NETWORK THEORY

UNIT-1:

Review of DC Network basics, Nodal and Mesh Analysis

NETWORK TOPOLOGY

* Terminology
* Cut-set and Tie-set matrices for planar networks with DC sources,
* related definitions and problems
* Source Transformation
* Duality

NETWORK THEOREMS

* Thevenin's Theorem
* Norton's Theorem
* Maximum Power Transfer Theorem
* Superposition Theorem
* Tellegen's "
* Reciprocity "
* Millers "
* Millman's "
* Compensation Theorems

with DC and AC excitations.

OHM'S LAW:

At a constant temperature, the current flowing through a resistor is directly proportional to the potential difference across the resistor.

$$I \propto V \quad (T = \text{const})$$

$$I = \frac{V}{R} \quad \text{where } V = \text{potential difference across } R$$

Potential drop in resistor, $V = IR$

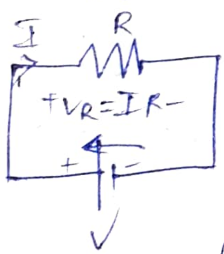
$$R = \frac{V}{I}$$

$I =$ Amperes (A)
$V =$ volts (V)
$R =$ ohms (Ω)
$R = \frac{\rho l}{A}$

$v(t) = R\,i(t)$ Time Invariant
$v(t) = R(t)\,i(t)$ X Time Variant

Resistor: dissipates energy.

$$R_t = R_{ref}(1 + \alpha \Delta T)$$



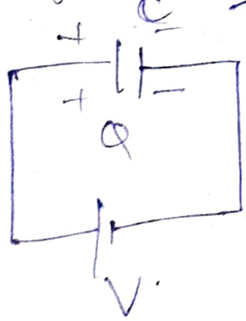
~~α~~

$$P = VI = I^2R = \frac{V^2}{R} \text{ watts (W)}$$

$$E = P \times t \text{ Joules (J)}$$

C/ charge principle

$$C = \frac{\epsilon_0 A}{d} \quad (A = \text{Overlapping plate area})$$



$$V = \frac{Q}{C}; \quad V = \frac{It}{C} = \frac{1}{C}\int_{-\infty}^{t} q(t)\,dt$$

$$i(t) = C\frac{dv}{dt}.$$

Capacitor: stores static energy.

Power, $P(t) = v(t)\,i(t)$

$$E = \int P(t)\,dt = \int v(t)\,C\frac{dv}{dt}\,dt = C\int v\,dv = \frac{CV^2}{2} = \frac{1}{2}CV^2$$

Inductor — flux principle

$i = \frac{\phi}{L}$

$\psi = N\phi$ = Total flux.

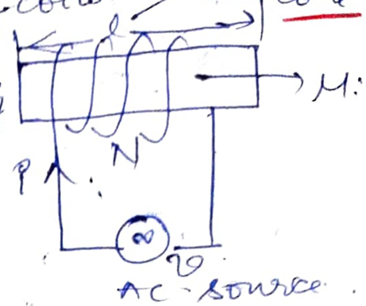
$L = \frac{\mu A N^2}{l}$

permeability; cross sectional area; No of coils; length of core.

$l \to$ length of core

$\mu \to$ permeability of the material.

ability of the material to allow the flow of flux.



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

Faraday's second law. $\boxed{v = N\frac{d\phi}{dt}}$

$i = \frac{1}{L}\int_{-\infty}^{t} v\,dt$

Inductor : stores dynamic energy.

$E = \frac{1}{2}Li^2$

$\psi = N\phi$

$\frac{d\psi}{dt} = N\frac{d\phi}{dt} = v$

$v \to$ AC

$i \to$ AC

flux is clockwise anticlockwise

$\psi \propto i$

$\psi = Li$

$\frac{d\psi}{dt} = \frac{Ldi}{dt}$

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

Derivation: Inductor is done from the last unlike both cases.

$N\frac{d\phi}{dt} = \frac{Ldi}{dt}$.

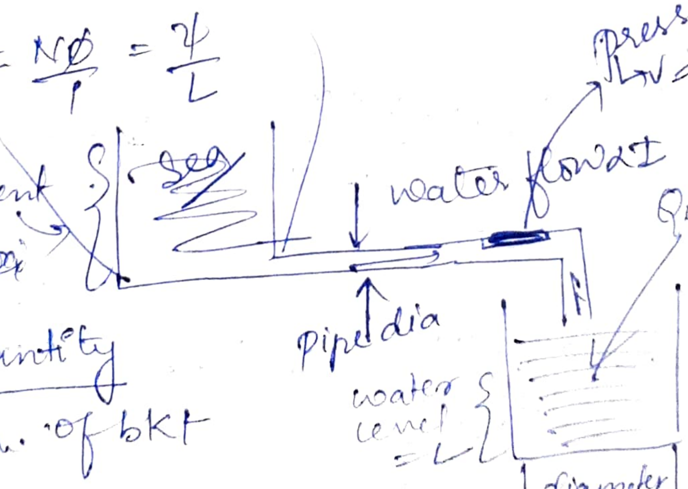
$N\frac{d\phi}{di} = L$; $L = N\frac{d\phi}{di} = \frac{N\phi}{i}$.

(as long as core is not saturated with linearity)

$L = \frac{N\phi}{i} = \frac{\psi}{L}$

water level → pot diff

source drive current



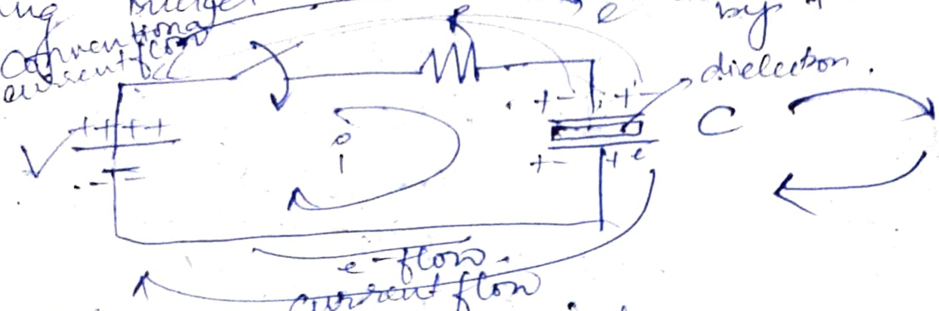
Water level = $\frac{\text{Quantity}}{\text{dia. of bkt}}$

$v = \frac{Q}{C}$

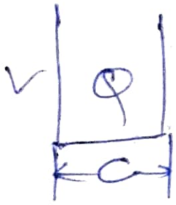
diameter of pipe $\propto \frac{1}{R}$.

μf, 10 μf, 100 μf, 1000 μf.

bottle mug bucket Drum.



switches close
tap open



bucket to store water

★ Capacitor to store charge.

charging Capacitor = filling bucket

water flowing through bucket ⇒ bucket will not fill.

Hence, place dielectric material.

$t = 0$ i = more

$t = \infty$ i = Decreasing

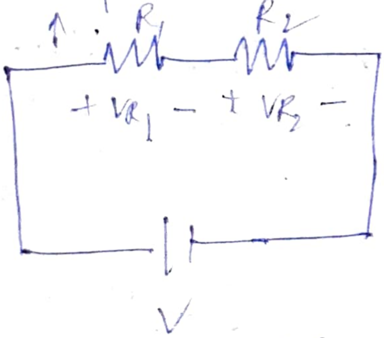
(Capacitor slowly becomes another source)

$C = \frac{\varepsilon A}{d}$ → Overlapping plate area.

distance b/w two plates.

(insulators) . Content between the plates.

Voltage Division Formulae.

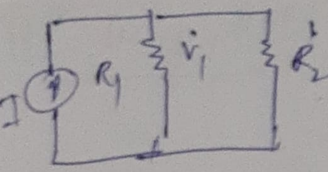


$V_{R_1} = \frac{V \times R_1}{R_1 + R_2}$, $V_{R_2} = \frac{V \times R_2}{R_1 + R_2}$

$V_{R_1} + V_{R_2} = V$.

$V_{C_1} = \frac{V \times C_2}{C_1 + C_2}$ / $V_{C_2} = \frac{V \times C_1}{C_1 \times C_2}$

$\psi_{L_1} = \frac{\psi_T \times L_1}{L_1 + L_2}$, $\psi_{L_2} = \frac{\psi_T \times L_2}{L_1 + L_2}$



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

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

$Q_{C_1} = \frac{Q_T \times C_1}{C_1 + C_2}$, $Q_{C_2} = \frac{Q_T \times C_2}{C_1 + C_2}$

$I_{L_1} = \frac{I \times L_2}{L_1 + L_2}$, $I_{L_2} = \frac{I \times L_1}{L_1 + L_2}$

Single source: VD, CD, QD, FD

R → S (VD), P (CD)

L → S (FD), P (CD)

C → (S) (VD), (P) (QD)

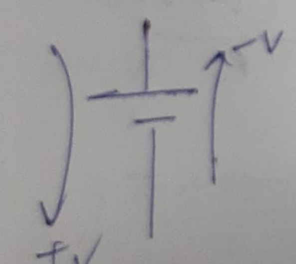
$\boxed{\text{Single source problems}}$

└ Series & Parallel

K-Laws → KVL, KCL

KCL → $\pm \Sigma I = 0$.

KVL: $\pm \Sigma emf \pm \Sigma IR = 0$

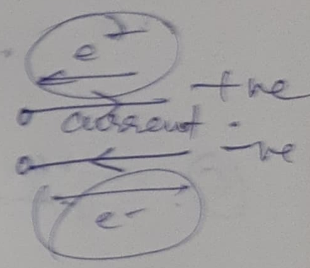


I, R

→ IR (same)

← −IR (opp)

$-IR_1$

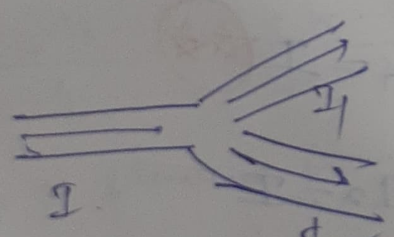


KVL

CR1	CR2
	40
60	
80	20.

100 R/

KCL



ohms Law

V=IR ← → $I = \frac{V}{R}$

KVL
loop/mesh
Mesh analysis
(1) Mesh/loop current
(2) Branch current
(3) Branch voltage
(4) Node voltage.

⇔ dual to each other

KCL
At Node
Nodal analysis
(1) Node voltage
(2) Branch voltage
(3) Branch current.

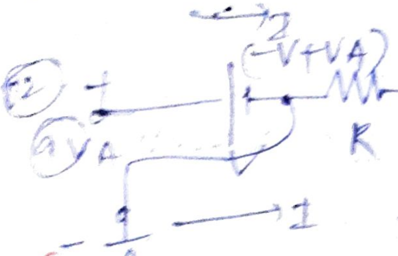
NODAL ANALYSIS

Rules

(1)

$$I = \frac{V_A - V_B}{R}$$

(2) (a)



$$I = \frac{V_A - V_B \mp V}{R} = \frac{(-V + V_A) - V_B}{R}$$

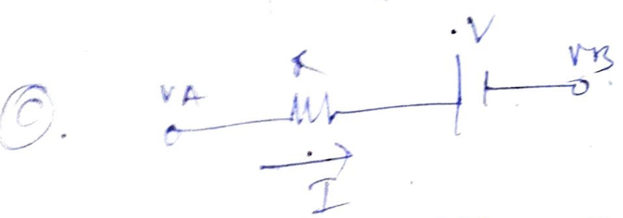
Whenever we want to know the voltage, start at the same point, go to ground following CGR, KVL sign convention.

$$\leftarrow I \qquad I = \frac{V_B - (-V + V_A)}{R}$$

(b)

$$I = \frac{(V + V_A) - V_B}{R}$$

(c)



$$I = \frac{V_A - (V + V_B)}{R}$$

(3) (a)

$$I_x = I$$

(b)

$$I_x = I$$

(c)

$$I_x = I$$

(d)

If branch contains a current source, branch current can be decided which is independent of voltage source, voltage drops.

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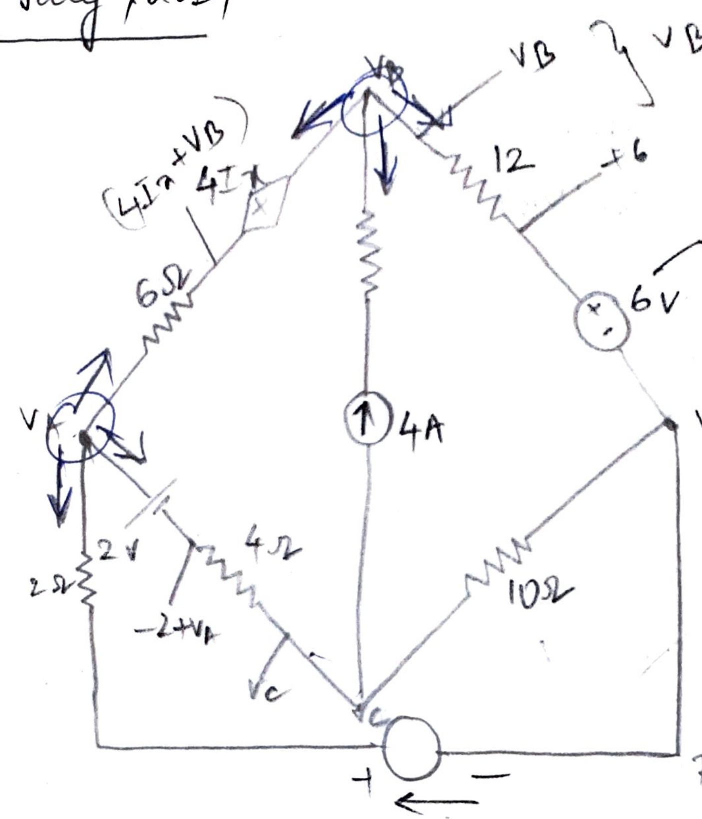


Source → consider the polarity.

