Chettinad College of Engineering & Technology
Approved by AICTE-New Delhi and Affiliated to Anna University Chennai

Academic Year 2023 -2024

Notes of Lesson

Year/Semester: I/II **Date:** 06.03.2024	**Department** : ECE **Subject Code/Title :** EC3251/ Circuit Analysis **Faculty Name** : Mrs.A.Karthikeyani	**Unit** : I to V **Total Hours** :60 Hrs **Subject Credit : 4**

Unit-II Network Theorems and Duality

UNIT – II

Network Theorem and Duality

Useful Circuit Analysis techniques – Linearity and superposition, Thevenin and Norton Equivalent Circuit, Maximum power Transfer, Delta-wye Conversion, Duals, Dual circuits. Analysis using dependent current sources and voltage sources.

Linearity and Superposition principle:

Superposition theorem:

" In any linear and bilateral network or circuit having multiple independent sources, the responses of an element will be equal to the algebraic sum of the responses of that element by considering one source at a time ".

Steps to apply:

(1) Select a single source acting alone. Short the other voltage sources and open the current sources ~~of internal~~

(2) Find the 'I' through or the voltage across the required element, due to the source under consideration, using a ~~sim~~ suitable network simplification technique.

(3) Repeat the above 2 steps for all the sources.

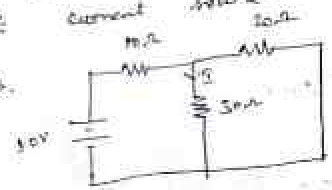
(4) Add all the individual effects produced by individual sources, to obtain the total current in or voltage across the element.

(3) Find the current I for the circuit shown by using superposition theorem.

Sol:

Step 1:

=> Here select any one of the voltage source (50v) and short circuit the voltage source and open circuit current source.



=> find the Req.

$$\frac{20 \times 30}{20+30} = \frac{600}{50} = 12\,\Omega$$

12Ω series with 10Ω

=> 12 + 10 = 22Ω

∴ $R_{eq} = 22\,\Omega$

=> ∴ Total current $I_T = \frac{V_T}{R_T}$

$$= \frac{50}{22} = 2.27\text{ A}$$

=> To find 'I' use current division Rule.

$$I_1 = I_T \times \frac{\text{Resistance of opp. Branch}}{\text{'R' of opp. Branch} + \text{'R' of current Branch}}$$

$$= 2.27 \times \frac{20}{20+30} = 2.27 \times \frac{20}{50}$$

$$\boxed{I_1 = 0.908\text{ A}} \downarrow$$

Step 2:

=> select 20v source and remove short circuit voltage source and open circuit current source.

=>

[Same steps will be followed as like step 1]

=> $R_{eq} = 27.5\,\Omega$

=> $I_T = \frac{20}{27.5} = 0.727\text{A}$ => $\boxed{I_T = 0.727\text{A}}$

=> To find 'I' use current division rule

=> $I_2 = I_T \times \frac{10}{10+30}$ => $\boxed{I_2 = 0.181\text{ A}} \downarrow$

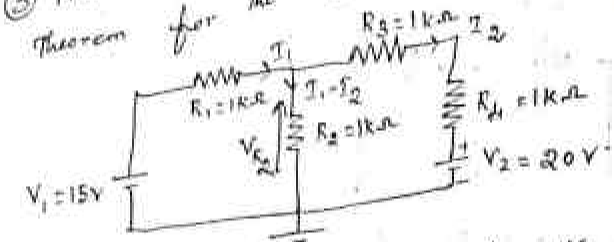
Step 3:
Both I_1 & I_2 => ↓ [Downward]

If both directions are same [Downward or upward] Add the currents.

∴ $I_{30\Omega} = 0.908 + 0.181$

$$\boxed{I_{30} = 1.089\text{ A} \downarrow}$$

③ Find the voltage across R_2 using superposition theorem for the circuit shown in figure.



Write the mesh matrix for the given circuit:

$$\begin{bmatrix} 2000 & -1000 \\ -1000 & 3000 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 15 \\ -20 \end{bmatrix}$$

Voltage across $R_2 = (I_1 - I_2) \times R_2$

$\therefore V_1 = 15V, \; V_2 = 20V$

$$\Delta = \begin{vmatrix} 2000 & -1000 \\ -1000 & 3000 \end{vmatrix} = 5 \times 10^6$$

$$\Delta_1 = \begin{vmatrix} 15 & -1000 \\ -20 & 3000 \end{vmatrix} = 25 \times 10^3$$

$$\Delta_2 = \begin{vmatrix} 2000 & 15 \\ -1000 & -20 \end{vmatrix} = -25 \times 10^3$$

$\therefore I_1 = \frac{\Delta_1}{\Delta} = 5mA$

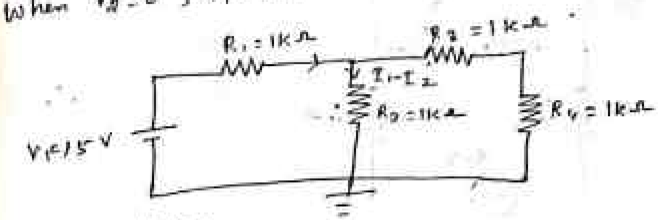
$I_2 = \frac{\Delta_2}{\Delta} = -5mA$

$\therefore I_1 - I_2 = 10 \times 10^{-3}$
$= 10mA$

$\therefore V_{R_2} = (I_1 - I_2) \times R_2 = 10 \times 10^{-3} \times 10^3 = 10V$

Case (i):

When $V_2 = 0$; $V_1 = 15V$



Mesh matrix:

$$\begin{bmatrix} 2000 & -1000 \\ -1000 & 3000 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 15 \\ 0 \end{bmatrix}$$

$\therefore \frac{\Delta_1}{\Delta} = I_1 = 9mA$, $I_2 = \frac{\Delta_2}{\Delta} = 3mA$

$\therefore \boxed{I_1 - I_2 = 6mA} \Rightarrow V_{R_2} = (I_1 - I_2) \times R_2$
$= 6 \times 10^{-3} \times 10^3 = 6V$ — ①

Case (ii):

When $V_1 = 0$, $V_2 = 20V$,

$I_1 = -4mA$, $I_2 = -8mA$

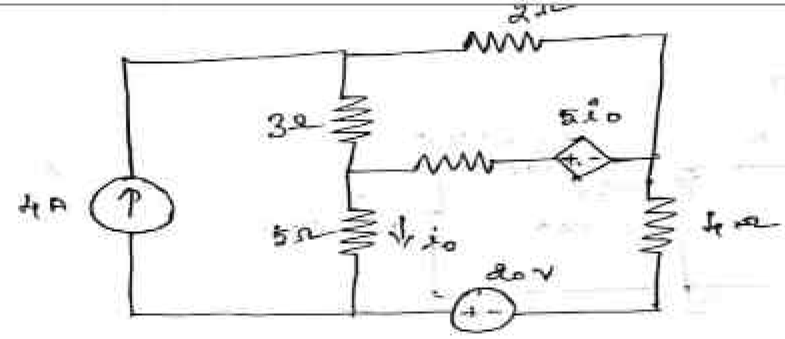
$\therefore I_1 - I_2 = (-4 + 8) \times 10^{-3}$
$= 4mA$

$\therefore \boxed{I_1 - I_2 = 4mA} \Rightarrow V_{R_2} = 4 \times 10^{-3} \times 10^3 = 4V$ — ②

$\therefore$ Add Eq. ② & Eq. ①

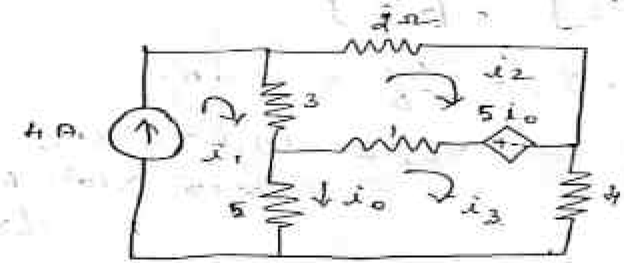
$\therefore \boxed{V_{R_2} = 10V}$

④ Find i_0 in the circuit in fig using superposition (Dependent source).



