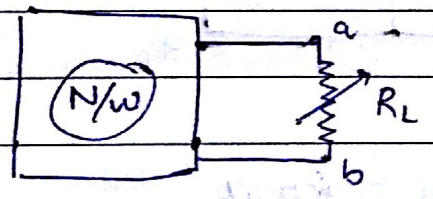
$= 5 + \frac{50}{15} \Rightarrow 5 + \frac{10}{3}$

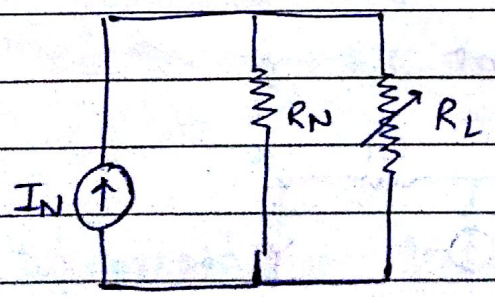
$= \frac{25}{3}\ \Omega$

Norton's Theorem

In a linear bilateral DC network consisting of multiple sources and resistance the response across any element can be given by converting rest of the network into an equivalent current source and a resistance in parallel with it

The current source is called norton current and denoted by I_N & the resistance is called norton resistance (R_N)





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(*) Determination of norton current (I_N)

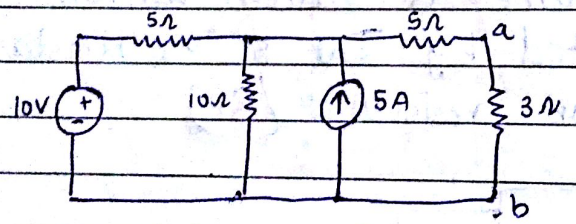
→ Remove the element connected across the desired terminals

→ Find short circuit current through terminals a b by shorting them due to the rest of network. This short circuit current gives the magnitude of norton's current

(*) Determination of norton resistance (R_N)

→ since norton's equivalent circuit is dual of thevenin's equivalent circuit ∴ norton's resistance will be same as the thevenin's resistance. All the method applicable for finding thevenin's resistance can be used for the determination of norton's resistance.

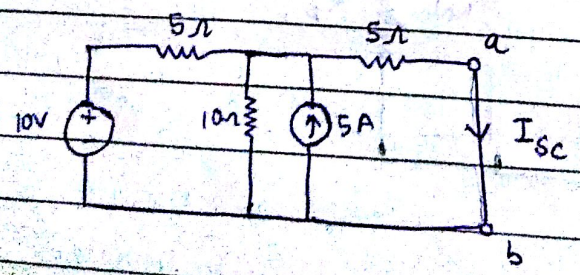
Que



Ans

$$R_N = R_{th} = \frac{25}{3}\,\Omega$$

For norton current :



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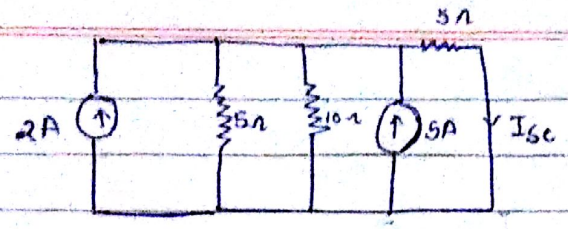
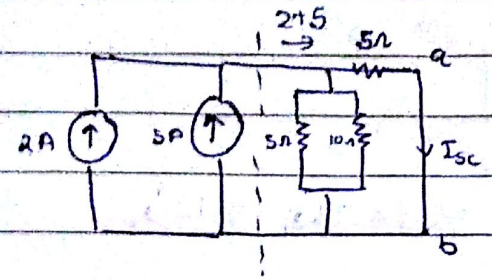
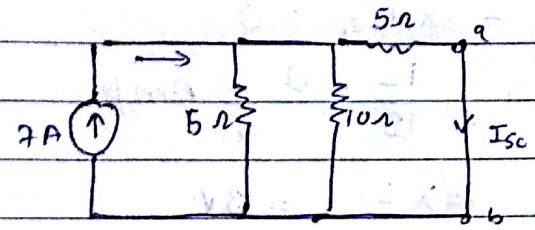
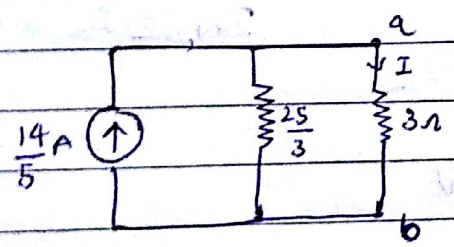