$V_D = 0$ [directly connected to ground]

Reference = 0V
Ground/Earth/Neutral.

$$\frac{VA-10}{2} + \frac{VA-(VB+4Ix)}{6} + \frac{(VA-2)-Vc}{4} = 0$$

$$\frac{6VA-60}{12} + \frac{2VA-2VB-8Ix}{12} + \frac{3VA-6-3Vc}{12} \rightarrow (i)$$

$$\frac{4Ix+VB-VA}{6} - 4 + \frac{VB-6}{12} = 0$$

$$\frac{Vc-(VA-2)}{4} + 4 + \frac{Vc-0}{10} = 0$$

I ↓ $+V$

$\mp$ ↓ $-V$

→ $+IR$

← $-IR$

I_x is flowing from D to B.

$$I_x = \frac{6-VB}{12}$$

① VA, VB, Vc are node voltages wrt ground (by default)

VA = 12.310 V

VB = 58.207 V

Vc = -4.063

I_x = -4.3505

Find

(i) V_A V_B V_C I_x

(ii) V_{AB} V_{BC} V_{CA} - Branch voltage

(Voltage at A wrt B ($V_A - V_B$))

(iii) Branch voltages.

$V_{AB} = V_A - V_B = -45.897\,V$

$V_{BC} = 62.27\,V$

$V_{CA} = -16.373.$

(iii) Branch currents

$I_{AB} = \frac{V_A - V_B - 4I_x}{6} = -10.54\,A$

$I_{BD} = 3.593$, $I_{BC} = -4$

$I_{CA} = -4.593$, $I_{CD} = -0.0406$

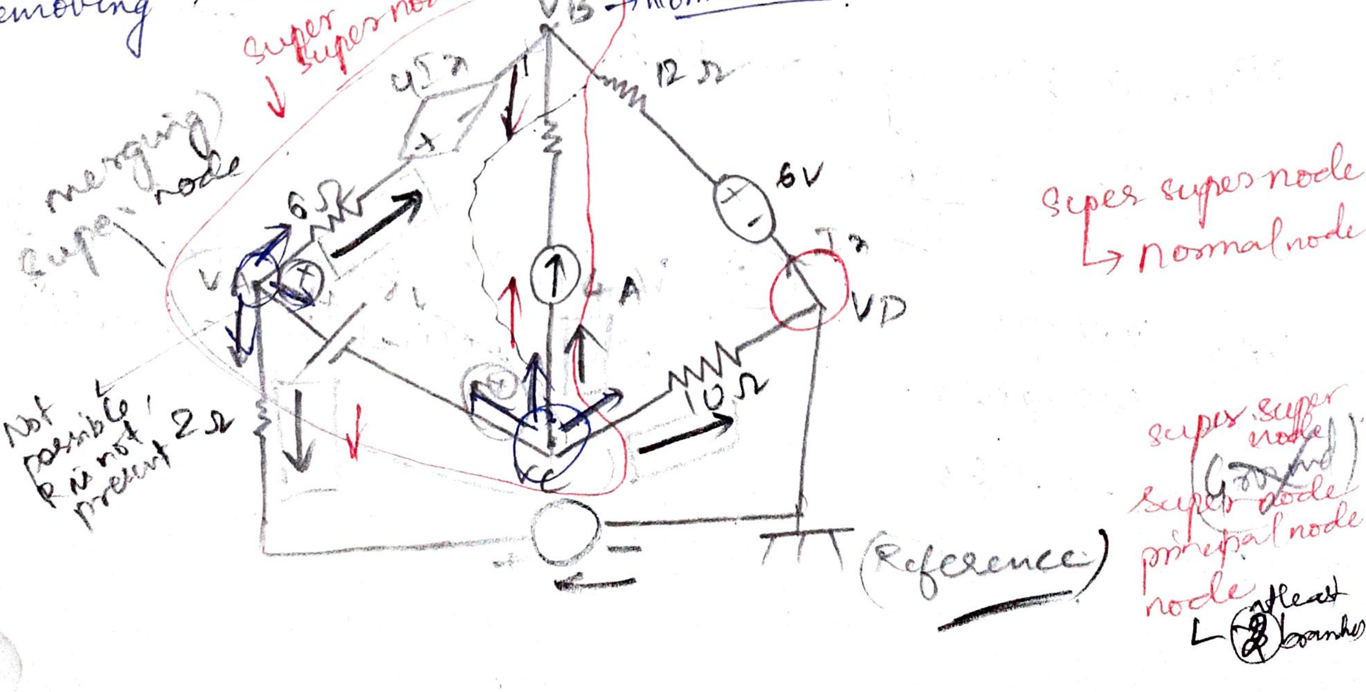
(iv) Apply ohm's Law, where there is a resistor

* Dont apply it, where there is no R

Voltmeter - ∞ Resistance, Ammeter - 0 Resistance

Voltage & current sources resistances is not known and should not apply ohm's law to voltage source & current source.

Removing the 4Ω resistor from the above circuit diagram.



It is not possible to do nodal analysis at V_A and V_C, so we will merge them known as SUPER NODE.

$$\therefore \frac{V_A-10}{2} + \frac{V_C}{10} + 4 + \frac{V_A-(4i_x+V_B)}{6} = 0 \rightarrow (1)$$ [Super Node Equation]

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3) When there is ONLY VOLTAGE SOURCE, between two principal nodes, go for the SUPER NODE.

$$\frac{(4i_x+V_B)-V_A}{6} - 4 + \frac{V_B-6}{12} = 0 \longrightarrow (2)$$

$8i_x + 2V_B - 2V_A - 48 + V_B - 6 = 0$

$3V_B - 2V_A + 8i_x - 54 = 0$

$3V_B - 2V_A - 54 + \frac{8}{12}(6-V_B) = 0$

$9V_B - 6V_A - 162 + 12 - 2V_B = 0$

$7V_B - 6V_A - 150 = 0 \rightarrow (2)$

$$i_x = \frac{6-V_B}{12} \rightarrow (3).$$

$$V_{AC} = V_A - V_C = +2V. \longrightarrow (4)$$

(04) To find V_{AB}, start at A, go to B. (or) Start at +ve go to -ve. + → (or) start at voltmeter red button, go to black button following CGR KVL convention

$\boxed{\text{Solve for } V_A, V_B, V_C, i_x}$

(1) N.V
(2) B. Voltage
(3) B. Current.

$$\frac{V_A-10}{2} + \frac{V_C}{10} + 4 + \frac{V_A-4i_x-V_B}{6} = 0.$$

$$\frac{15V_A - 150 + 3V_C + 120 + 5V_A - 20i_x - 5V_B}{30} = 0,$$

$20V_A - 5V_B + 3V_C - 30 - 20i_x = 0 \longrightarrow (1).$

$20V_A - 5V_B + 3V_C - 30 - \frac{20}{12}(6-V_B) = 0.$

$60V_A - 15V_B + 9V_C - 90 - 30 + 5V_B = 0.$

$60V_A - 10V_B + 9V_C - 60 = 0. \longrightarrow (1).$

$-6V_A + 7V_B - 150 = 0 \longrightarrow (2).$

$V_A \quad - V_C = 2 \longrightarrow (3).$

$\boxed{I_y = \frac{V_C}{10} + 4}$

2 | 2, 10, 6
  | 1, 5, 3

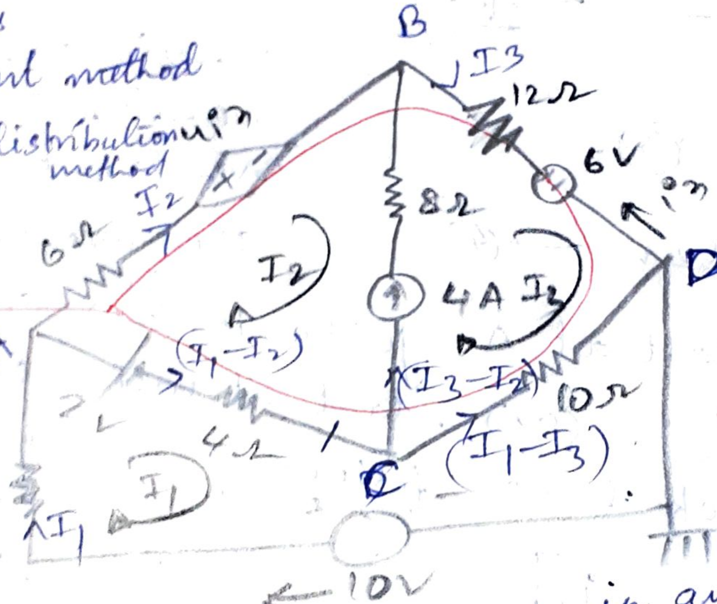
$i_x = \frac{6-V_B}{12}$

$V_A = V_C + 2$

~~60VA − 15VB~~

MESH ANALYSIS:

Two methods
(i) Loop current method
(ii) Current distribution method



Steps
① Loop currents
② Branch current
③ 4 equations

★ Mesh eq is not possible for loop containing I_2, I_3 because voltage across 4A current source is not known

(Q5) When there is a current source in any branch go for super mesh.

$$-10 + 2I_1 + 2 + 4(I_1 - I_2) + 10(I_1 - I_3) = 0 \rightarrow ①$$

(Super mesh eq)
$$-4(I_1 - I_2) - 2 + 6I_2 + 4i_x + 12I_3 + 6 - 10(I_1 - I_3) = 0 \rightarrow ②$$

$$i_x = -I_3 \rightarrow ③$$

$$I_3 - I_2 = +4 \rightarrow ④$$

Solve for I)
$I_1 =$
$I_2 =$
$I_3 =$
$i_x =$
} LOOP CURRENTS

II BRANCH CURRENTS

III BRANCH VOLTAGE:

voltage at A wrt B

$V_{AB} = 6I_2 + 4i_x$.

$V_{BC} = 12I_3 + 6 - 10(I_1 - I_3)$

$V_{CA} = -4(I_1 - I_2) - 2$

× takes lot of time.

$V_{AB} = V_A - V_B$
$V_{BC} = V_B - V_C$
$V_{CA} = V_C - V_A$

IV NODE VOLTAGE:

$V_A = -8I_1 + 10$

$V_B =$

$V_C =$

(Dont go via current source, preferably shortest path)

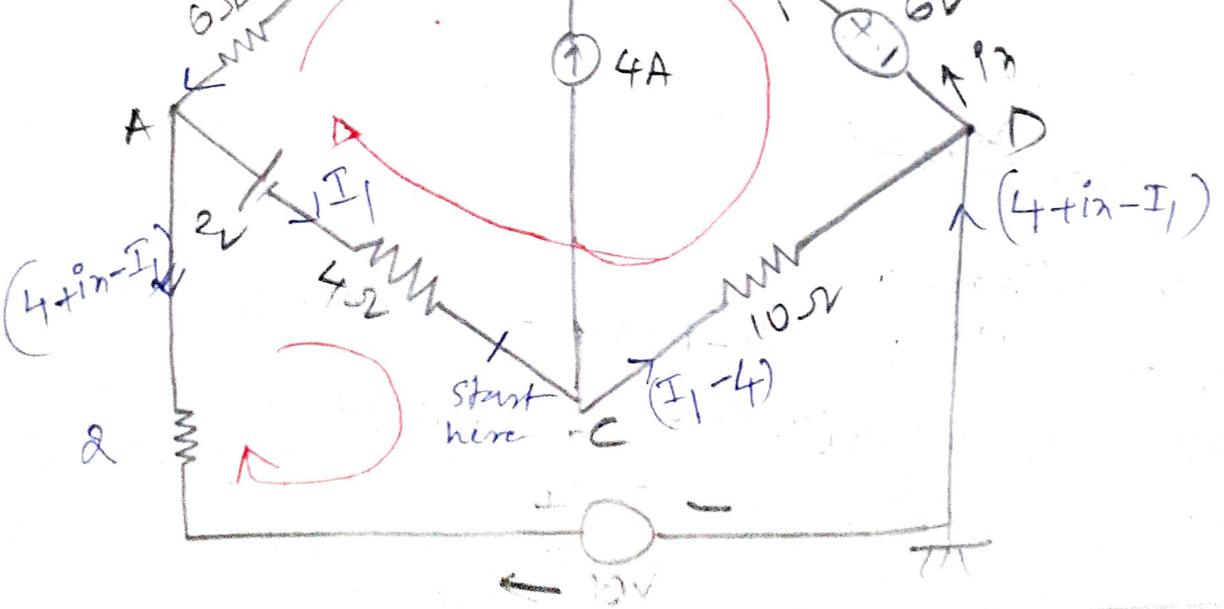
Disadvantages

(1) More number of unknown
(2) More " of equation
~~(3) More equations~~
(4) More mistakes
(5) More steps.

(ii) Current distribution method.

Advantages

① Less no of unknowns
② Less no of eqns
③ Less no of mistakes
④ Less steps.



$-10-2(4+i_x-I_1)+2+4I_1+10(I_1-4)=0 \longrightarrow ①$

$=4I_1-2-6(4+i_x)+4i_x-12i_x+6-10(I_1-4)=0 \longrightarrow ②$

H.W

Solve I) $I_1=$ Branch currents

$i_x=$

II) B.V =

III) N.V =

$-10-8-2i_x+2I_1+2+4I_1+10I_1-40=0$

$-18-2i_x+2I_1+2+14I_1-40=0$

$16I_1-16-2i_x-40=0$

$16I_1-2i_x-56=0 \times 7 \longrightarrow ①$.

$-4I_1-2-24-6i_x+4i_x-12i_x+6-10I_1+40=0$

$-4I_1-26-14i_x+46-10I_1=0 \longrightarrow ②$.