Soln:

Mesh analysis:



Loop 1

$$-4 + 8i_1 - 3i_2 - 5i_3 = 0$$

$$\Rightarrow 8i_1 - 3i_2 - 5i_3 = 4$$

Loop 2:

$$2i_2 + i_2 - i_3 + 3i_2 - 3i_1 - 5i_0 = 0$$

$$-3i_1 + 6i_2 - i_3 - 5i_0 = 0 \rightarrow (2)$$

Loop 3:

$$10i_3 - i_2 - 5i_1 + 5i_0 = 0 \rightarrow (3)$$

$$\therefore i_3 = i_1 - i_0 = 4 - i_0$$

$$i_1 = 4A;\ i_3 = 4 - i_0$$

$\therefore$ Subst (2) & (3)

$$-12 + 6i_2 - 4 + i_0 - 5i_0 = 0$$

$$-16 + 6i_2 - 4i_0 = 0$$

$$6i_2 - 4i_0 = 16$$

$$3i_2 - 2i_0 = 8 \rightarrow (4)$$

$$\therefore 40 - 10i_0 - i_2 - 20 + 5i_0 = 0$$

$$-5i_0 - i_2 = -20$$

$$\Rightarrow 5i_0 + i_2 = 20 \rightarrow (5)$$

$$-2x + 3y = 8$$

$$5x + y = 20$$

$$(2) \times 3 \Rightarrow 15x + 3y = 60$$

$$-2x + 3y = 8$$

$$(+)\quad (-)\quad (-)$$

$$17x = \cancel{68}\ 52$$

$$x = 52/17$$

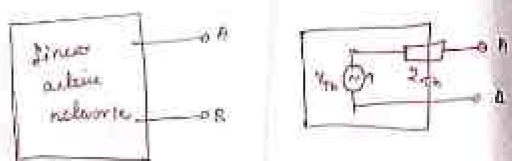
$$\boxed{i_0 = 3.0588\,A}$$

Thevenin's Theorem

Statement

"Any linear active n/w with o/p terminals A & B as shown in figure can be replaced by a single voltage source ($V_{Th} = V_{oc}$) in series with a single impedance ($Z_{Th} = Z_i$)."

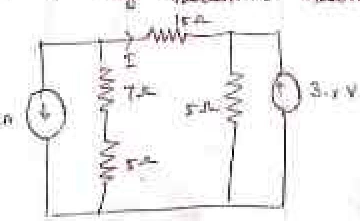
V_{Th} → Thevenin volt ; V_{oc} = OC voltage



$R_{Th} \equiv Z_{Th}$ (if C & L are absent)

$$\therefore I_L = \frac{V_{Th}}{R_{Th} + R_L}$$

(6) Find 'I' using Thevenin's theorem:



Solution: (We need to find R_{Th}).

Consider the R_L [I current flowing through R_L]

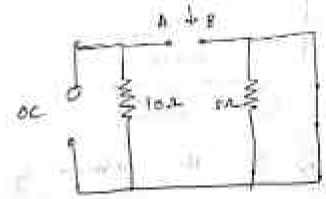
Step 1: To find R_{Th}:

In order to find R_{Th} we need to do 3 steps

(i) Remove the R_L.

(ii) SC the volt. source (iii) OC the current source]

(iii) The circuit diagram will be,



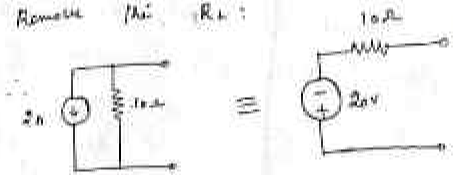
We need to find Total 'R' across A & B.

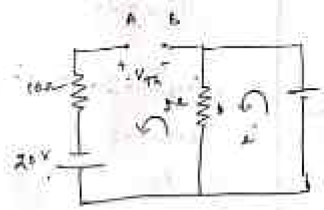
Note: If SC is in parallel with 5Ω, don't consider that 'R' (5Ω)

$\therefore \boxed{R_{Th} = 10\Omega}$

Step 2: To find V_{Th}:

Remove the R_L:





$\left[\because i = \frac{3.5}{5}\right]$

Apply the KVL to the loop which is having V_{Th}:

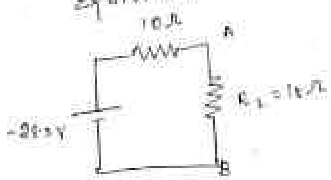
⇒ A & B terminals is opened current across 10Ω,

$5 \times 0.7 + V_{Th} + 20 = 0$ (or) $-5 \times 0.7 - V_{Th} - 20 = 0$.

$\Rightarrow \boxed{V_{Th} = -23.5\text{ V}}$

Step 3:

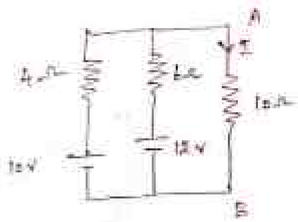
Equivalent circuit



$$I = \frac{V_{th}}{R_{th}+R_L} = \frac{-23.5}{10+16}$$

$$\boxed{I = -0.94A}$$

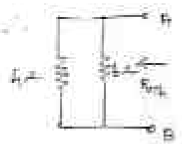
(8) Determine the current I in the network by using Thevenin's theorem:



Step 1 To find R_{Th}:

(i) Remove the R_L ($\therefore I \Rightarrow R_L = 10\Omega$)

(ii) Remove voltage source by their S.C



$$\therefore R_{Th} = \frac{4\times 6}{4+6} = \frac{24}{10} = 2.4\Omega$$

$$\boxed{R_{Th} = 2.4\Omega}$$

Step 2 To find V_{Th}:

Apply KVL,

$-12 + 6I + 4I + 10 = 0$

$10I - 2 = 0$

$I = 2/10 = 0.2A$

$\boxed{I = 0.2A}$

$\therefore V_{Th} = 6I - 12$

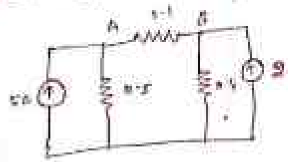
$= 6\times 0.2 - 12$

$= -10.8V$

Step 4:

$$I_L = \frac{V_{Th}}{R_{Th}+R_L} = \frac{-10.8}{2.4+10} = -0.871A$$

(9) It is required to find current thro' the 0.1Ω resistor in figure using Thevenin's theorem.