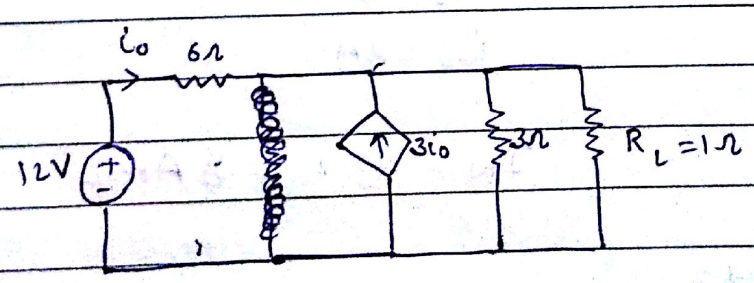
$$I_{sc} = \frac{(5 // 10)}{(5//10 + 5)} \times 7A$$

$$I_N = I_{sc} = \frac{14}{5} A \Rightarrow 4.2 \text{ Amp}$$



$$I = \frac{35}{17} \text{ Amp}$$

Qus



find current through R_L using :-

(i) Thevenin's theorem

(ii) Norton's theorem

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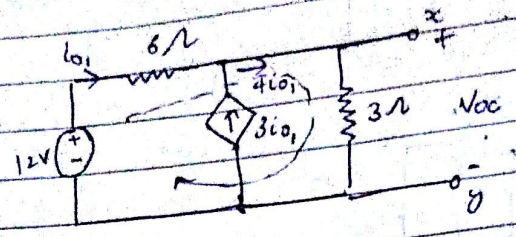
Ans =

Calculation of V_{th}



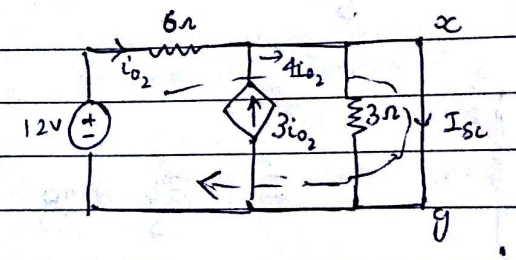
$$V_{th} = V_{oc} = 3 \times 4 i_{o_1} = 12 i_{o_1}$$

$$12 - 6 \times i_{o_1} - 3 \times 4 i_{o_1} = 0$$

$$i_{o_1} = \frac{\cancel{12}}{\cancel{18}} \; \frac{2}{3} \text{ Amp}$$

$$V_{th} = \frac{\cancel{12}^{4} \times 2}{\cancel{3}} = 8V$$

Calculation of I_N



$$I_N = I_{sc} = 4 i_{o_2}$$

$$12 - 6 i_{o_2} = 0$$

$$i_{o_2} = 2A$$

$$I_N = 4 \times 2 = 8 \text{ Amp}$$

Method 2

$$R_{th} = R_N = \frac{V_{oc}}{I_{sc}} = \frac{8}{8} = 1\Omega$$

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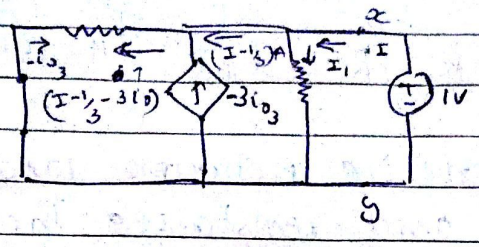
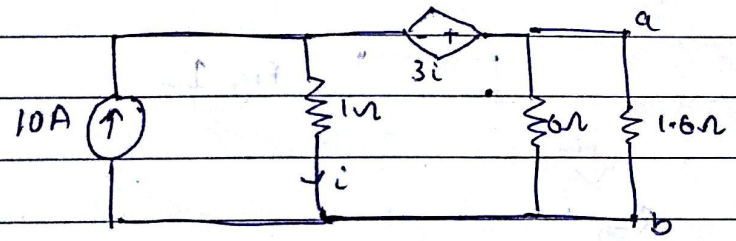


$$I_1 = \frac{1}{3} A$$

$$1 - 6\left(I - \frac{1}{3} - 3i_{o_3}\right) = 0$$

$$i_o = \frac{1}{6} A$$

Q. Find voltage across 1.6Ω using
(i) Thevenin's theorem
(ii) Norton's theorme



MAXIMUM POWER TRANSFER THEOREM

A linear bilateral DC network consisting of multiple sources and resistances. The power transfer will be max^m across any resistance R_L if the resistance R_L is equal in magnitude to the equivalent resistance of the rest of the network.