$-14I_1-14i_x+20=0$

$I_1=\frac{206}{63}=3.2698 \quad i_x=\frac{-116}{63}=-1.8412$

$I_1=3.27$ A

$i_x=-1.84$ A

Branch Voltages:

$V_{AB}=(4+i_x)6=(4-1.84)6=2.16\times 6=12.96$ V

$V_{BC}=-12i_x+6-10(I_1-4)=+12\times(+1.84)+6-10(3.27-4)$

$=12\times 1.84+6-10(-0.73)$

V_{CA}

$=12\times 1.84+6+7.3$

$V_{BC}=35.38$

$V_{CA} = -4I_1 - 2.$

$= -4 \times 3.27 - 2$

$= -13.08 - 2$

$V_{CA} = -15.08$

Node Voltage:

$V_A = 2(4 + i_x - I_1) + 10.$

$= 2(4 - 1.84 - 3.27) + 10$

$V_B = 12 I_x + 6 =$

$V_C = 10(I_1 - 4)$

$R_a = \frac{R_{ab} R_{ca}}{R_{ab} + R_{bc} + R_{ca}}$ $R_b = \frac{R_{bc} R_{ab}}{R_{ab} + R_{bc} + R_{ca}}$ $R_c = \frac{R_{ca} R_{bc}}{R_{ab} + R_{bc} + R_{ca}}$

$R_{ab} = R_a + R_b + \frac{R_a R_b}{R_c}$

$R_{bc} = R_b + R_c + \frac{R_b R_c}{R_a}$

$R_{ca} = R_c + R_a + \frac{R_c R_a}{R_b}$

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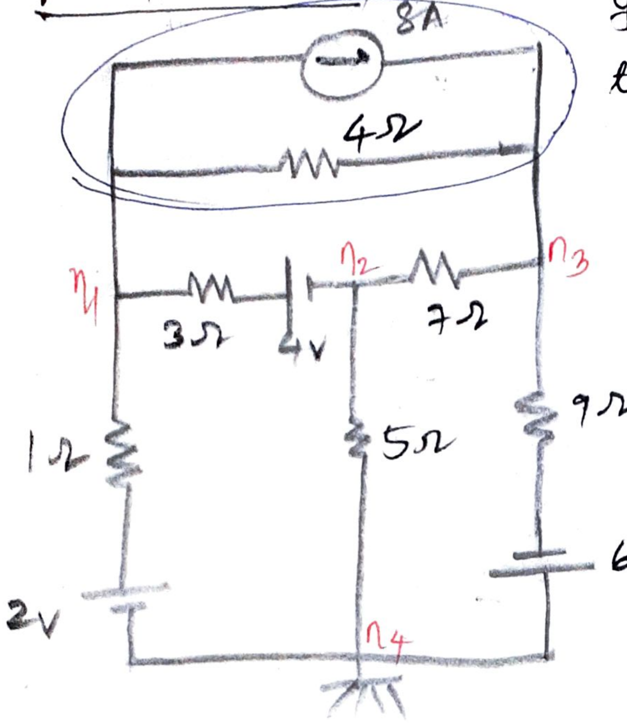
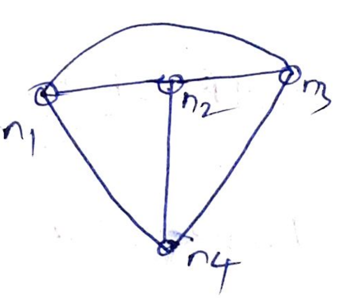
GRAPH THEORY

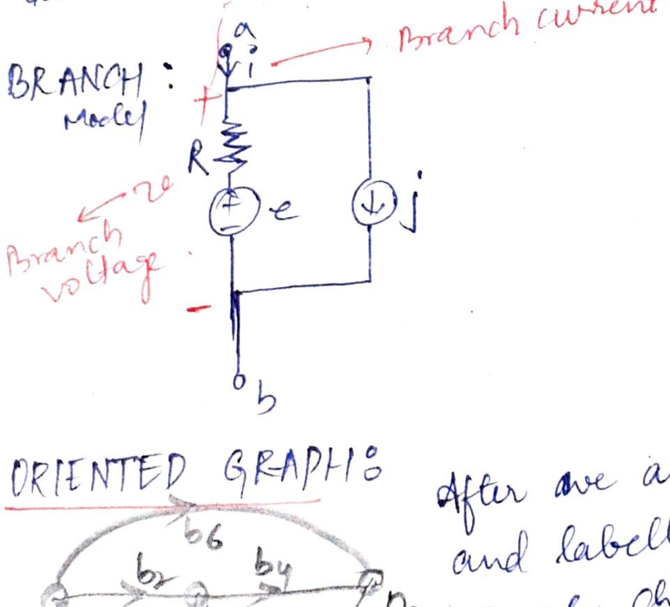
Find branch currents using tie-set schedule?



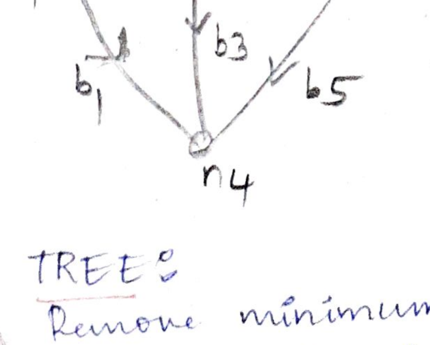
01) GRAPH: It is the skeleton of given ckt containing all nodes and branches.



02) BRANCH: Model



02) ORIENTED GRAPH:



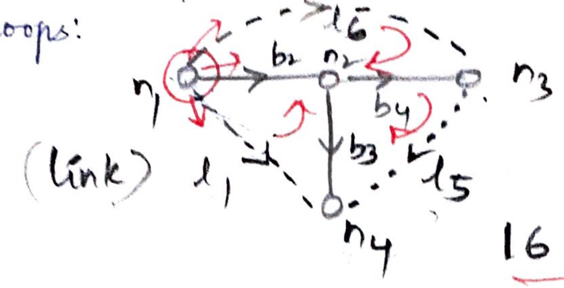
After we assign current direction, and labelling each branch then graph changes to oriented graph.

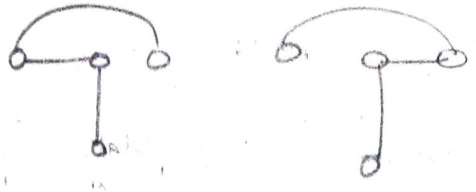
Note: The current directions are not fixed (@ your choice)

03) TREE:

Remove minimum number of branches such that there should not be any closed loops.

Possible loops:





16 POSSIBLE TREES

04 TIE-SET MATRIX: [M]

	b_1	b_2	b_3	b_4	b_5	b_6
l_1	1	-1	-1	0	0	0
l_5	0	0	-1	1	1	0
l_6	0	-1	0	-1	0	1

(ii) Go along with link current direction

same	+1
opp	-1
~~else~~	0.

(i) Corresponding to each link, one loop is closed.

05 PROPERTIES:

(a). $MV = 0$; $M = \begin{bmatrix} 1 & -1 & -1 & 0 & 0 & 0 \\ 0 & 0 & -1 & 1 & 1 & 0 \\ 0 & -1 & 0 & -1 & 0 & 1 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \\ v_5 \\ v_6 \end{bmatrix}$

(KVL/Mesh equations)

$$\Rightarrow v_1 - v_2 - v_3 = 0$$
$$-v_3 + v_4 + v_5 = 0$$
$$-v_2 - v_4 + v_6 = 0.$$

Link currents

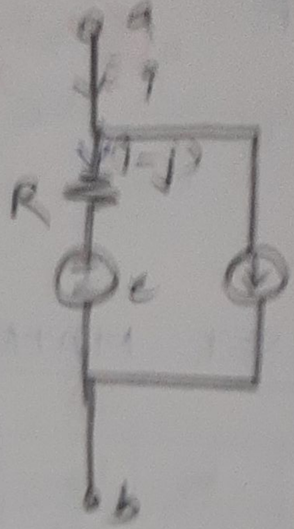
current in the link

(b) $M^T I = i$ (KCL/ Nodal equations)

$$\begin{bmatrix} 1 & 0 & 0 \\ -1 & 0 & -1 \\ -1 & -1 & 0 \\ 0 & 1 & -1 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} I_1 \\ I_5 \\ I_6 \end{bmatrix} \Rightarrow \begin{bmatrix} I_1 \\ -I_1 - I_6 \\ -I_1 - I_5 \\ I_5 - I_6 \\ I_5 \\ I_6 \end{bmatrix} = \begin{bmatrix} i_1 \\ i_2 \\ i_3 \\ i_4 \\ i_5 \\ i_6 \end{bmatrix} = [i]$$

05) c. $\rightarrow v = R(i-j)+e$

Ohm's Law Voltage Equation



06) <u>Combine:</u>

$Mv = 0$

$M[R(i-j)+e]=0$

$M[R(M^T I - j)+e]=0$

☆☆ $\boxed{MRM^T I = M(Rj - e)}$

M→ <u>Tie set Matrix</u>

R, j, e.

$$R=\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 3 & 0 & 0 & 0 & 0 \\ 0 & 0 & 5 & 0 & 0 & 0 \\ 0 & 0 & 0 & 7 & 0 & 0 \\ 0 & 0 & 0 & 0 & 9 & 0 \\ 0 & 0 & 0 & 0 & 0 & 4 \end{bmatrix}$$ b×b 6×6

$$j=\begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ +8 \end{bmatrix}$$ → (Orientation is compatible ⇒ +8) b×1

j → current sources.

e → voltage source

$$e=\begin{bmatrix} 2 \\ 4 \\ 0 \\ 0 \\ -6 \\ 0 \end{bmatrix}$$ → in accordance with Orientation, it is opp (+ve −, take +)

07) Solve for I :

$$\begin{bmatrix} & & \end{bmatrix}_{3\times3} \begin{bmatrix} I \end{bmatrix}_{3\times1} = \begin{bmatrix} \end{bmatrix}_{3\times1}$$

use Cramer's Rule

08) $M^T I = i \rightarrow$ Branch currents (Solution to given question).

$$M = \begin{bmatrix} 1 & -1 & -1 & 0 & 0 & 0 \\ 0 & 0 & -1 & 1 & 1 & 0 \\ 0 & -1 & 0 & -1 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 1 & -1 & -1 & 0 & 0 & 0 \\ 0 & 0 & -1 & 1 & 1 & 0 \\ 0 & -1 & 0 & -1 & 0 & 1 \end{bmatrix}_{3\times6} \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 3 & 0 & 0 & 0 & 0 \\ 0 & 0 & 5 & 0 & 0 & 0 \\ 0 & 0 & 0 & 7 & 0 & 0 \\ 0 & 0 & 0 & 0 & 9 & 0 \\ 0 & 0 & 0 & 0 & 0 & 4 \end{bmatrix}_{6\times6} \begin{bmatrix} 1 & 0 & 0 \\ -1 & 0 & -1 \\ -1 & 1 & 0 \\ 0 & 1 & -1 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}_{6\times3}$$

$$\begin{bmatrix} 1 & -1 & 5 & 0 & 0 & 0 \\ 0 & 0 & -5 & 7 & 9 & 0 \\ 0 & -3 & 0 & -7 & 0 & 4 \end{bmatrix}_{3\times6} \begin{bmatrix} 1 & 0 & 0 \\ -1 & 0 & -1 \\ -1 & 1 & 0 \\ 0 & 1 & -1 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}_{6\times3} \begin{bmatrix} I \end{bmatrix} = \begin{bmatrix} +1 & -1 & -1 & 0 & 0 & 0 \\ 0 & 0 & -1 & 1 & 1 & 0 \\ 0 & -1 & 0 & -1 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} +1 & -1 & -1 & 0 & 0 & 0 \\ 0 & 0 & -1 & 1 & 1 & 0 \\ 0 & -1 & 0 & -1 & 0 & 1 \end{bmatrix} \left(\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 3 & 0 & 0 & 0 & 0 \\ 0 & 0 & 5 & 0 & 0 & 0 \\ 0 & 0 & 0 & 7 & 0 & 0 \\ 0 & 0 & 0 & 0 & 9 & 0 \\ 0 & 0 & 0 & 0 & 0 & 4 \end{bmatrix}_{6\times6} \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 8 \end{bmatrix}_{6\times1} - \begin{bmatrix} 2 \\ 4 \\ 0 \\ 0 \\ -6 \\ 0 \end{bmatrix} \right)$$

$$\Rightarrow \begin{bmatrix} 1+1-5 & -5 & 1 \\ 5 & +5+7+9 & -7 \\ 3 & -7 & 3+7+4 \end{bmatrix}_{3\times3} = \begin{bmatrix} 1 & 1 & -1 & 0 & 0 & 0 \\ 0 & 0 & -1 & 1 & 1 & 0 \\ 0 & -1 & 0 & -1 & 0 & 1 \end{bmatrix} \left(\begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 32 \end{bmatrix} - \begin{bmatrix} 2 \\ 4 \\ 0 \\ 0 \\ 6 \\ 0 \end{bmatrix} \right)$$

$$\Rightarrow \begin{bmatrix} -3 & -5 & 1 \\ 5 & 21 & -7 \\ 3 & -7 & 14 \end{bmatrix} = \begin{bmatrix} 1 & -1 & -1 & 0 & 0 & 0 \\ 0 & 0 & -1 & 1 & 1 & 0 \\ 0 & -1 & 0 & -1 & 0 & 1 \end{bmatrix}_{3\times6} \begin{bmatrix} -2 \\ -4 \\ 0 \\ 0 \\ -6 \\ 32 \end{bmatrix}_{6\times1}$$

$$\begin{bmatrix} -3 & -5 & +1 \\ 5 & 21 & -7 \\ 3 & -7 & 14 \end{bmatrix} \begin{bmatrix} I \end{bmatrix} = \begin{bmatrix} 2 \\ -6 \\ 36 \end{bmatrix}_{3\times 1}$$

$$\begin{bmatrix} -3 & -5 & +1 \\ 5 & 21 & -7 \\ 3 & -7 & 14 \end{bmatrix} \begin{bmatrix} I_1 \\ I_5 \\ I_6 \end{bmatrix} = \begin{bmatrix} 2 \\ -6 \\ 36 \end{bmatrix}$$

$$-3I_1 - 5I_5 + I_6 = 2$$
$$5I_1 + 21I_5 - 7I_5 = -6$$
$$3I_1 - 7I_5 + 14I_6 = 36$$

$I_1 = -1.63\,A$, $I_5 = 1.3\,A$, $I_6 = 3.566\,A$

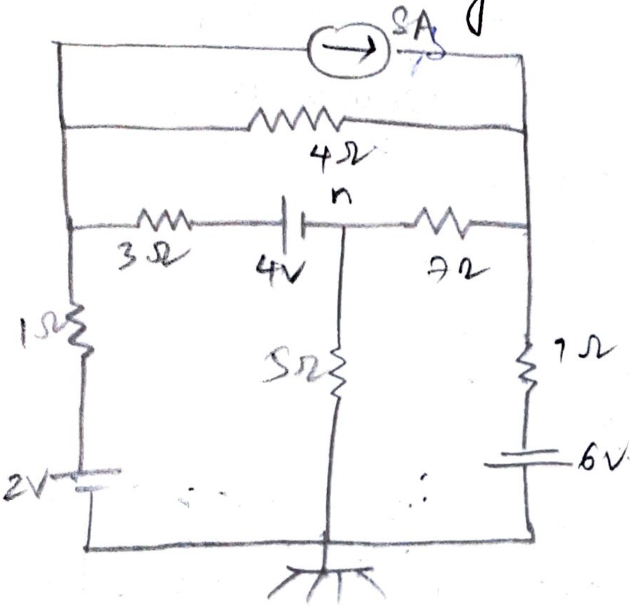
$$\begin{bmatrix} 1 & 0 & 0 \\ -1 & 0 & 1 \\ -1 & 1 & 0 \\ 0 & 1 & -1 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} I_1 \\ I_5 \\ I_6 \end{bmatrix} = \begin{bmatrix} i_1 \\ i_2 \\ i_3 \\ i_4 \\ i_5 \\ i_6 \end{bmatrix}$$

$$\begin{bmatrix} 1.63 \\ 1.63 - 3.56 \\ 1.63 - 1.3 \\ 1.3 - 3.56 \\ 1.3 \\ 3.56 \end{bmatrix} = \begin{bmatrix} i_1 \\ i_2 \\ i_3 \\ i_4 \\ i_5 \\ i_6 \end{bmatrix}$$