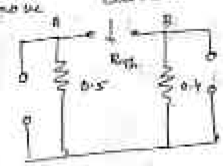


Solution:

(i) To find R_{Th}

(1) Here $R_L = 0.1\Omega$ (Disconnect)

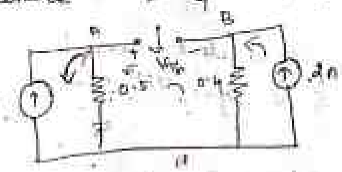
(2) Remove current source by O.C



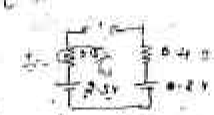
$\therefore R_{Th} = 0.5 + 0.4 = 0.9\Omega$

(ii) To find V_{Th}

Remove R_L & apply KVL for the V_{Th} loop



$[V_{Th} = V_{AB}]$



$\therefore -V_{Th} + 0.5\times(5) - 0.4\times 2 = 0$ [A = +ve ; B = -ve]

$-V_{Th} + 2.5 - 0.8 = 0$

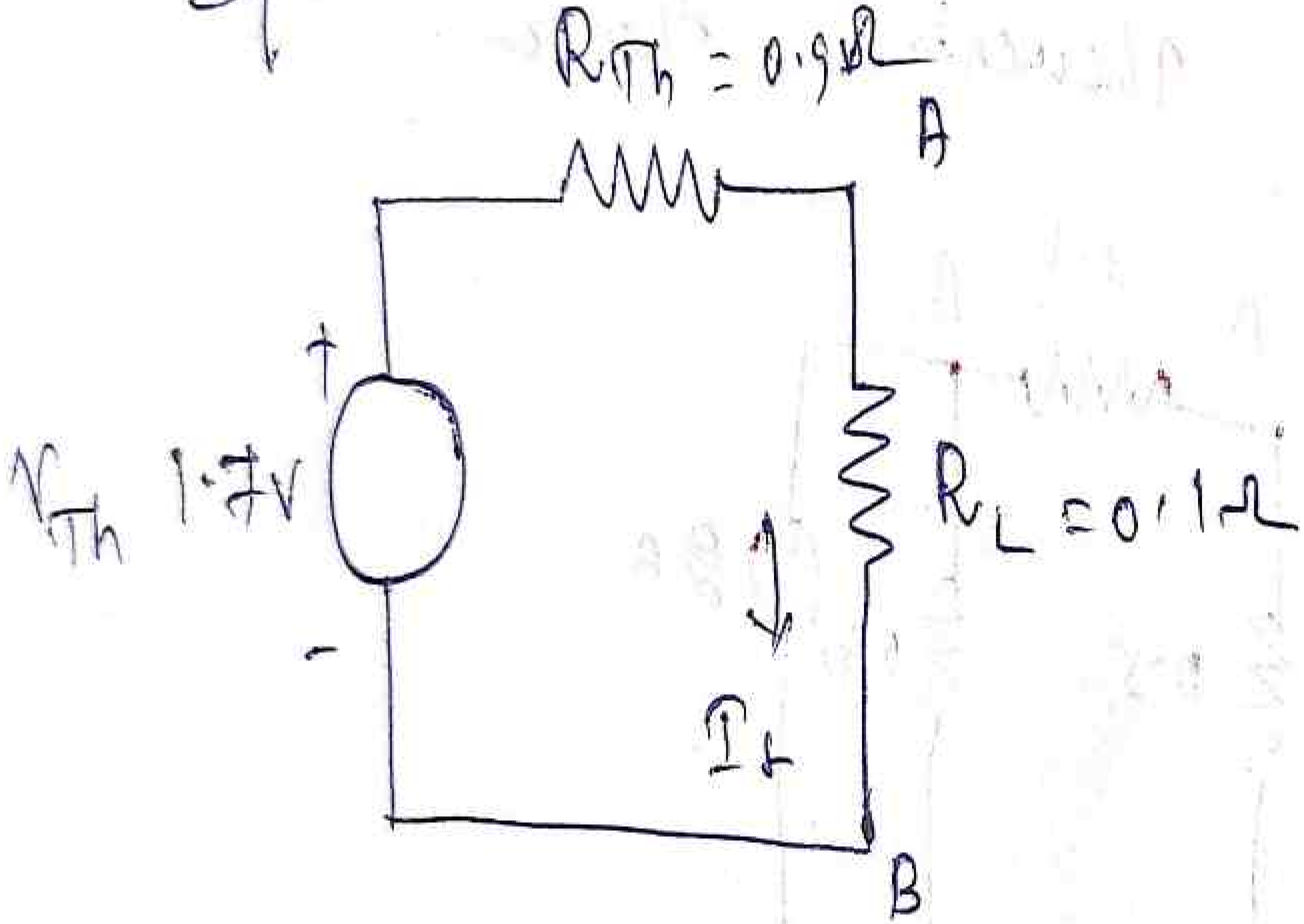
$-V_{Th} = -1.7V \Rightarrow \boxed{V_{Th} = 1.7V}$

SBR+SEMP

(iii)

$$I_L = \frac{V_{Th}}{R_{Th}+R_L} = \frac{1.7V}{0.9+0.1} = 1.7A$$

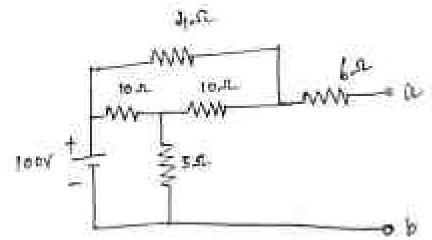
Equivalent circuit :



Thevenin's Theorem Based problems:

(9) Find the Thevenin's Equivalent circuit at (a, b)

(May-9, 16 Marks)

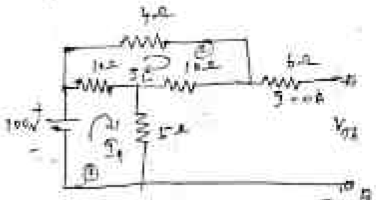


Solution:

(i) V_{Th}, (ii) R_{Th}

(i) steps to find V_{Th}:

(Find the OC voltage)



Apply KVL for loop (1),

$-100 + 10(I_1 - I_2) + 5I_1 = 0$

$15I_1 - 10I_2 = 100 \rightarrow (1)$

Apply KVL for loop (2),

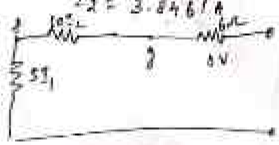
$4I_2 + 10I_2 + 5(10)(-I_1 + I_2) = 0$

$-10I_1 + 24I_2 = 0$

$\Rightarrow 10I_1 - 24I_2 = 0 \rightarrow (2)$

Solving, $I_1 = 9.2307A$

$I_2 = 3.8461A$



$5 \times I_1 = 46.1535V$

$10I_2 = 10 \times 3.8461A$

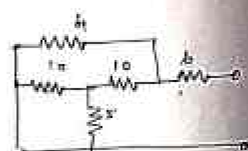
$I_2 = 38.46$

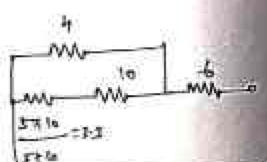
$V_{TH} = 38.46 + 46.1535$

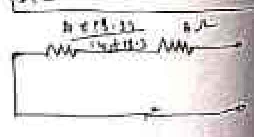
$= 84.6145V$

Step 2: R_{eq}:

Remove the sources:

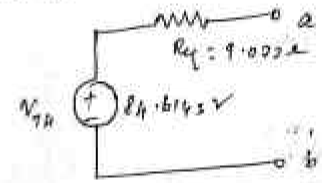




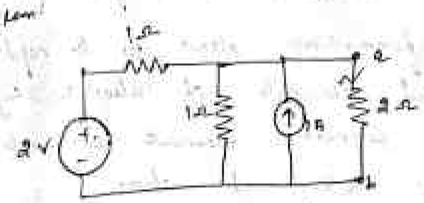


$R_{eq} = 9.077Ω$

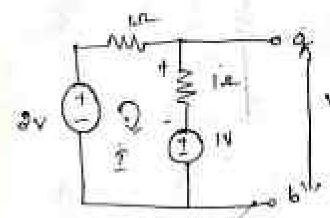
∴ The Thevenin's equivalent circuit is,



(10) Calculate the current through the 2Ω resistor in the circuit shown below using Thevenin's Theorem. (Dec-10, May-12) (8 Marks)