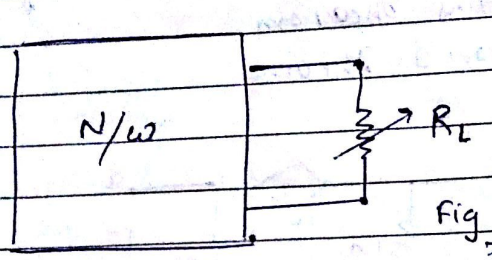
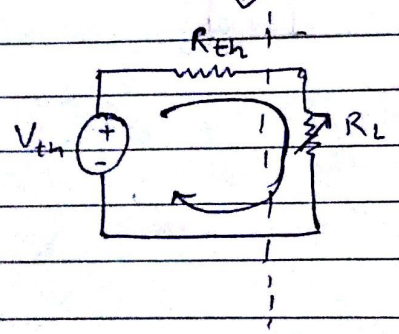


Fig 1.



$R_L = R_{th}$

Fig 2.

Proof :

In fig 2. current I is given by

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

$$P_L = I^2 R_L$$

$$= \left(\frac{V_{th}}{R_{th} + R_L}\right)^2 \times R_L$$

$$P_L = V_{th}^2 \times \frac{R_L}{(R_{th} + R_L)^2}$$

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for P_L to be maximum

$$\frac{dP_L}{dR_L} = 0$$

$$\frac{d}{dR_L}\left[\frac{V_{th}^2 \; R_L}{(R_{th}+R_L)^2}\right] = 0$$

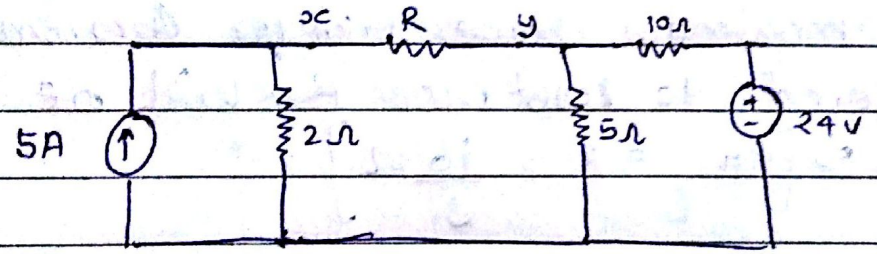
$$V_{th}^2\left[\frac{(R_{th}+R_L)^2 \times 1 - R_L \times 2(R_{th}+R_L)}{(R_{th}+R_L)^4}\right] = 0$$

$$V_{th}^2\left[\frac{\cancel{(R_{th}+R_L)}\,[R_{th}+R_L-2R_L]}{(R_{th}+R_L)^4}\right] = 0$$

$$\underline{\underline{R_{th} = R_L}}$$

$$P_{max} = \frac{V_{th}^2}{(R_{th}+R_{th})^2} \times R_{th}$$

$$\boxed{P_{max} = \frac{V_{th}^2}{4R_{th}}}$$



) What should be the value of R such that max power transfer take place from the rest of network to R. Obtain the amount of power. Also calculate the effeciency under the condition of maxm power and when load resistances is half the eq. resistances.

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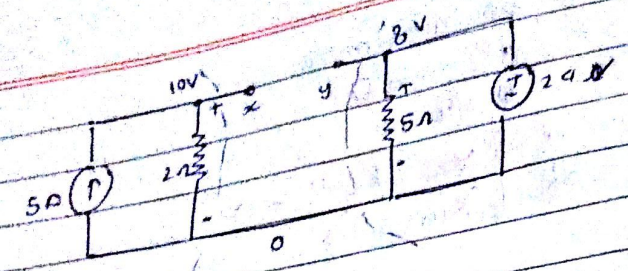
Ans =



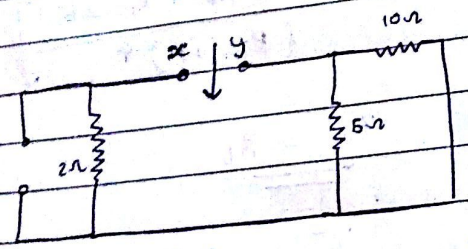
$V_{5\Omega} = \frac{5}{5+10} \times 24$