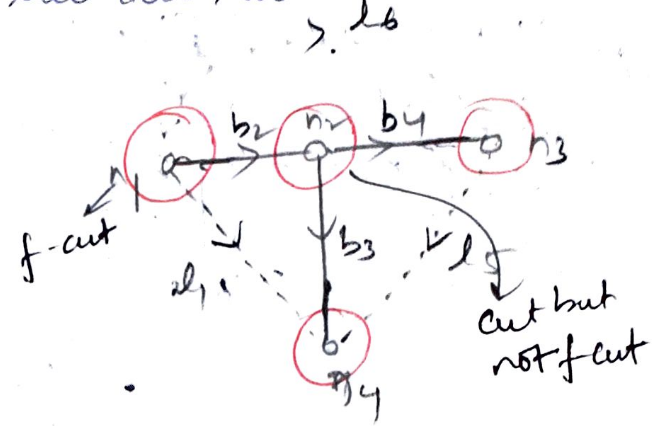
$i_1 = -1.63$ A
$i_2 = -1.93$ A
$i_3 = 0.33$ A
$i_4 = -2.26$ A
$i_5 = 1.3$ A
$i_6 = 3.56$ A

25th July 2019

Find branch voltages using cut set schedule?



Since problem is same, graph oriented graph and tree are same.



04) Cut-set Matrix (Aa)
Incident matrix.

o ⟶ o +1

o ⟵ o −1

o 0

	b_1	b_2	b_3	b_4	b_5	b_6
n_1	1	1	0	0	0	1
n_2	0	−1	1	1	0	0
n_3	0	0	0	−1	1	−1
n_4	−1	0	−1	0	−1	0

(★ Add vertically get zero ⟹ correct)

05) Properties:

$Mv = 0$ (Mesh equation)

$M^T I = i$ (Nodal)

$v = R(i - j) + e$

Consider the node with single line.

$$\underbrace{MRM^T}_{\text{loop Impedence matrix.}} I = M \underbrace{(Rj - e)}_{\text{Loop voltage Source vector.}}$$

$Ai = 0$

$A^T V = v$

$i = G(v - e) + j$

06) $$\underbrace{AGA^T}_{\text{Node Admittance matrix.}} \underline{V} = A(Ge - j)$$

A = Reduced I.M.

$$[G] = \begin{bmatrix} 1/1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1/3 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1/5 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1/7 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1/9 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1/4 \end{bmatrix}$$

07) Solve for $V =$ ______ $I = \begin{bmatrix} I_1 \\ I_5 \\ I_6 \end{bmatrix}$, $V = \begin{bmatrix} V_1 \\ V_3 \\ V_5 \end{bmatrix}$

08) $A^T V = 29$.

$V \rightarrow$ Node voltage.

$$A^T = \begin{bmatrix} 1 & 1 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & -1 & 1 & -1 \\ -1 & 0 & -1 & 0 & -1 & 0 \end{bmatrix}_{3\times 6} \begin{bmatrix} 1/1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1/3 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1/5 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1/7 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1/9 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1/4 \end{bmatrix}_{6\times 6} \begin{bmatrix} 1 & 0 & -1 \\ 1 & 0 & 0 \\ 0 & 0 & -1 \\ 0 & -1 & 0 \\ 0 & 1 & -1 \\ 1 & -1 & 0 \end{bmatrix}_{6\times 3}$$

$$= \begin{bmatrix} 1 & 1 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & -1 & 1 & -1 \\ -1 & 0 & -1 & 0 & -1 & 0 \end{bmatrix} \left(\begin{bmatrix} 1/1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1/3 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1/5 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1/7 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1/9 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1/4 \end{bmatrix}_{6\times 6} \begin{bmatrix} 2 \\ 4 \\ 0 \\ 0 \\ -6 \\ 0 \end{bmatrix}_{6\times 1} - \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 8 \end{bmatrix} \right)$$

$$\Rightarrow \begin{bmatrix} 1 & 1/3 & 0 & 0 & 0 & 1/4 \\ 0 & 0 & 0 & -1/7 & 1/9 & -1/4 \\ -1 & 0 & -1/5 & 0 & -1/9 & 0 \end{bmatrix}_{3\times 6} \begin{bmatrix} 1 & 0 & -1 \\ 1 & 0 & 0 \\ 0 & 0 & -1 \\ 0 & -1 & 0 \\ 0 & 1 & -1 \\ 1 & -1 & 0 \end{bmatrix}_{6\times 3} = \text{''}$$

$$\Rightarrow \begin{bmatrix} 1+1/3+1/4 & -1/4 & -1 \\ -1/4 & 1/7+1/9+1/4 & -1/9 \\ -1 & -1/9 & 1+1/5+1/9 \end{bmatrix} [V] = \begin{bmatrix} 1 & 1 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & -1 & 1 & -1 \\ -1 & 0 & -1 & 0 & -1 & 0 \end{bmatrix} \left(\begin{bmatrix} 2 \\ 4/3 \\ 0 \\ 0 \\ -6/9 \\ 0 \end{bmatrix} - \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 8 \end{bmatrix} \right)$$

$$\Rightarrow \begin{bmatrix} \frac{19}{12} & -1/4 & -1 \\ -1/4 & \frac{127}{252} & -1/9 \\ -1 & -1/9 & \frac{59}{45} \end{bmatrix} [V] = \begin{bmatrix} 1 & 1 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & -1 & 1 & -1 \\ -1 & 0 & -1 & 0 & -1 & 0 \end{bmatrix}_{3\times 6} \begin{bmatrix} 2 \\ 4/3 \\ 0 \\ 0 \\ -6/9 \\ -8 \end{bmatrix}_{6\times 1}$$

$$\begin{bmatrix} \frac{19}{12} & -1/4 & -1 \\ -1/4 & \frac{127}{252} & -1/9 \\ -1 & -1/9 & \frac{59}{45} \end{bmatrix} \begin{bmatrix} V_1 \\ V_3 \\ V_5 \end{bmatrix} = \begin{bmatrix} 2+4/3-8 \\ 0-6/9+8 \\ -2+6/9+0 \end{bmatrix}_{3\times 1}$$

$$\frac{19}{12}v_1 - \frac{v_3}{4} - v_5 = -\frac{14}{3}$$

$$-\frac{v_1}{4} + \frac{127}{252}v_3 - \frac{v_5}{9} = \frac{22}{3}$$

$$-v_1 - \frac{v_3}{9} + \frac{59v_5}{45} = -\frac{4}{3}$$

$v_1 = -1.3406 \quad v_3 = 13.6923 \quad v_5 = -0.8791$

$A^T V = v$

$$\underset{6\times3}{\begin{bmatrix} 1 & 0 & -1 \\ 1 & 0 & 0 \\ 0 & 0 & -1 \\ 0 & -1 & 0 \\ 0 & 1 & -1 \\ 1 & -1 & 0 \end{bmatrix}} \underset{3\times1}{\begin{bmatrix} \overset{-1.3406}{v_1} \\ \overset{13.7}{v_3} \\ \overset{-0.87}{v_5} \end{bmatrix}} = \begin{bmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \\ v_5 \\ v_6 \end{bmatrix}$$

$$\begin{bmatrix} -1.3406 + 0.87 \\ -1.3406 \\ 0.87 \\ -13.7 \\ 13.7 + 0.87 \\ -1.3406 - 13.7 \end{bmatrix} = \begin{bmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \\ v_5 \\ v_6 \end{bmatrix} \Rightarrow \begin{bmatrix} -0.4706 \\ -1.3406 \\ 0.87 \\ -13.7 \\ 14.57 \\ -15.0406 \end{bmatrix}$$

	Athre	V.V. Berg	PCJ & LN CB, RC, S-S
$n_1 n_2 n_3 n_4$	vertices (v)	Nodes (N)	Nodes
$b_1 b_2 b_3 b_4 b_5 b_6$	edges (e)	Branches (b)	Branches
l_4, l_5, l_6	Links (l)	Links (l)	Chord (c)
b_2, b_3, b_4	branches	—	twigs
	$l = e-(v-1)$	$l = b-(N-1)$	$c = b-(N-1)$

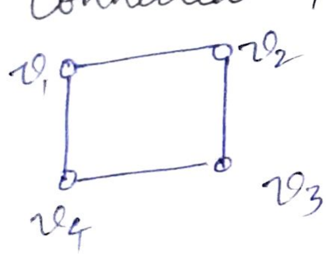
1) Notes
2) C/W pending
3) T/B.
4) Previous Question Bank

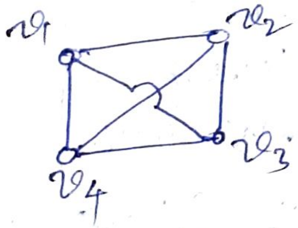
1) Sub-graph: part of the graph is called sub-graph.
2) Spaning sub-graph: If subgraph contain all the vertices, it is called as spaning subgraph

Ex: All Trees.

All Trees are spaning subgraphs. All spaning sub graphs may not be trees.

3) Connected v/s Complete





Not Connected.

If path contain atleast one edge it is connected graph
If path contain only one edge, it is called complete graph
Complete graph is connected graph, but connected graph is not complete graph.

4) No of edges in complete graph $= \frac{v(v-1)}{2}$ $\qquad \frac{4\times 3}{2} = 6$

5). Degree of vertex $\Rightarrow$ No of edges connected to vertex is called as degree.

$$\sum_{i=1}^{n} \delta(v_i) = 2 \times e$$

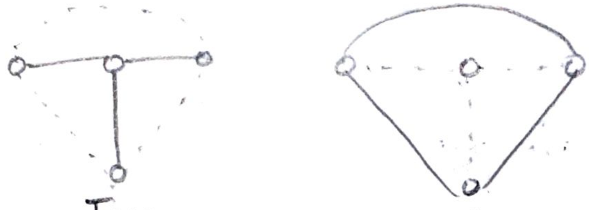
$\delta(v_1) + \delta(v_2) + \delta(v_3) + \delta(v_4)$

$3 + 3 + 3 + 3 = 2 \times 6.$

6) Total possible number of trees given by $(v)^{v-2} = 4^{4-2} = 4^2 = 16.$
(valid for complete graph)

For connected graph, $|AA^T|$

7) COMPLEMENT OF TREE (Co-tree):



Tree

Co-tree

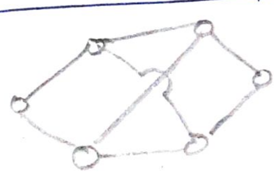
All co-trees are not trees. Some co-trees are trees.

Tree

8) Rank of Incidente Matrix is atmost $v-1$.

9) Proper tree if voltage sources and capacitors included in the branch and current sources and Inductors included in links. Proper trees are useful to write state equations.

10) Planar v/s Non planar:



Planar → (2D)

(Dual Network) ny

3D

Non planar:
No dual.

11) f-ckt (fundamental circuit):

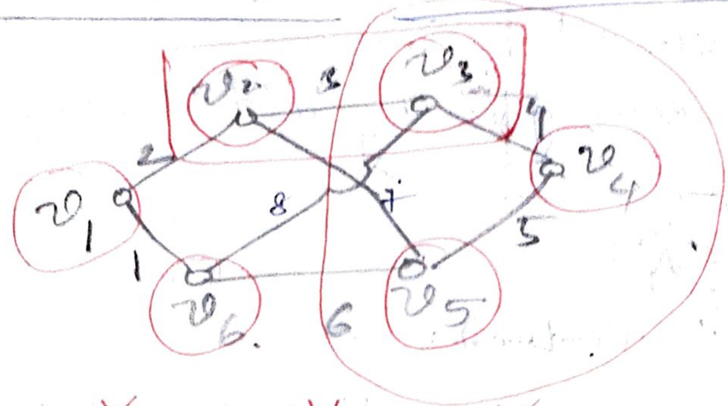
Corresponding to each link, one loop is closed, that loop is called as fundamental circuit

$l = b - (N-1)$

No of links = No of f ckts.

= No of mesh equations needed to analyse the problem

12) Cut, Valid cut, Not a cut / Invalid cut, f-cut:



(1,2) (2,7,3) (4,5) (2,7,8,4) etc

Not a Cut (1), (2,3), (7,3), (4) (5)

Invalid Cut (2, 7, 3, 6)

DUALITY

Two networks are dual to each other when the mesh equations of one ckt are in the same mathematical form of nodal equations of other circuit.

Properties

$V_C(0^-) \leftrightarrow I_L(0^-)$

$R \leftrightarrow G$

$L \leftrightarrow C$

Voltage $\leftrightarrow$ Current

Voltage Source $\rightarrow$ Current Source

Thevenin $\leftrightarrow$ Norton.

Voltage Division $\leftrightarrow$ Current Division

KVL $\leftrightarrow$ KCL

Nodal $\leftrightarrow$ mesh/loop.