Step 1: To find V_{Th} (Remove or disconnect $R_L = 2Ω$)



Apply KVL,

$-2 + 2I + 1 = 0 \Rightarrow 2I = 1 \Rightarrow I = 1/2 = 0.5 \Rightarrow \boxed{I = 0.5A}$

∴ $V_{Th} = 1 + 0.5 = 1.5V$

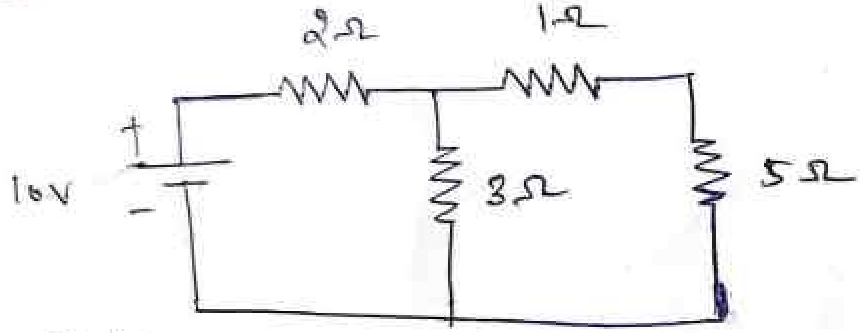
∴ $V_{Th} = 1.5V$

$R_{eq}: \frac{1 \times 1}{1+1} = 1/2 = 0.5Ω$

$I_L = \frac{V_{Th}}{R_{Th} + R_L} = \frac{1.5}{0.5 + 2} = 0.6A$

Thevenin's Theorem Based problem:

(16) Find 'I' thru' 5Ω by Thevenin's Theorem



[Hint:
For solving in Thevenin's Theorem, we need to do following steps:

1. Remove 'R_L'

[R_L is nothing but the 'R' I flowing thru the particular 'R' (which asked in question)]

2. Apply KVL to find the loop currents.

3. Find V_{Th} on the R_L part.

4. Find $R_{eq} \equiv R_{Th}$ by removing all sources.

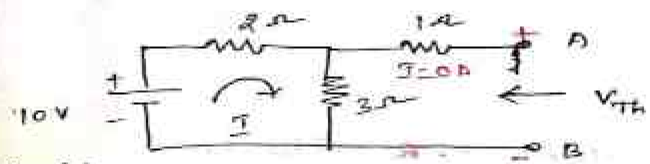
5. Draw Equ. circuit.

6. Find $\boxed{I_L = \dfrac{V_{Th}}{R_{Th} + R_L}}$ (R_{eq})

Solution:

Step 1:

Remove 'R_L' to find V_{Th}:



Step 2: Apply KVL to the loop:

$\therefore -10 + 5I_1 = 0 \Rightarrow 5I = 10 \Rightarrow \boxed{I = 2A}$

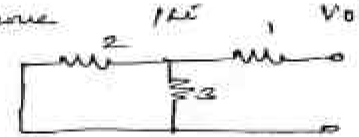
Step 3:

$\therefore V_{Th} = 3 \times I + 0 \times 1 = 3 \times 2 = 6V$

Step 4: To find R_{eq} (R_{Th}):

Remove the voltage source,

$\therefore$



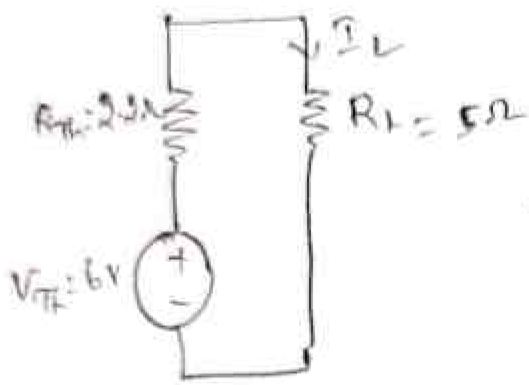
$2 \| 3 \Rightarrow \dfrac{2 \times 3}{2 + 3} = 6/5 = 1.2\,\Omega$

$1.2\,\Omega$ series with 1.

$\therefore 2.2\,\Omega \Rightarrow \boxed{R_{Th} = 2.2\,\Omega}$

∴ Step 5:

Equi circuit:



Step 6:

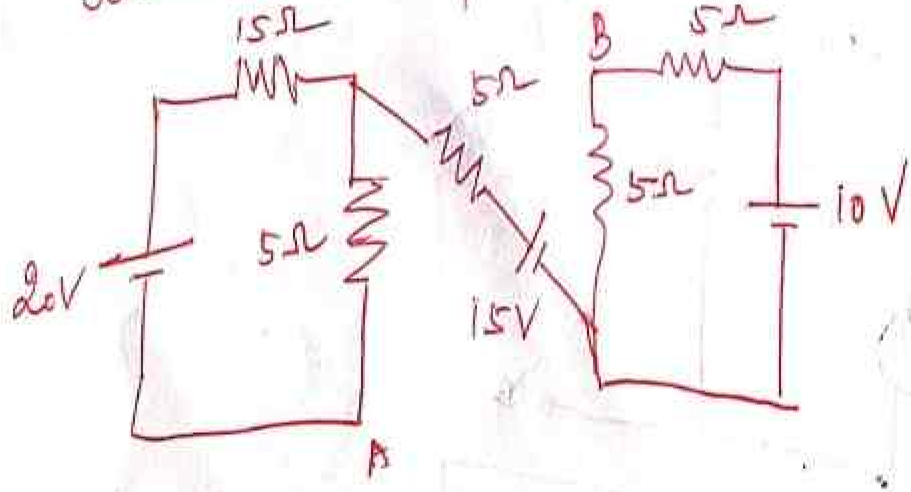
$$I_L = \frac{V_{Th}}{R_L + R_{eq}\,(\text{or})\,(R_{Th})} = \frac{6}{2.2+5}$$

$$= \frac{6}{7.2}$$

$$\boxed{I_L = 0.8333A}$$

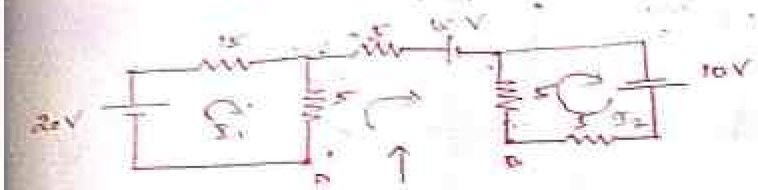
Thevenin's Theorem: problems:

(18) Determine the Thevenin's equivalent across the terminals A & B as shown in figure.