$= 8V$

$V_{xy} = V_{x0} - V_{y0}$

$= 10 - 8$

$= 2V$



$R_{xy} = 2 + (5 \| 10)$

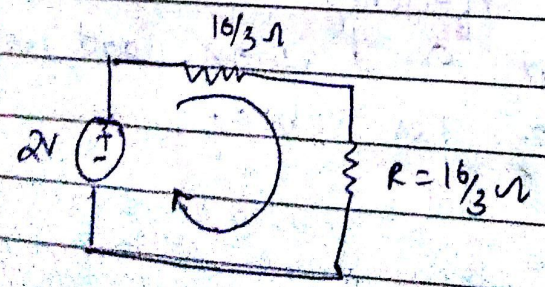
$= \frac{16}{3}$

Acc to maximum power transfer theorem, the power transfered to resistance R will be maximum when $\Rightarrow \left[R_{th} = R = \frac{16}{3}\Omega \right]$

$V_{th} = V_{xy} = 2V$

$P_{max} = \frac{V_{th}^2}{4R_{th}} = \frac{(2)^2}{4 \times 16/3}$

$= \frac{3}{16}$ Watt



$\eta = \frac{\text{o/p power}}{\text{i/p power}}$

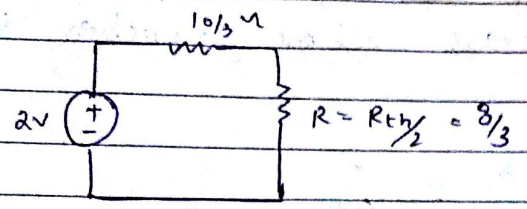
$$I = \frac{2}{32/3} = \frac{3}{16} A$$

$$\text{O/p power} = I^2 \times R$$

$$= \left(\frac{3}{16}\right)^2 \times \frac{16}{3} = \frac{3}{16} \text{ Watt}$$

$$\text{I/p power} = 2 \times \frac{3}{16} = \frac{6}{16} \text{ watt}$$

$$\eta = \frac{3/16}{6/16} = \frac{1}{2} = 50\%$$



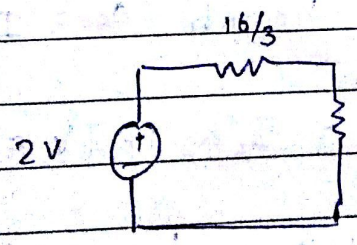
$$I = \frac{2}{8} = \frac{1}{4} A$$

$$\text{O/p Power } (I^2R) = \left(\frac{1}{4}\right)^2 \times R = \frac{1}{16} \times \frac{8}{3} = \frac{1}{6} \text{ Watt}$$

$$\text{I/p power } (IV) = 2 \times \frac{1}{4} = \frac{1}{2} \text{ Watt}$$

$$\eta = \frac{1/6}{1/2} = \frac{1}{3} = 33.33\%$$

(b) Calculate the efficiency of circuit when load Resistance 'R' is double the source resistance



$$I = \frac{2}{16} = \frac{1}{8} A$$

$$\text{O/p power} = \frac{1}{64} \times \frac{32}{3} = \frac{1}{6} \text{ watt}$$

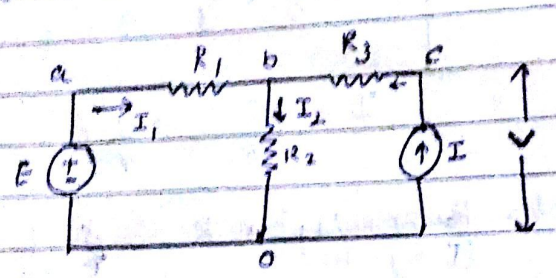
$$\frac{32}{16} = \frac{32}{3}$$

η = power $= \frac{IV}{\frac{1}{3} \times 3} = \frac{1}{1}$

$\eta = \frac{1/3}{1/1} = \frac{2}{3} = 66\%$

TELLENGEN'S THEOREM

In a linear or non linear, time varying or time invariant circuit. The sum of instantaneous powers across all the branches is equal to zero.



power given the source → +ve
power consumed → -ve

power in branch oa = EI_1
power in branch ab = $-I_1^2 R_1$
power in branch bc = $-I^2 R_3$
power in branch ob = $-I_2^2 R_2$
power in branch oc = IV