Tie set $\leftrightarrow$ Cut-set

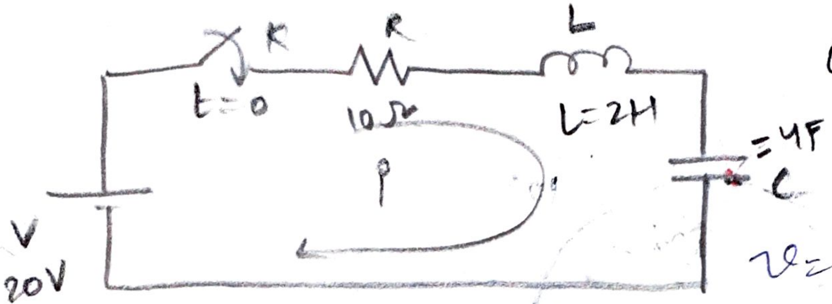
Voltage Dependent Current Source $\leftrightarrow$ Current Dependent Voltage Source

Series $\leftrightarrow$ parallel

Open $\leftrightarrow$ Close.

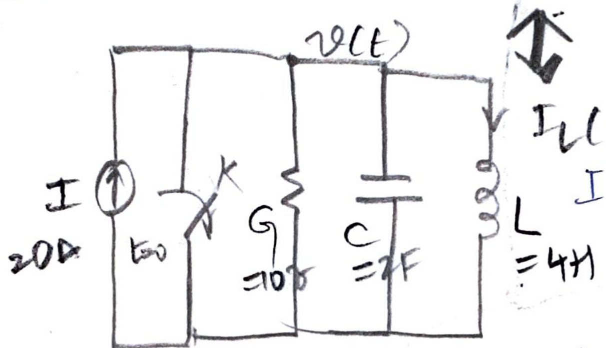
Q (Charge) $\leftrightarrow$ ϕ (Flux)

Obtain dual Network.



$V_c(0^-) = V' = 4V$

$v = Ri(t) + L\frac{di}{dt} + \frac{1}{C}\int_{-\infty}^{t} i(t)dt$



$I_L(0^-) = 4A$

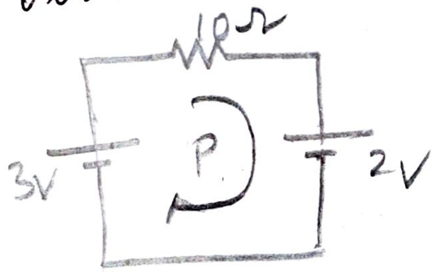
$I = vG + C\frac{dv}{dt} + \frac{1}{L}\int v dt$

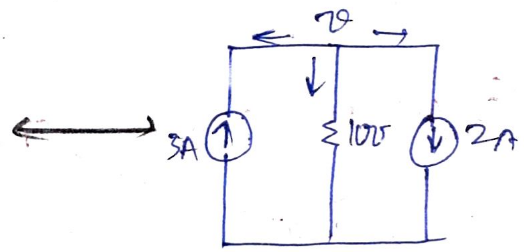
Duality

It is not equivalent

26th July 2019

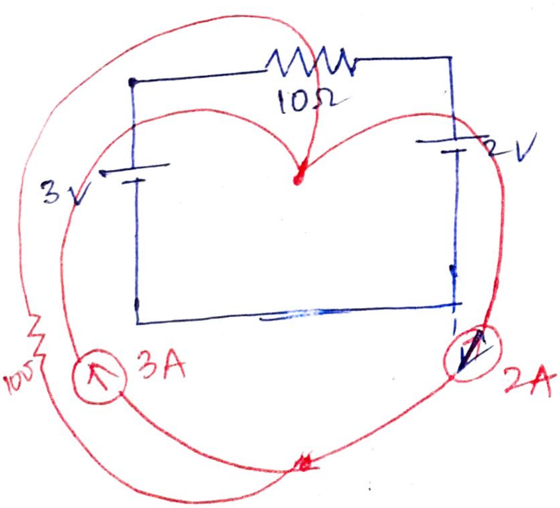
Obtain the dual network.





$-3+10i+2$

$-3+10v+2$



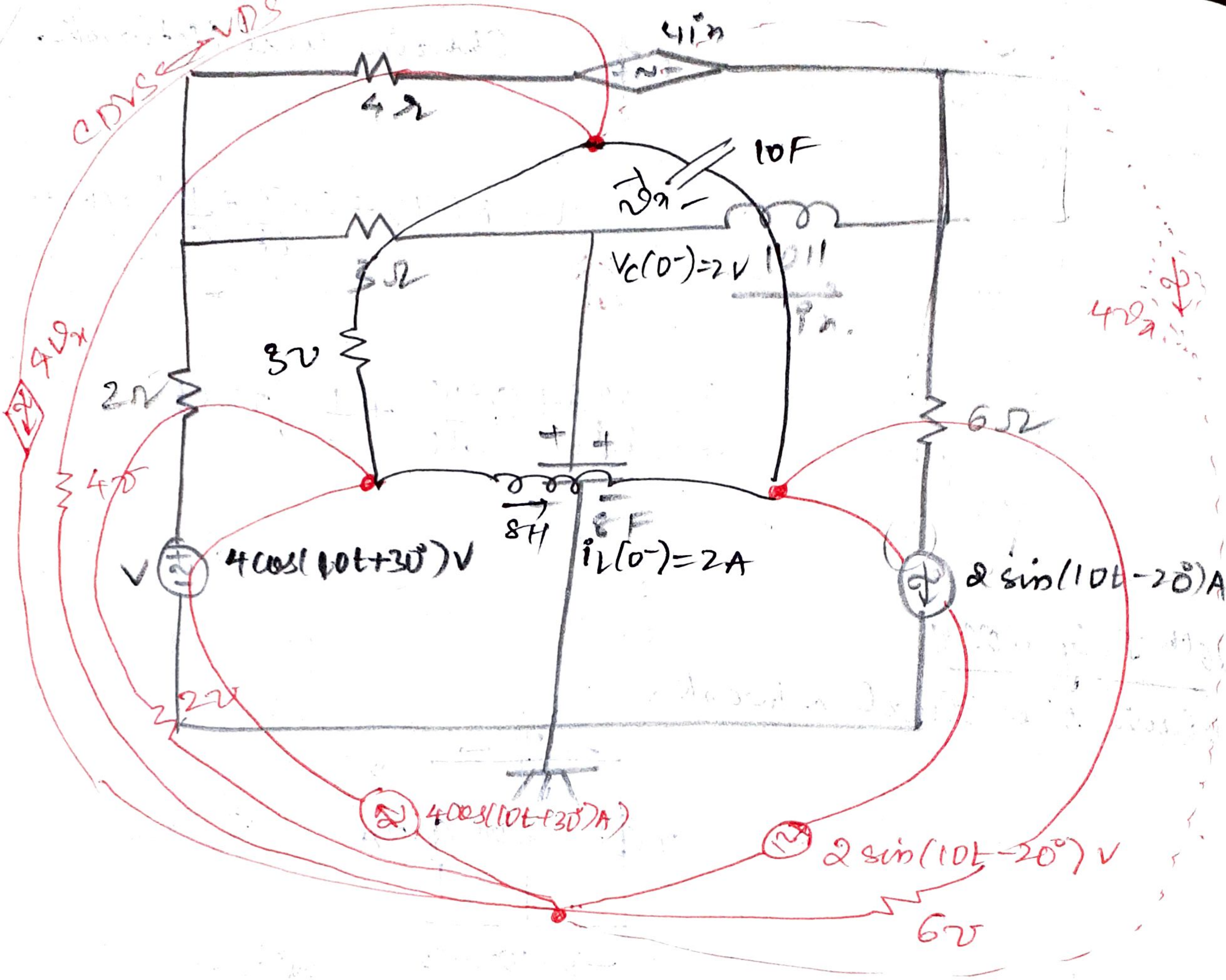
SIGN CONVENTION

CCW +ve to −ve ↑

CCW −ve to +ve ↓

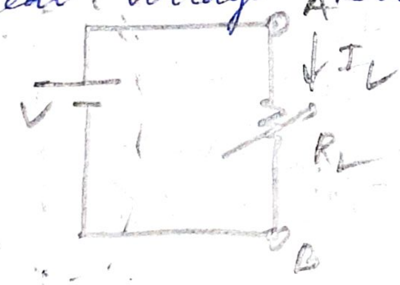
CW +ve to −ve ↓

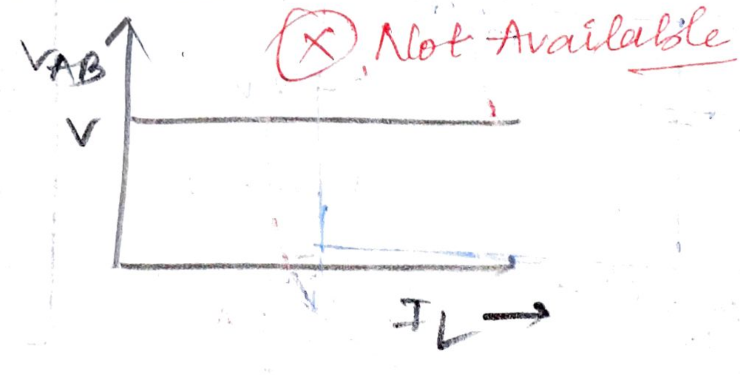
CW −ve to +ve ↑



SOURCE TRANSFORMATION : (S.T):

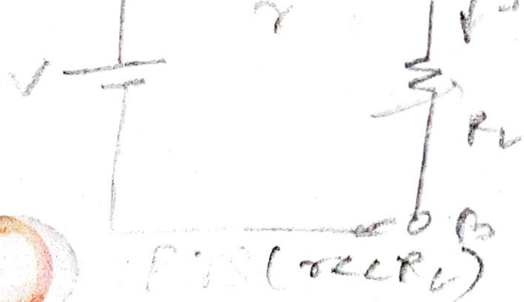
Ideal voltage source

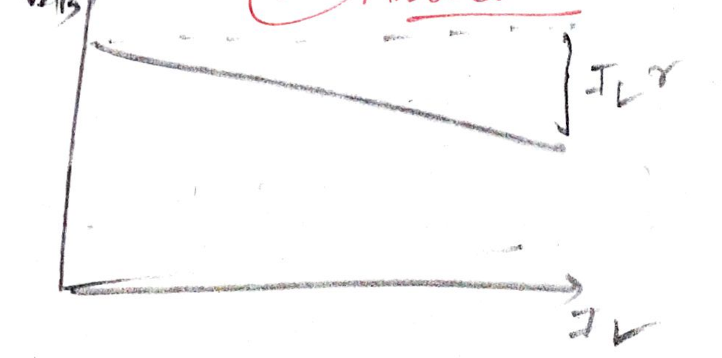




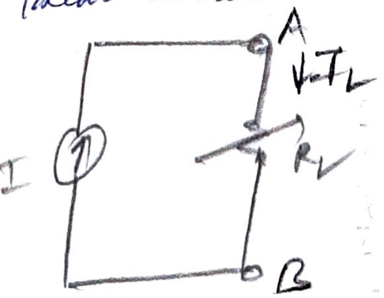
Ideal voltage source (r = 0)

Practical voltage source

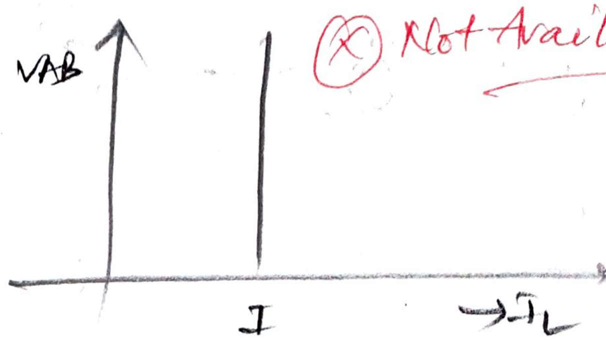




Ideal Current Source:

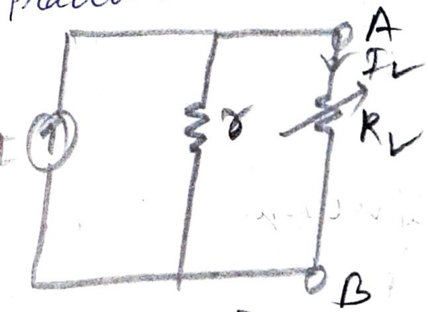


I.C.S ($r=\infty$)



Ⓧ Not Available

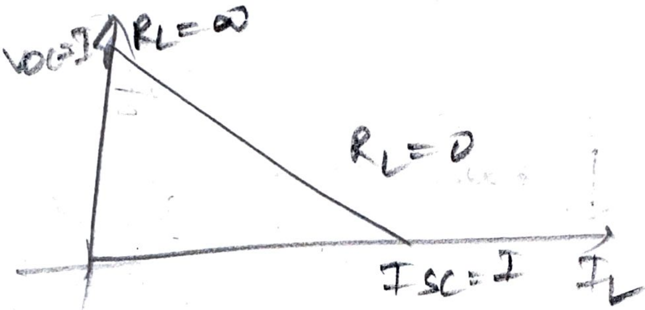
Practical Current Source:



($r >> R_L$)

P.C.S

31st July 2019



Ⓧ Not Available

01. $V_{AB} = V_{OC} = \boxed{V = Ir}$

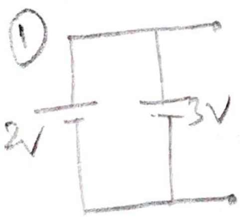
02. $I_{SC} = \boxed{\frac{V}{r} = I}$

03. $R_{AB} = r$.

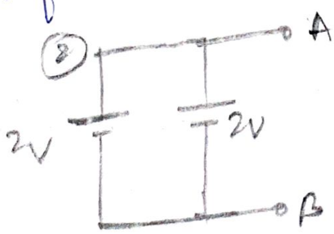
What is it?
How to use it
where to apply
where not to use?

Donts:

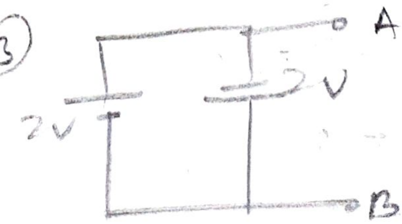
→ Wherever we are finding response (current, voltage, power, phase, frequency etc), that element (R, C, L, VS, CS, AC, DC, dependent, independent) should not be disturbed (or) modified using any transformation techniques such as source transformation & star-delta transformation.