Solution:

The given circuit can be redrawn as follows



Step 1: To find V_{th}:

Apply KVL to loop 1,

$$-20 + 15I_1 + 5I_1 = 0$$

$$20I_1 = 20 \Rightarrow \boxed{I_1 = 1A}$$

Apply KVL to loop 2,

$$-10 + 10I_2 = 0$$

$$\Rightarrow \boxed{I_2 = 1A}$$

$$-5I_1 - 10 + 15 - 5I_2 - V_{th} = 0$$

$$-5 + 15 - 5 - V_{th} = 0$$

$$V_{th} = -5\ V \Rightarrow \boxed{V_{th} = 5\ V}$$

Step 2: To find R_{th}:

$$= \left(\frac{15 \times 5}{15+5}\right) + 5 + 5\|5 = \frac{75}{20} + 5 + \frac{25}{10}$$

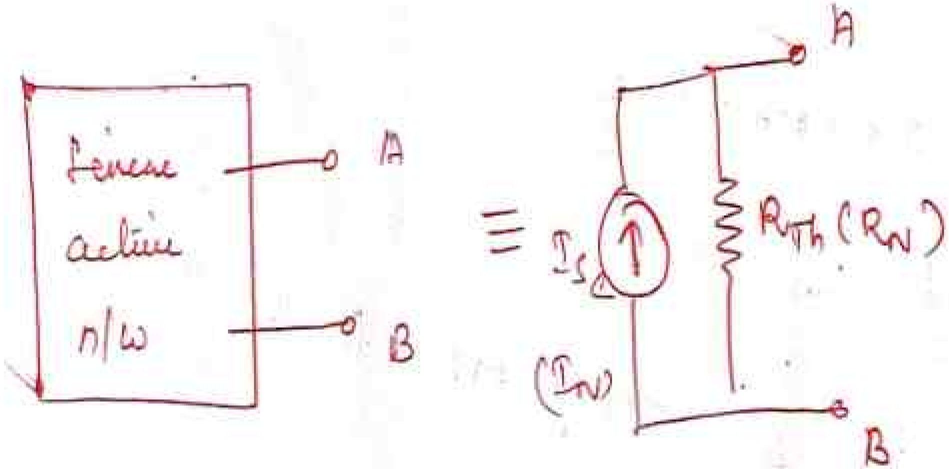
$$= 11.25\ \Omega$$

Norton's Theorem:

"Dual to Thevenin's Theorem".

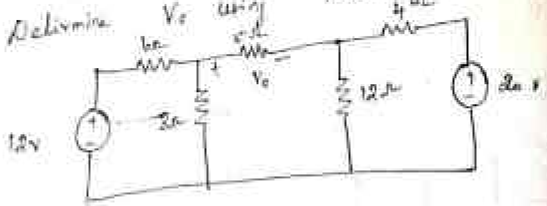
Statement:

"Any linear active n/w with o/p terminals A, B as shown in figure can be replaced by a single current source $I_{SC} (I_N)$ in parallel with a single impedance Z_{Th} ($= R_{Th} = R_N$)".



Norton's Theorem Based problems

(19) Determine V_0 using Norton's Theorem.



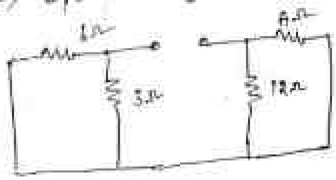
Step 1: $R_L = 5\Omega$ Remove R_L

Step 2: To find R_N:

→ Remove the R_L

→ Short volt/ sources

→ open current sources



$$= \frac{6\times 3}{6+3} + \frac{4\times 12}{4+12}$$

$$= \frac{18}{9} + \frac{48}{16}$$

$$= 2+3 = 5\Omega$$

$\boxed{R_N = 5\Omega}$

Step 3: To find I_{sc} (or) I_N.

$$\begin{bmatrix} R_{11} & R_{12} & R_{13} \\ R_{21} & R_{22} & R_{23} \\ R_{31} & R_{32} & R_{33} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix}$$

$$\begin{bmatrix} 9 & -3 & 0 \\ -3 & 15 & -12 \\ 0 & -12 & 16 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} 12 \\ 0 \\ -20 \end{bmatrix}$$

$\therefore I_1 = 0.6A$, $I_2 = -2.2A$, $I_3 = -2.9A$

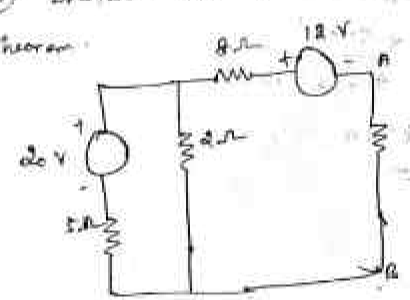
$$I_N = I_2 = -2.2A$$

$$I_L = \frac{I_N \times R_N}{R_N + R_L} = 1.1A$$

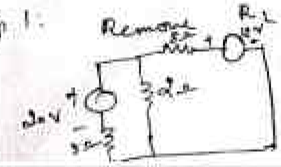
$$V_0 = I_L R_L$$

$\boxed{V_0 = 5.5V}$

(20) Evaluate the I thro' 10Ω resistor by Norton Theorem.



Step 1. Remove R_L & short it.



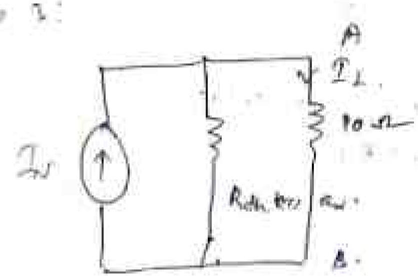
I_N :

$$\begin{bmatrix} 7 & -2 \\ -2 & 10 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 20 \\ -12 \end{bmatrix}$$

$$I_2 = \frac{-44}{66} = -0.66$$

$$\boxed{I_N = -0.66\,A}$$

Step 3 :



$$I_L = I_N \times \frac{R_N}{R_N + R_L}$$

$$= -0.666 \times \frac{9.428}{9.428 + 10}$$

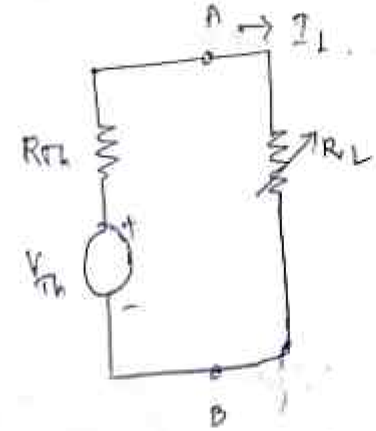
$$I_L = -0.323\,A$$

MAXIMUM POWER TRANSFER THEOREM:

if "Purely Resistive circuit & R_L is Variable"

Statement:

"Maximum power will be delivered from a Voltage source to a load, when the load 'R' is equal to the internal 'R' of the source".



$\therefore R_{Th} = R_L$.

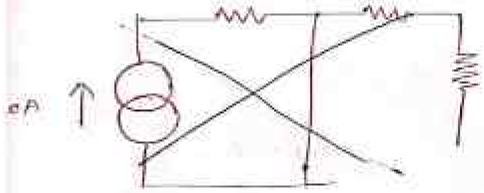
$$\therefore I_L = \frac{V_{Th}}{R_L + R_L} = \frac{V_{Th}}{2R_L}$$

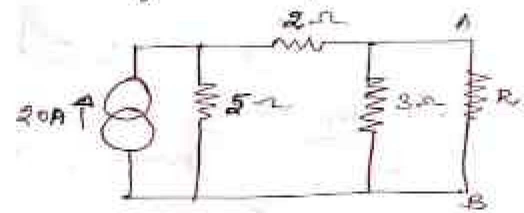
Max. power delivered to R_L = $I_L^2 R_L$

$$= \frac{V_{Th}^2}{4R_L^2} \times R_L$$

$$= \frac{V_{Th}^2}{4R_L}$$

7) The circuit shown in figure, R absorbs max. power compute the value of 'R' & max. power.