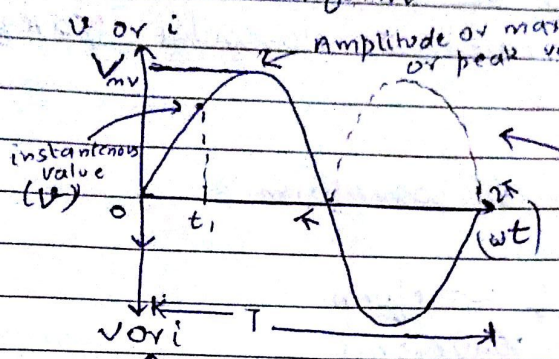
$$\left[EI_1 - I_1^2 R_1 - I^2 R_3 - I_2^2 R_2 + IV = 0 \right]$$

$$\left[\underbrace{EI_1 + IV}_{\text{power delivered to the circuit}} = \underbrace{I_1^2 R_1 + I^2 R_3 + I_2^2 R_2}_{\text{power consumed by the circuit}} \right]$$

UNIT - 2 Single Phase AC Circuits

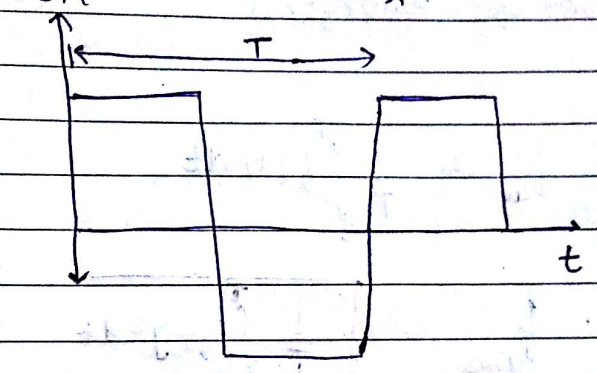
Various AC waveform

(1.)



→ easy to generate
→ mathematical manipulation is easy
→ differation & integration is easy

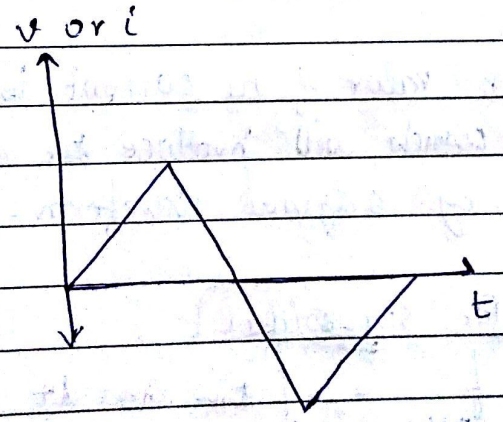
(2.)



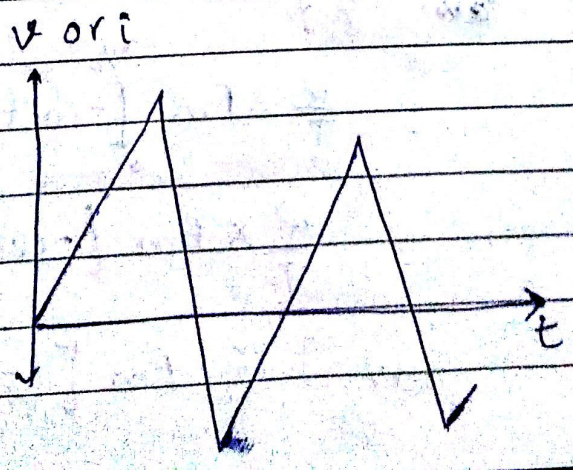
$\frac{1}{T}$ = frequency (f) (Hz)

$\omega = 2\pi f$ (rad/sec)

(3)



(4.)



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$T = 2\pi$

Reason behind universal use of sinusodial waveform:

→ Generation of sinusoidal voltage is simpler as compared to other voltages.