① 

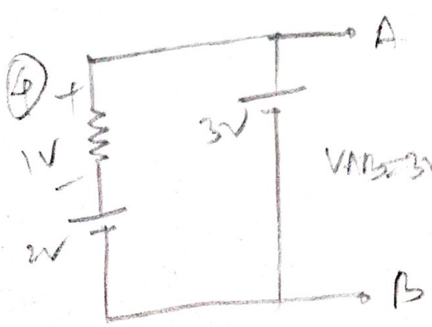
V_{AB} = Not possible

② 

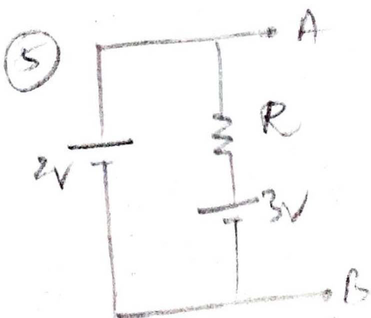
$V_{AB} = 2V$

③ 

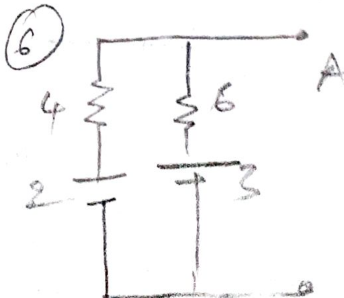
V_{AB} = Not possible

④ 

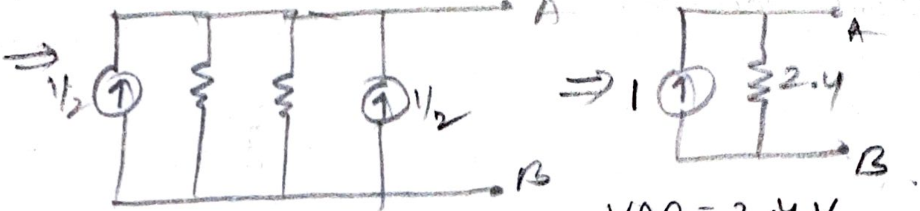
$V_{AB} = 3V$

⑤ 

$V_{AB} = 2V$

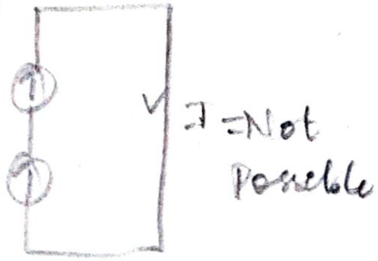
⑥ 

Applying ST ⇒

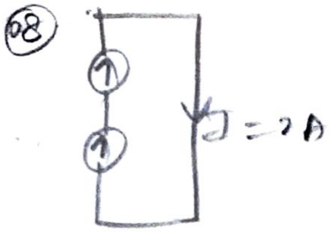


$V_{AB} = 2.4V$.

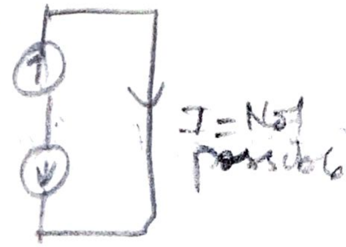
07

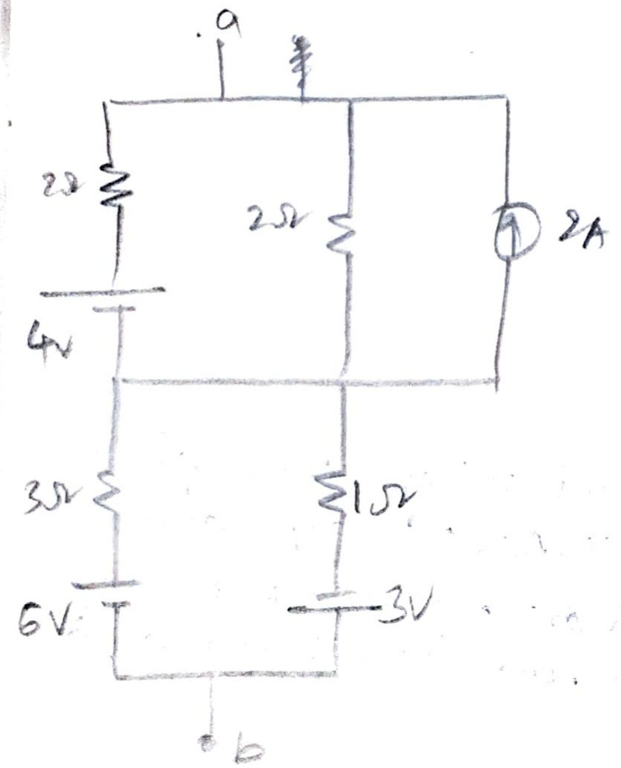


08



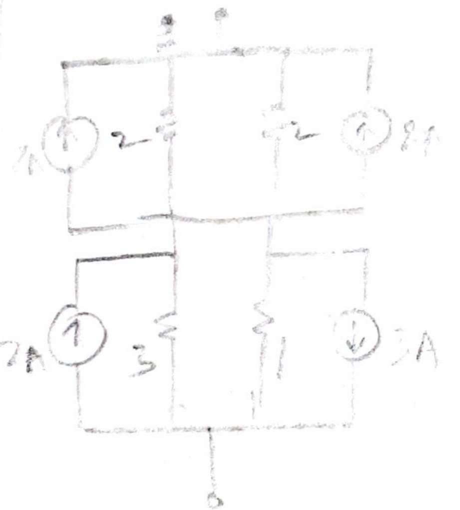
09



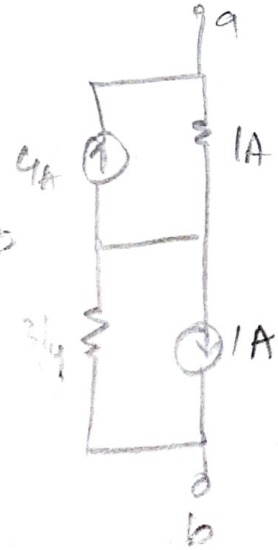


Convert into single voltage source equivalent

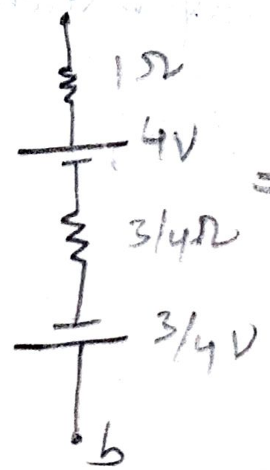
We can add CS in series, voltage source in ~~parallel~~ parallel



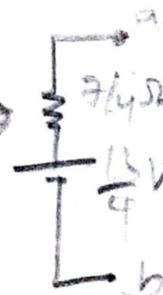
⇒



⇒

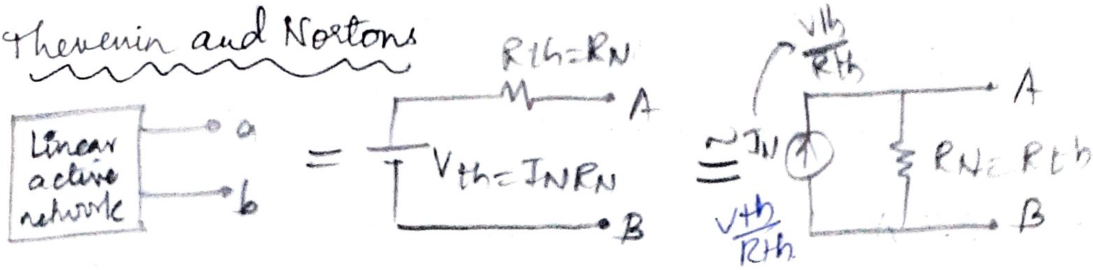


⇒



THEOREMS:-

Thevenin and Nortons



$V_{th} = V_{oc} = V_{AB}$ (Open circuit voltage across AB)

$I_{sc} = I_N =$ Current flowing from A to B.

$R_{th} \to$ Resistance viewed from AB keeping all voltage sources short and current sources open.

01st August 2019

Thevenins + Nortons

01) All sources are Independent.

V_{th}, I_{Nor}, R_{th}, R_{NOR}

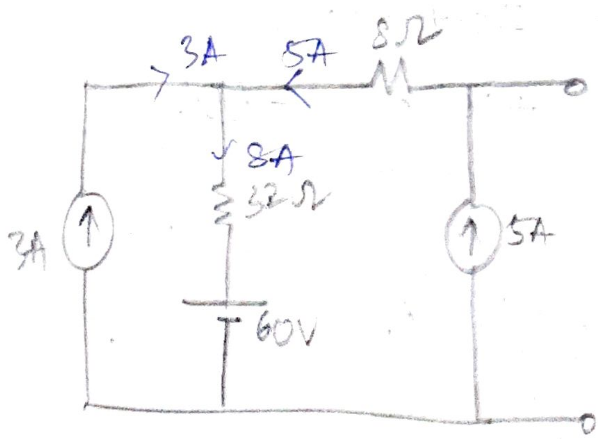
02) Some sources are dependent and others are Independent.

V_{th}, I_N, R_{th} $\left(R_{th} = \frac{V_{th}}{I_{Nor}}\right)$

03) All sources are dependent (PASSIVE Network)

$V_{th} = 0$; $I_{Nor} = 0$ R_{th} (Indirectly)

Apply 1V across AB; find $I \Rightarrow R_{th} = \frac{1V}{I}$ (or) $\frac{V}{1A}$ (or) $\frac{V}{I}$



Find Thevenin's Equivalent.

* All are independent sources.

① VD, CD, QD, FD.

② N; Mesh → cant apply if sources are having diff frequencies.

03) S.T

04) Y-Δ

05) Superposition principle $f(x_1+x_2) = f(x_1) + f(x_2)$

Five statements given earlier

$V_{OC} = V_{AB} = V_{th} = 5 \times 8 + 8 \times 32 + 60 = 356\text{ V}$

$R_{th} = 8 + 32 = 40\Omega$

$R_N = 40\Omega$

$I_N = \frac{356}{40} = 8.9\text{ A}.$

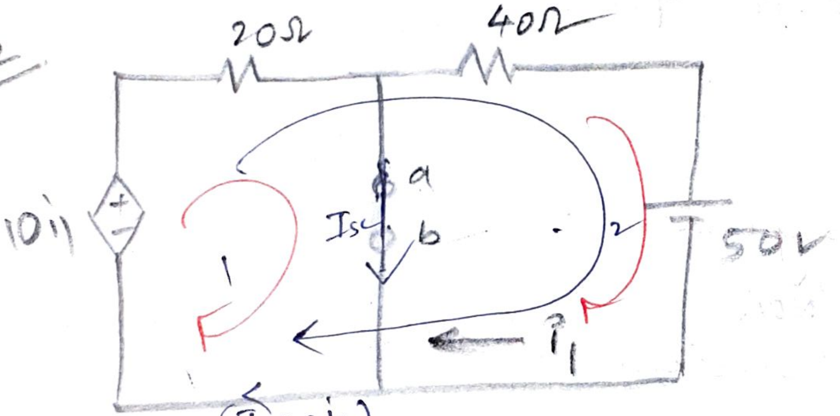
$$\begin{array}{r} 8.9 \\ 4\overline{)356} \\ 32 \\ \hline 36 \end{array}$$

$I_{SC} = 5 + \frac{60}{40} + \cancel{8000}\ 8 \times \cancel{\frac{32}{40}}\ \cancel{9.8}\text{ A}.$

$= 5 + \frac{60}{40} + \frac{3 \times 32}{40} = \frac{356}{40} = \underline{8.9}$

Ass - Thursday

02



$-10i_1 + 10i_1 + 40i_1 + 50 = 0$

$50i_1 + 50 = 0\ \boxed{i_1 = -1}$ → (open ckt condition)

$V_{th} = 40 \times i_1 + 50 = 50 - 40 = 10\text{V}.\ \boxed{V_{th} = 10}$

$I_{SC} = ?$

$\cancel{-10i_1 + 20I_{SC}} = 0.\quad -10i_1 + 20(I_{SC} + i_1) = 0$

$20I_{SC} + 10i_1 = 0 \rightarrow (1).$

$40i_1 + 50 = 0.$

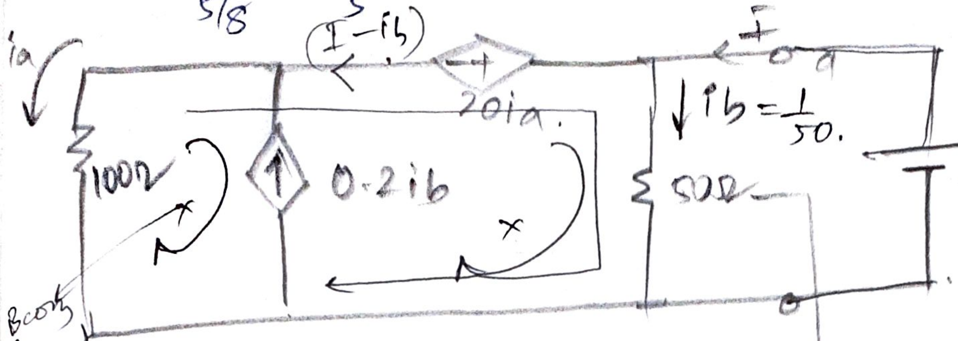
$i_1 = -\frac{5}{4} = -1.25\text{ A}\quad \boxed{i_1 = -1.25\text{ A}}$

$$\begin{array}{r} 1.25 \\ 4\overline{)5} \\ 4 \\ \hline 10 \\ 8 \\ \hline 20 \end{array}$$

$20I_{SC} - 12.5 = 0$

$I_{SC} = \frac{12.5}{20} = \frac{1.25}{2}\ \boxed{I_{SC}\ 0.625\text{ A}}$

$R_{Eq.} = \frac{10}{5/8} = \frac{80}{5} = 16\Omega$.



$0.2ib + I - ib = ia$

$I - 0.8ib = ia$

$ib = \frac{1}{50}$.

$-20ia + 1 - 100ia = 0$

$ia = \frac{1}{120}$.

$I - \frac{0.8}{50} = \frac{1}{120}$.