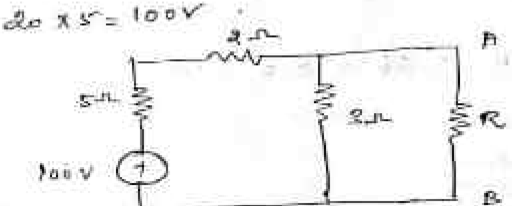


Solution:

Step 1:

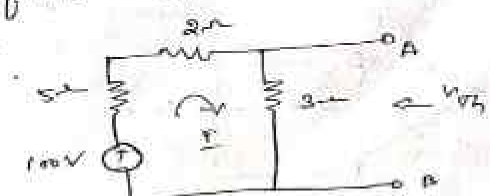
Convert current source II with 5Ω to voltage source:

$20 \times 5 = 100V$



Step 2:

To find V_{Th} Remove R_L (Here 'R' = R_L)

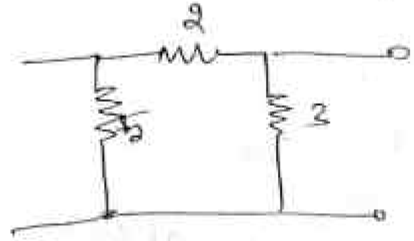


$-100 + 10I = 0 \Rightarrow \boxed{I = 10A}$

$\therefore V_{Th} = V_{AB} = 3 \times I = 3 \times 10 = 30V$

Step 3: To find R_{Th}:

Remove Sources & R_L



$\therefore$ 2 & 3 in series $\Rightarrow 5 \parallel 5 = \frac{5 \times 5}{5+5} = \frac{25}{10} = 2.5\Omega$

$\therefore \boxed{R_{Th} = 2.5\Omega}$

Step 4

At max. power, $R_{Th} = R_L$ $\quad (R_L = 2.5\Omega)$

$\therefore I_L = \frac{V_{Th}}{2R_{Th}} = \frac{V_{Th}}{5} = \frac{30}{5} = 6A$

$P_L = \frac{V_{Th}^2}{4R_L} = \frac{30^2}{4 \times 2.5} = \frac{900}{10}$

$\boxed{P_L = 90W}$

(or)

$P_L = I_L^2 R_L = 36 \times 2.5 = 90W$

Dual circuits

=> "2 electrical n/ws are said to be dual n/ws if the mesh equations of one n/w is = to the node eqn' of the other."

=> In an electrical n/w, there is a pair of terms which can be interchanged to get new circuits called dual n/w

Dual elements are,

Original ⟺ Dual

I ⟺ V

I source ⟺ V source

R ⟺ conductance (G)

C ⟺ L

Loop ⟺ Node

KCL ⟺ KVL

series ⟺ parallel

OC ⟺ SC

Impedance ⟺ Admittance

Steps to be followed to draw the dual n/w.

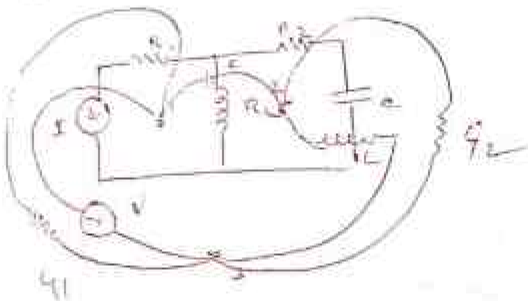
① => In each loop, place node & place an extra node (Ref. node) outside the circuit.

② => Draw the lines connecting adjacent nodes passing thru' each element and also to ref node.

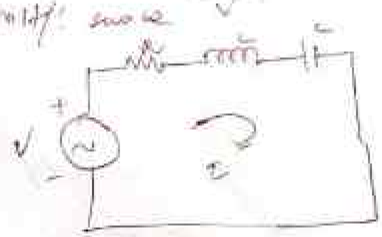
③ Draw dual n/w by replacing dual of each element in the line passing thru' original element.

(3) Draw the dual n/w for the given n/w

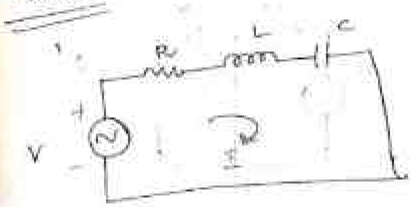
Solution



(4) Consider R-L-C series circuit with voltage source V



Solution



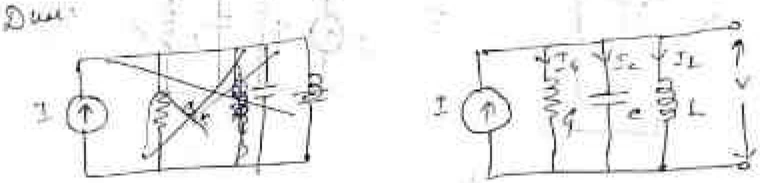
Apply KVL to this ckt,

$$-V + IR + L\frac{dI}{dt} + \frac{1}{C}\int I\,dt = 0$$

$$\therefore V = IR + L\frac{dI}{dt} + \frac{1}{C}\int I\,dt$$

$$\boxed{V = V_R + V_L + V_C} \rightarrow (1)$$

Dual:

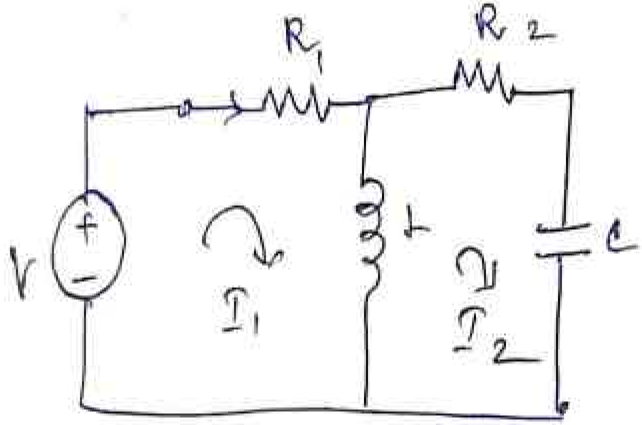


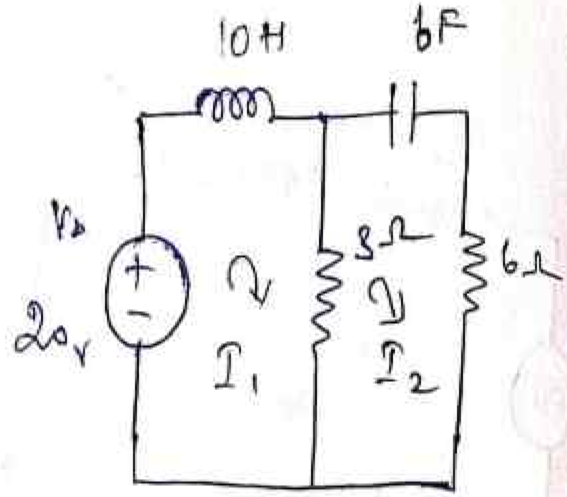
$$\Rightarrow I = I_G + I_C + I_L \rightarrow (2)$$

Conclusion

1. Eqn (1) & (2) are same
2. Mesh & node Eqn's are identical
3. N/W Behave likely with interchanged variables

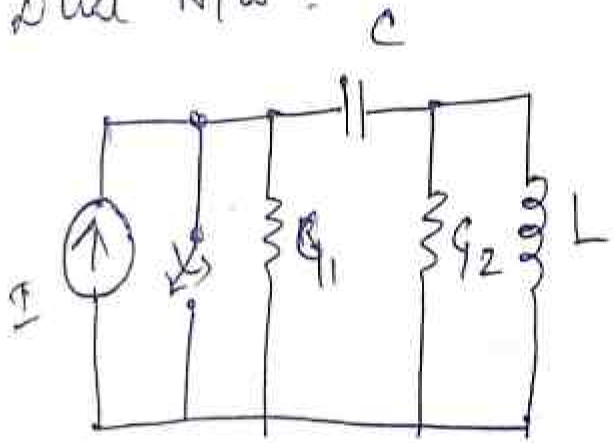
Q3 Draw the dual n/w for the given n/w.