→ The manipulation or mathematical operation can be easily performed on sinusoidal waveform

(*) Specification of waveform :-

→ Average value of waveform

→ RMS value of waveform

$$f_{av} = \frac{1}{T}\int_0^T f(t)\,dt$$

$$f_{rms} = \sqrt{\frac{1}{T}\int_0^T [f(t)]^2\,dt}$$

(*) Qualitatively RMS value of a current is the amount of DC current which will produce the same heat as, is produced by original waveform.

for sinusoidal

$$f_{av} = \frac{1}{T/2}\int_0^{T/2} F_m \sin t\,dt$$

$$= \frac{2}{T} \times F_m \left[-\cos t\right]_0^{T/2}$$

$$= \frac{2}{T} \times F_m \left[-\cos T/2 + 1\right]$$

$$f_{av} = \frac{2}{T} F_m \left[1 - \cos T/2\right]$$

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$T = 2\pi$; $b_{av} = \frac{2}{2\pi} \times F_m [1 - \cos\pi]$

$$\boxed{b_{av} = 2\frac{F_m}{\pi}}$$

$$b_{rms} = \sqrt{\frac{1}{T}\int_0^T [b(t)]^2 dt}$$

$$= \sqrt{\frac{1}{T}\int_0^T F_m^2 \sin^2 t \, dt}$$

$$= \sqrt{\frac{1}{T} \times F_m^2 \int_0^T \frac{1-\cos 2t}{2} dt}$$

$$= \sqrt{\frac{F_m^2}{2T}\left[t - \frac{\sin 2t}{2}\right]_0^T}$$

$$= \sqrt{\frac{F_m^2}{2T}\left[T - \frac{\sin 2T}{2} - \left(0 - \frac{0}{2}\right)\right]}$$

$$= \sqrt{\frac{F_m^2}{2T}\left(T - \frac{\sin 2T}{2}\right)}$$

$T = 2\pi$

$$b_{rms} = \sqrt{\frac{F_m^2}{2 \times 2\pi}\left(2\pi - \frac{\sin 4\pi}{2}\right)}$$

$$\boxed{b_{rms} = \frac{F_m}{\sqrt{2}}}$$

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Ques Find the (1) average value (2) rms value (3) form factor (4) peak factor for (a) square wave form with Amplitude = E_m

(b) Δ wave

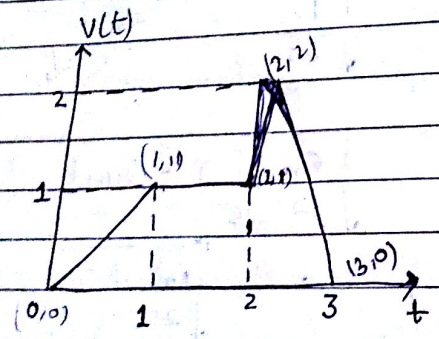
(c) Sawtooth wave

HOME ASSIGNMENT

FORM FACTOR (FF) = $\dfrac{\text{RMS value}}{\text{AV value}}$

PEAK FACTOR (PF) = $\dfrac{\text{Max}^m/\text{peak value}}{\text{RMS value}}$

Ques



Ans

$$f_{av} = \frac{1}{T}\left[\int_0^T f(t)\,dt\right]$$

$$= \left[\text{Area under the waveform}\right] \div \text{Time period}$$

$$\text{Area} = \frac{1}{2}\times 1\times 1 + 1\times 1 + \frac{1}{2}\times 1\times 2$$

$$= \frac{5}{2}$$

36
72
108

108
42
60

190
32
198
144

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avg value $= \frac{5/2}{3} = \frac{5}{6}$ volts

$$v(t) = \begin{cases} t & ; \ 0 \le t < 1 \\ 1 & ; \ 1 \le t \le 2 \\ -2(t-3) \ (-2t+6) & ; \ 2 \le t < 3 \end{cases}$$

$$V_{rms} = \sqrt{\frac{1}{3}\left[\int_0^1 t^2\,dt + \int_1^2 1\,dt + \int_2^3 (-2t+6)^2\,dt\right]}$$

$$= \sqrt{\frac{1}{3}\left[\left[\frac{t^3}{3}\right]_0^1 + [t]_1^2 + \left[\frac{4}{3}t^3 + 36t - 12t^2\right]_2^3\right]}$$

$$= \sqrt{\frac{1}{3}\left[\frac{1}{3} + 1 + \left[36 + \cancel{108} - \cancel{108} - \frac{32}{3} + 72 - 48\right]\right]}$$

$$= \sqrt{\frac{1}{3}\left[\frac{1}{3} + 1 + 60 - \frac{32}{3}\right]}$$

$$= \sqrt{\frac{1}{3}\left[\frac{1 + 3 + 180 - 32}{3}\right]}$$

$$= \sqrt{\frac{1}{3}\left[\frac{144}{3}\right]}$$

$$= 4$$

36
72
108

108
41
60

180
32
148
144

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