$I = \frac{0.8}{50} + \frac{1}{120}$

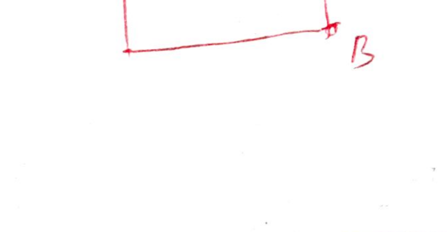
$= \frac{1}{10}\left[\frac{8}{50} + \frac{1}{12}\right]$

$I = 0.024$

MTech
1) Gate
2) MBA
- CAT

MAXIMUM POWER TRANSFER THEOREM:

I)



$I_L = \frac{Vs}{Rs + RL}$

$P_{R_L} = I_L^2 R_L = \frac{Vs^2}{(Rs+R_L)^2} \times R_2$

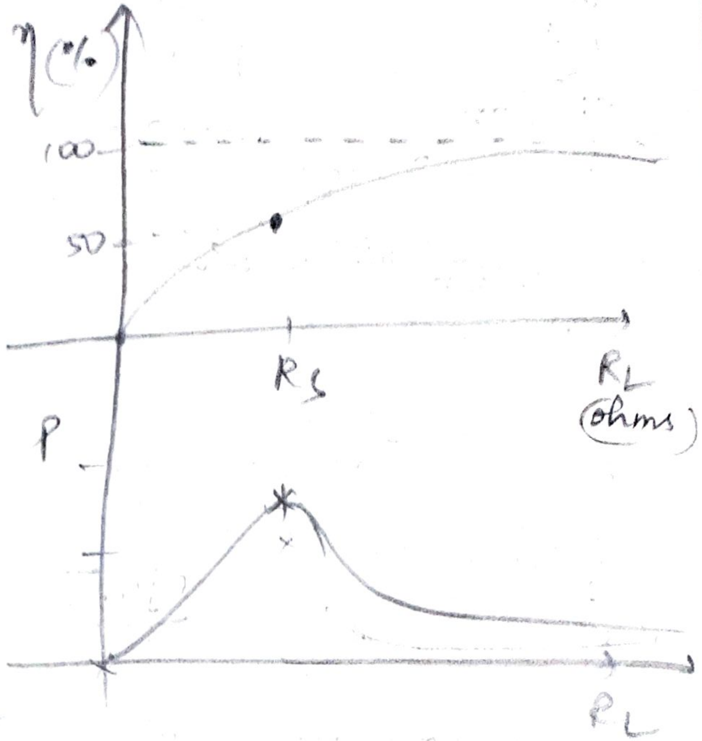
$\frac{dP_{R_L}}{dR_L} = 0 \Rightarrow \boxed{R_L = R_S}$ condition!

$$\boxed{P_{max} = \frac{Vs^2}{4 \times R_L}}$$

II) $\eta = 50\%$ if $R_L = R_S$.
efficiency

$\eta = 100\%$ if $R_L = \infty$

$\eta = 0\%$ if $R_L = 0$.



4 possibilities

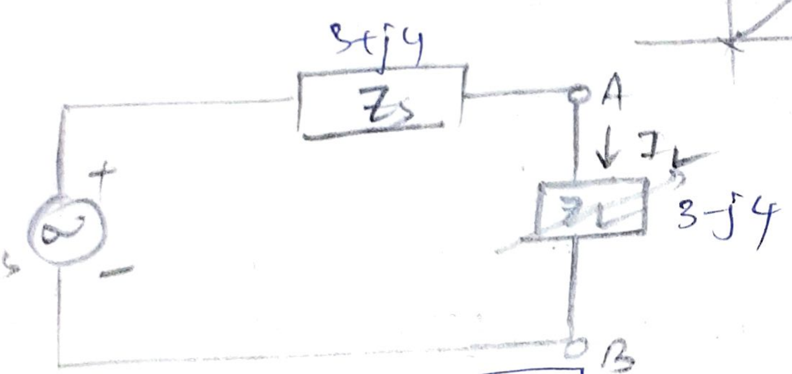
① $R_L = 0$

② $R_S = 0$

③ $R_L = R_S$

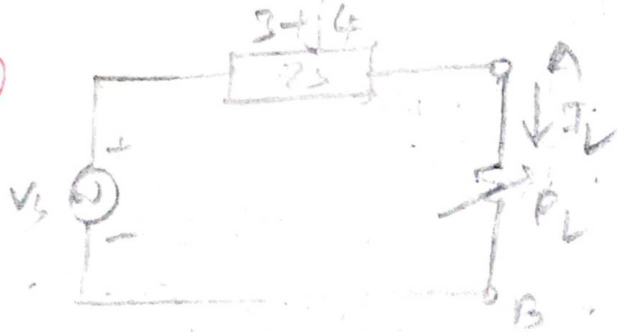
④ $R_S = R_L$

II)



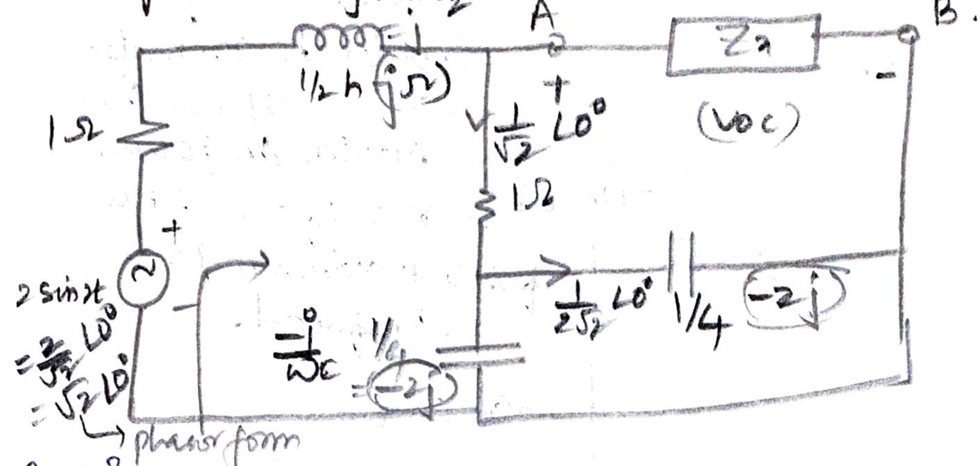
Condition $\boxed{Z_L = Z_S^*}$ $P_{max} = \frac{V_S^2}{4 \times R_L}$

III)



$R_L = |Z_S| = |3+j4| = 5$ $P_{max} = \frac{V_S^2}{2(R_S+R_L)}$

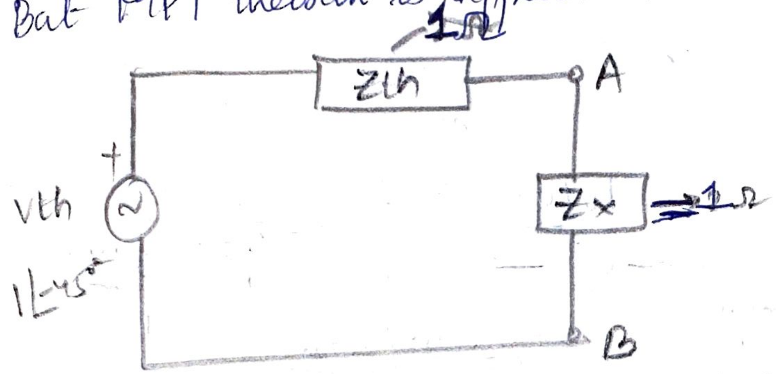
09th August 2019



For what value of Z_x, Maximum Power Transferred to Z_x & also find Max Power Transferred

Case 2

But MPT theorem is applied on thevenin Equivalent.



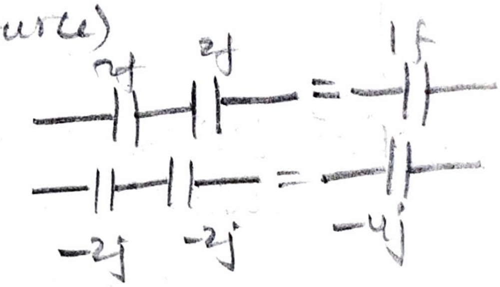
$X_L = j\omega L = j\times 2\times\frac{1}{2}$

$X_L = j$

$X_C = \frac{-j}{\omega C}$

$= \frac{-j}{2\times\frac{1}{4}} = -2j$

Z_T (total impedance looking from the source)



$Z_T = 1+j+1-j = 2\Omega$

$I_T = \frac{\sqrt{2}\angle 0^\circ}{2}$

$= \frac{1}{\sqrt{2}}\angle 0$

$V_{AB} = 1\times\frac{1}{\sqrt{2}}\angle 0^\circ - \cancel{2}j\times\frac{1}{\cancel{2}\sqrt{2}}\angle 0^\circ$

$= \frac{1}{\sqrt{2}}\angle 0^\circ - j\frac{1\angle 0^\circ}{\sqrt{2}} = \frac{1}{\sqrt{2}}(1-j)\angle 0^\circ = \frac{1}{\sqrt{2}}\times\sqrt{2}\angle -45^\circ$

$V_{th} = 1\angle -45^\circ$ → RMS.

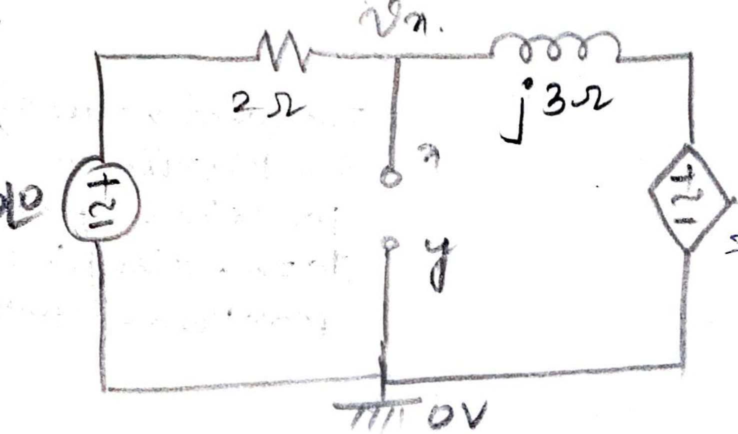
Zth ⇒ total Impedance viewed from A, B, keeping ~~the~~ all the ~~all~~ independent sources constant.

$Z_{th} = (1+j)\,||\,(1-j)$

$= 1\Omega$

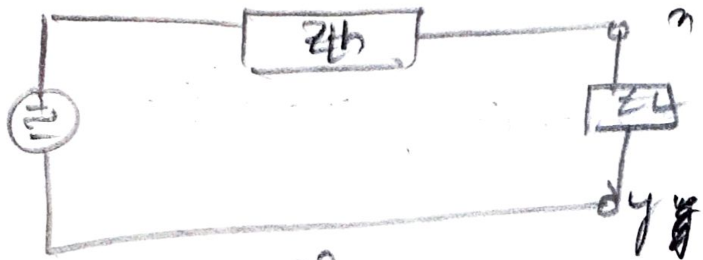
$P_{max} = \frac{V_s^2}{4\times R_L} = \frac{1^2}{4\times 1} = 0.25$ Watts

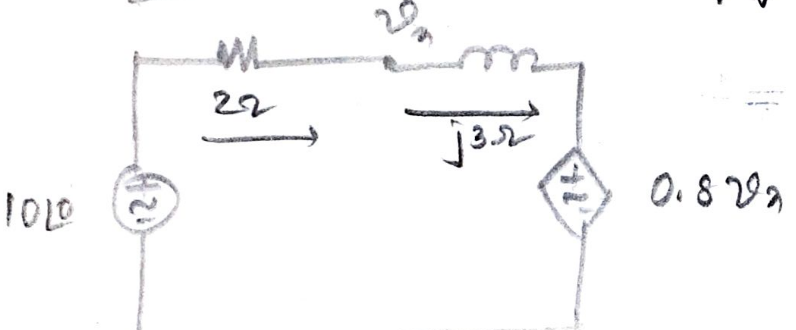
Q) what load impedance should be connected across x, y so that Maximum power is transferred? Also, find Maximum power Transfered.



$0.8 V_{xy} = 0.8 V_x$

$V_{xy} = V_x$





$$\frac{10\angle 0 - V_x}{2} = \frac{V_x - 0.8 V_x}{j3 = 3\angle 90^\circ}$$

$V_x = 10\angle 7.6^\circ$

$\cancel{30\angle 90 - 3j}$

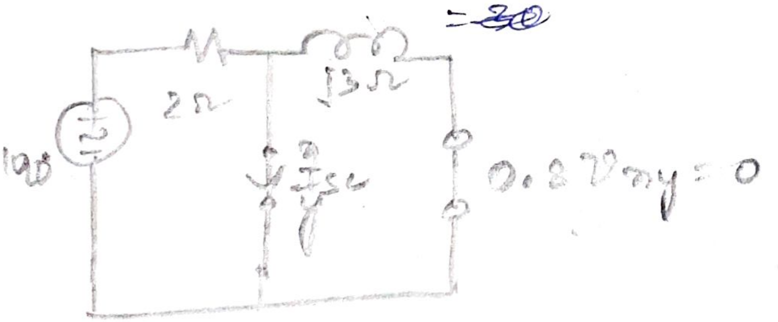
$30\angle 90^\circ - 3\angle 90^\circ V_x = 2V_x - 1.6V_x$.

$30\angle 90^\circ = 0.4V_x + 3\angle 90^\circ V_x$

$$V_x = \frac{30\angle 90^\circ}{0.4+3\angle 90^\circ} = \frac{30\angle 90^\circ}{0.4+3j} = \frac{30j}{0.4+3j} = \frac{30\angle 90^\circ}{3.026\angle 82.4}$$

$= \cancel{30}$

$\boxed{V_{th} = 10\angle 7.6}$



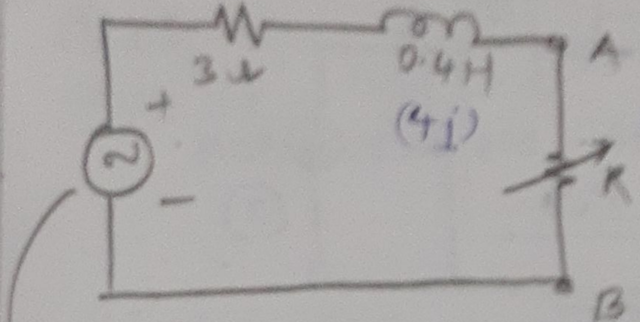
I_{sc} = short-circuit current

$I_{sc} = \frac{10\angle 0}{2} = 5\angle 0^\circ$

$\Rightarrow Z_{th} = \frac{10\angle 7.6^\circ}{2\angle 0^\circ} = 2\angle 7.6^\circ$ $\boxed{Z_{th} = 2\angle 7.6^\circ}$.