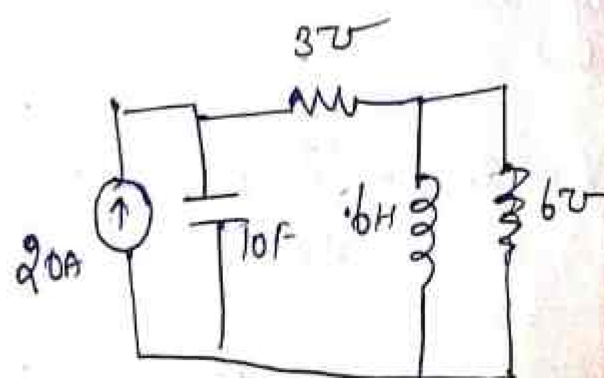


Soln 1:

Dual n/w:



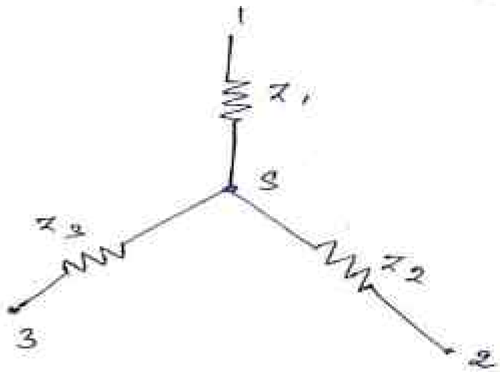
|||

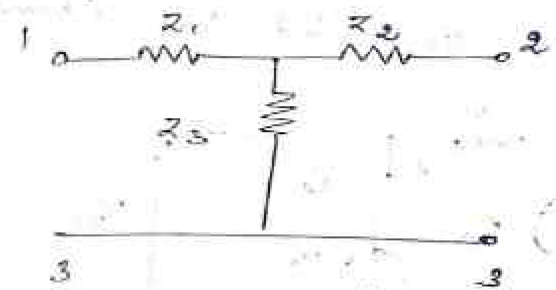


Delta - Star & Star (T) - Delta (Δ) (π) Transformations:

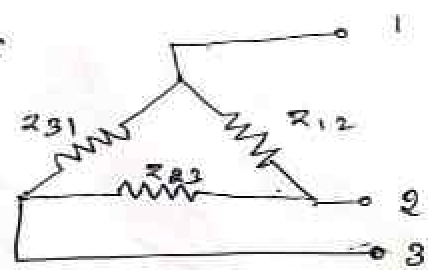
⇒ For the complicated networks, these transformations considerably reduce the complexity of the network & analysed quickly.

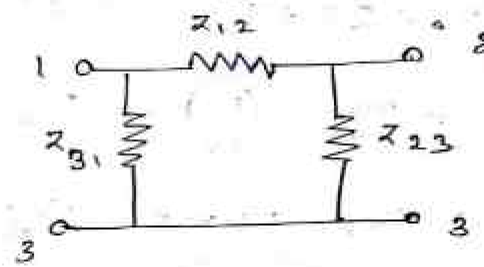
⇒ These transformations allow us to replace 3 star connected elements of network by equivalent delta connected elements without affecting 'I' in other branches.



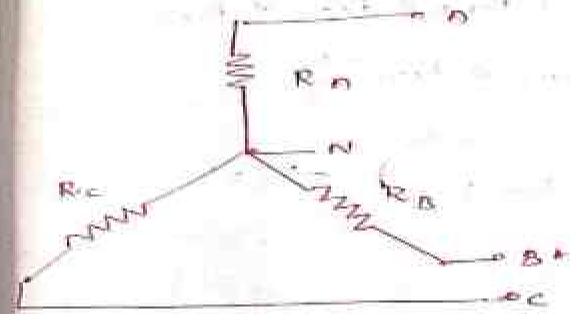


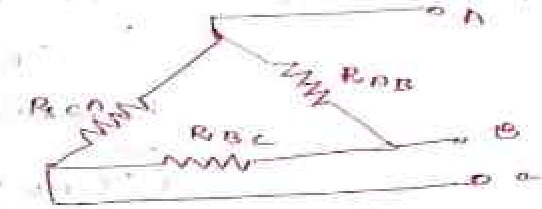
Star (or) T connection





Star to Delta (or) T to π Transformations :





W.K.T,

$$R_A = \frac{R_{AB} R_{CA}}{R_{AB} + R_{BC} + R_{CA}} \rightarrow (1)$$

$$R_B = \frac{R_{BC} R_{AB}}{R_{AB} + R_{BC} + R_{CA}} \rightarrow (2)$$

$$R_C = \frac{R_{CA} R_{BC}}{R_{AB} + R_{BC} + R_{CA}} \rightarrow (3)$$

Multiply . (1) & (2)

$$R_A R_B = \frac{R_{AB}^2 R_{BC} R_{CA}}{(R_{AB} + R_{BC} + R_{CA})^2} \rightarrow (4)$$

× (2) & (3)

$$R_B R_C = \frac{R_{BC}^2 R_{AB} R_{BC}}{(R_{AB} + R_{BC} + R_{CA})^2} \rightarrow (5)$$

× (3) & (1)

$$R_C R_A = \frac{R_{CA}^2 R_{AB} R_{BC}}{(R_{AB} + R_{BC} + R_{CA})^2} \rightarrow (6)$$

Add (A), (B)(C) & (D), we get

$$R_AR_B + R_BR_C + R_CR_A = \frac{R_{AB}R_{BC}R_{CA}(R_{AB}+R_{BC}+R_{CA})}{(R_{AB}+R_{BC}+R_{CA})^2}$$

$$= \frac{R_{AB}R_{BC}R_{CA}}{(R_{AB}+R_{BC}+R_{CA})} \to (7)$$

$$= R_{AB}R_C$$

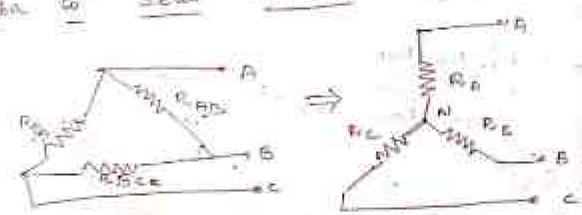
$$\Rightarrow \boxed{R_{AB} = \frac{R_AR_B+R_BR_C+R_CR_A}{R_C}}$$

|||ly, $R_{BC} = \dfrac{R_AR_B+R_BR_C+R_CR_A}{R_A}$

$$R_{CA} = \frac{R_AR_B+R_BR_C+R_CR_A}{R_B}$$

$\cancel{R_{AB}}$

Delta to Star Conversion



⇒ Easy to analyse

A, B, C → Terminals

⇒ To find Eff. R' b/n A & B (Delta connection)

$$R_{AB} = \frac{(R_{BC}+R_{CA})R_{AB}}{R_{AB}+R_{BC}+R_{CA}} \to (A)$$

Star connection → Resi. b/n A & B

$$R_{AB} = R_A + R_B \to (B)$$

(A) ≡ (B)

$$R_A + R_B = \frac{R_{AB}(R_{BC}+R_{CA})}{R_{AB}+R_{BC}+R_{CA}} \to (C)$$

|||ly,

$$R_{BC} = \frac{R_{BC}(R_{CA}+R_{AB})}{R_{AB}+R_{BC}+R_{CA}} \to (D)$$

D ⇒ $R_B + R_C = \dfrac{R_{BC}(R_{CA}+R_{AB})}{R_{AB}+R_{BC}+R_{CA}} \to (E)$

|||ly,

$$R_C + R_A = \frac{R_{CA}(R_{AB}+R_{BC})}{R_{AB}+R_{BC}+R_{CA}} \to (F)$$

(C) − (E) ⇒ $R_A - R_C = \dfrac{\cancel{R_{AB}R_{BC}} + R_{AB}R_{CA} - R_{BC}R_{CA} - \cancel{R_{BC}R_{AB}}}{R_{AB}+R_{BC}+R_{CA}}$

$$R_A - R_C = \frac{R_{AB}R_{CA} - R_{BC}R_{CA}}{R_{AB}+R_{BC}+R_{CA}} \to (G)$$

Add (F) & (G) ⇒

$$2R_A = \frac{R_{AB}R_{CA} + \cancel{R_{CA}R_{BC}} + R_{AB}R_{CA} - \cancel{R_{BC}R_{CA}}}{R_{AB}+R_{BC}+R_{CA}}$$

$$2R_A = \frac{2R_{AB}R_{CA}}{R_{AB}+R_{BC}+R_{CA}}$$

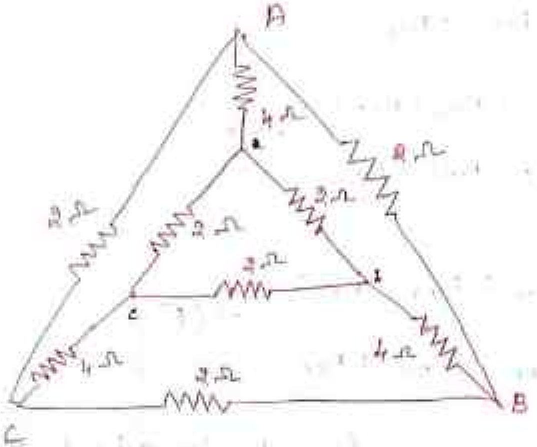
$$\boxed{R_A = \frac{R_{AB}R_{CA}}{R_{AB}+R_{BC}+R_{CA}}}$$

Illy,

$$R_B = \frac{R_{BC}\,R_{AB}}{R_{AB}+R_{BC}+R_{CA}}$$

$$R_C = \frac{R_{CA}\,R_{BC}}{R_{AB}+R_{BC}+R_{CA}}$$

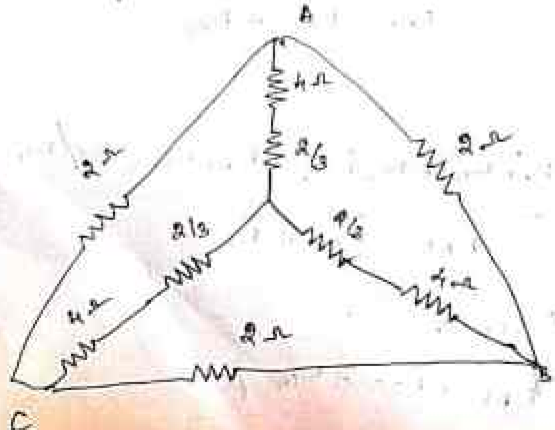
(1) Find the R_{eq} b/n A & B for the given circuit



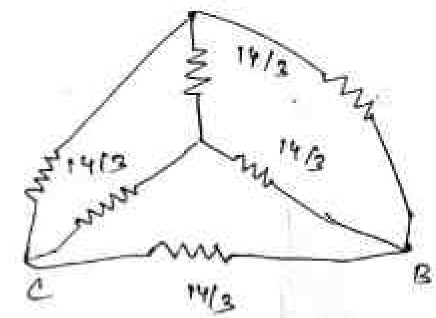
2Ω's ⇒ in center are in Δ or π

Step 1:

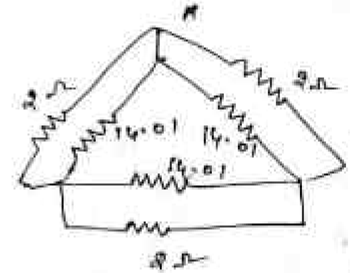
Δ to Star



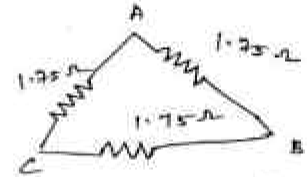
Step 2:



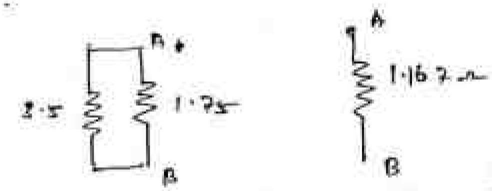
Step 3:



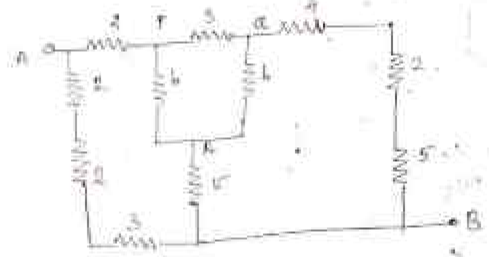
Step 4:



Step 5:



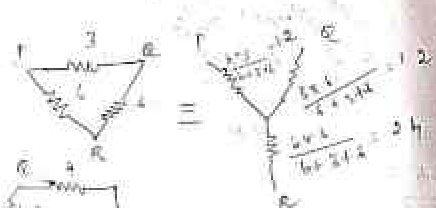
12. Calculate the effective R b/w points A & B in the given circuit.

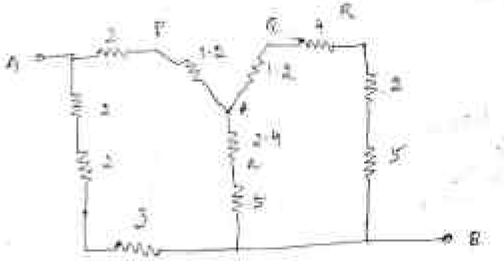


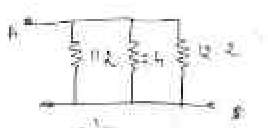
Solution:

Step 1:

ΔPQR =>



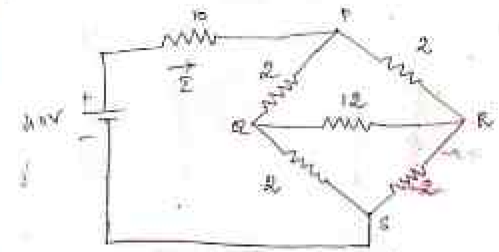




$\frac{1}{R_{eq}} = \frac{1}{11.2} + \frac{1}{7.4} + \frac{1}{12.2} = 0.3064$

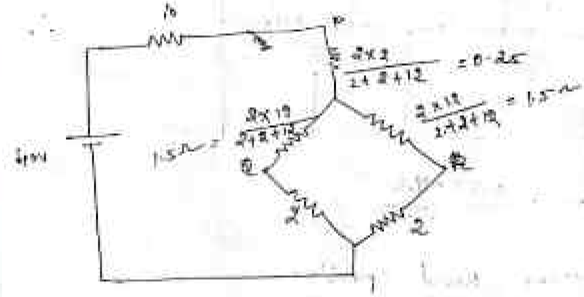
$\therefore R_{eq} = 3.26\Omega$

(13) For the circuit shown in figure, find the current flowing through the 10Ω R.

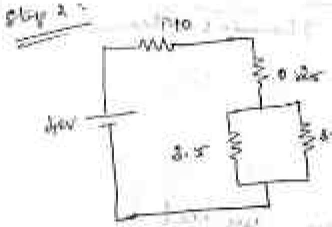


Solution:

Step 1: Apply Δ to T => in PQR



Step 2:



Step 3

$3.5 \parallel 3.5 \Rightarrow 1.75$ series with 0.25 & 10

$I_T = \frac{40}{10 + 0.25 + 1.75}$

$\boxed{I = 3.33A}$