$Z_L = Z_s^* = 2\angle -7.6^\circ \Rightarrow \boxed{Z_L = 2\angle -7.6^\circ}$.

$$P_{max} = \frac{V_s^2}{4\times R_L} = \frac{10^2}{4\times 2\cos 7.6^\circ} = \frac{100}{4\times 1.98} = \frac{100}{4.196} = 12.626 \text{ watts}$$



Find the maximum power transferred to R.

Deside Condition — $R = |Z_s|$

Already in Thevenin Equivalent

$10\sqrt{2}\cos(10t - 20)$

$10\angle{-20^\circ}$

$Z_s = 3 + 4j \quad R = |3 + j4| = 5$

$$P_{max} = \frac{V_s^2}{2(R_s + R_L)} = \frac{10^2}{2\times(3+5)}$$

$$P = \frac{\overset{50}{100}}{2\times 8} = 6.25 \text{ watts}$$

SUPERPOSITION THEOREM

Definition: Any linear active network containing atleast one independent source, then the final response is equal to addition of individual responses.

Case 1: All sources are independent

$$f(x_1 + x_2 + x_3) = f(x_1) + f(x_2) + f(x_3)$$

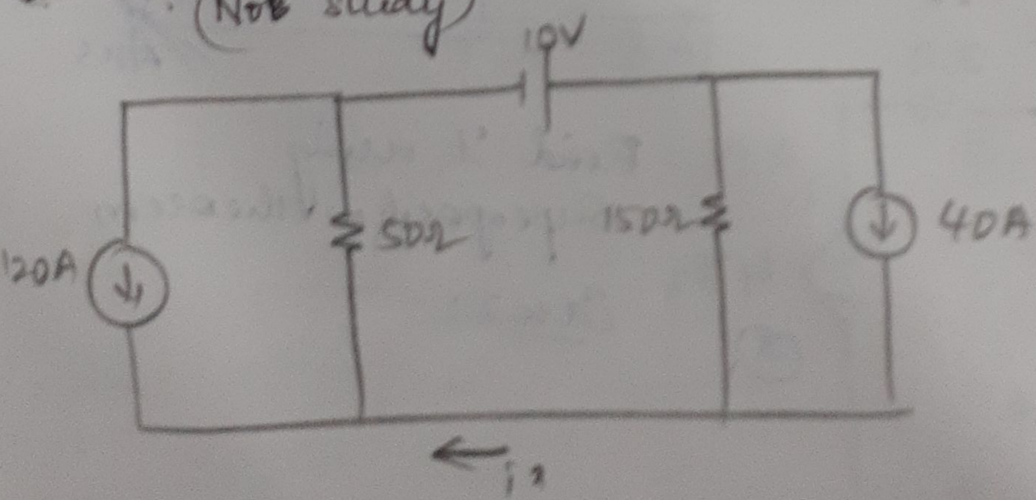
Case 2: Some sources are dependent

" " " Independent

$$f(x_1 + \overset{\text{Dependent}}{x_2} + x_3) = f(x_1 + x_2) + f(x_2 + x_3)$$

independent

Case 3: All are dependent → passive → no response (Not study)



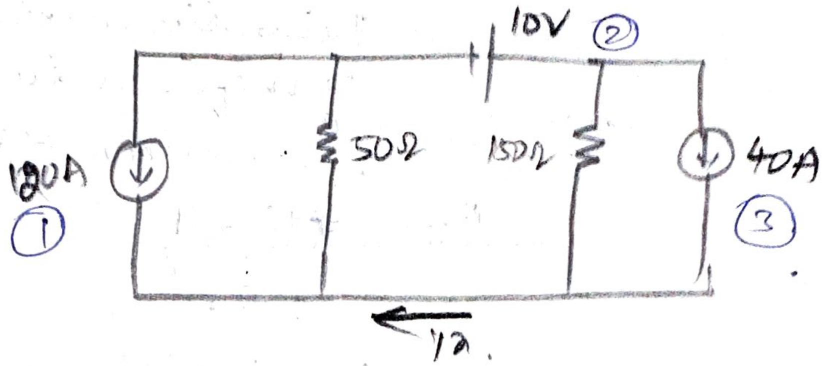
Find I_x using Superposition theorem.

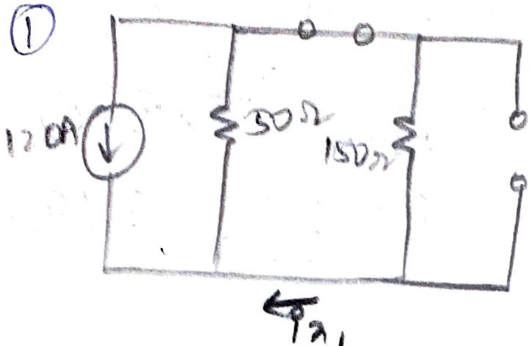
three sources

I_{x_1} – Consider Source 1

I_{x_2} – " " 2

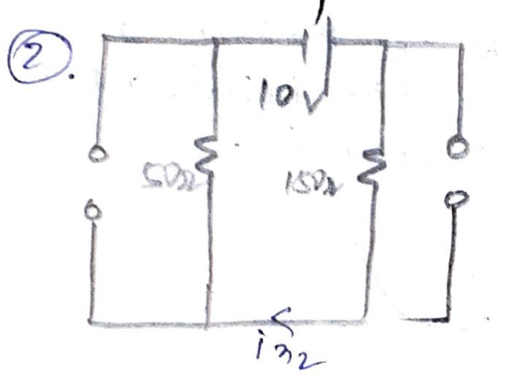
I_{x_3}





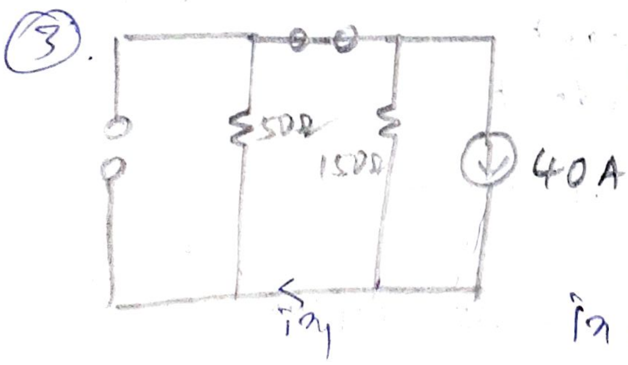
$i_{x_1} = -\frac{120 \times 50}{200} = -30$

$\boxed{i_{x_1} = -30A}$



$i_{x_2} = \frac{10}{200} = \frac{1}{20} = 0.05A$

$\boxed{i_{x_2} = 0.05A}$

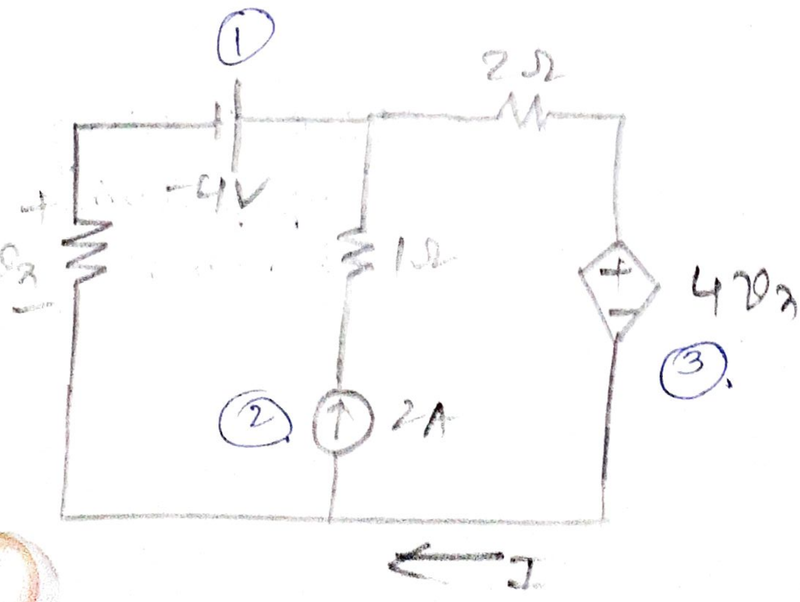


$i_{x_3} = \frac{40 \times 150}{200} = +30A$

$\boxed{i_{x_3} = +30A}$

$i_x = i_{x_1} + i_{x_2} + i_{x_3} = -30 + 0.05 + 30$

$\boxed{i_x = 0.05A}$ Ans

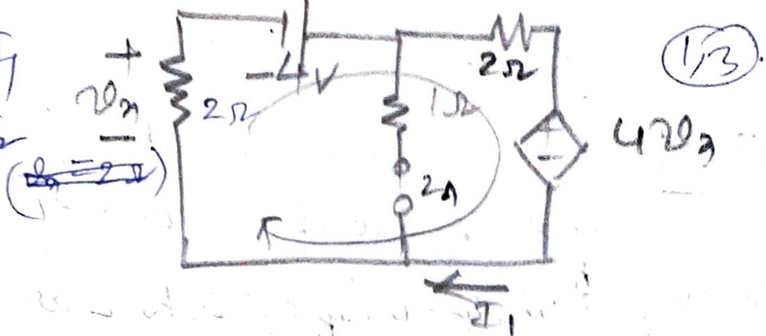


Find I using Superposition theorem

Case 2:

① ③ $\rightarrow I_1$

② ③ $\rightarrow I_2$



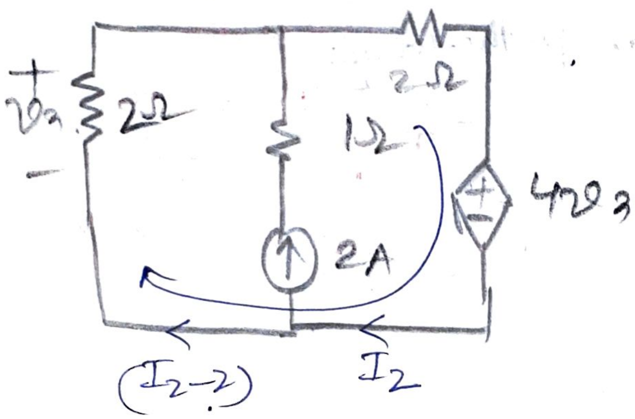
$2I_1 + 4 + 2I_1 + 4v_x = 0.$ $\quad v_x = -2I_1$

$4I_1 + 4v_x + 4 = 0.$

$4I_1 - 8I_1 + 4 = 0.$

$4I_1 = 4$

$\underline{I_1 = 1\ A}$



$2I_2 + 4v_x + 2(I_2 - 2) = 0. \quad$ — ①.

$v_x = -2(I_2 - 2) \quad$ — ②.

$2I_2 - 8(I_2 - 2) + 2(I_2 - 2) = 0.$

$2I_2 - 6(I_2 - 2) = 0.$

$-4I_2 + 12 = 0$

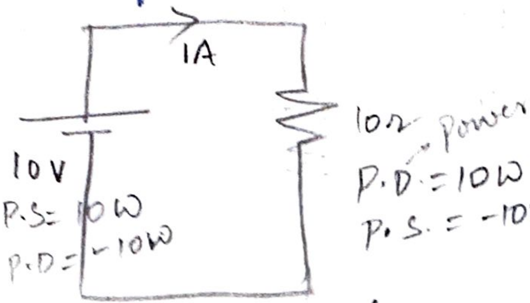
$\boxed{I_2 = 3A}$

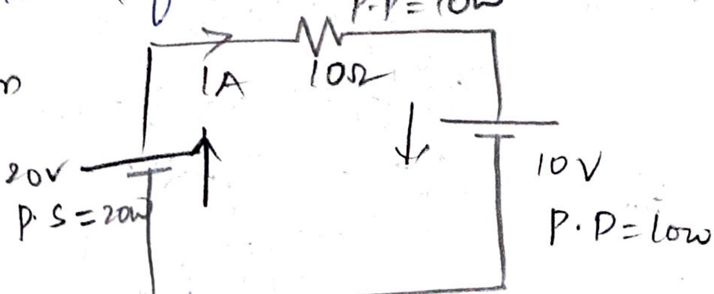
$I = I_1 + I_2 = 1 + 3 = 4A$ // $\quad \boxed{I_1 = 4A}$

08th August 2019

~~MILLER'S~~ TELLEGAN'S THEOREM

Total Power in the network is zero if KVL and KCL are satisfied. Mathematically, $\sum_{K=1}^{n} v_K i_K = 0$ (if KVL & K.CL are satisfied)





Net Power Supplied = 0

Point this source will supply everytime

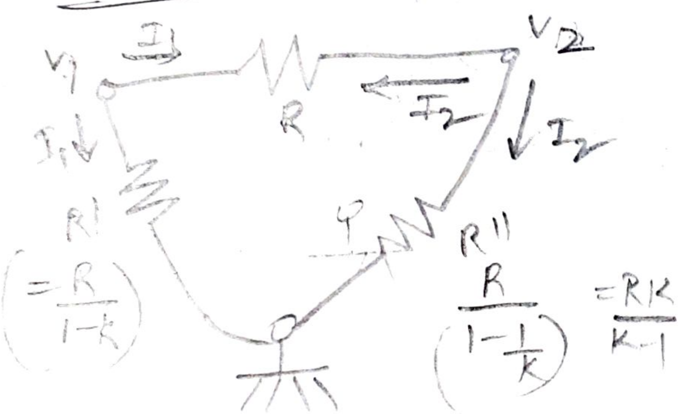
Sign Convention for the Source:

P. Dissipation = +ve
P. supply = −ve

P.S = +ve
P.S = −ve.

Independent of the current direction, R always dissipates power.

~~MILLER'S~~ MILLER'S THEOREM

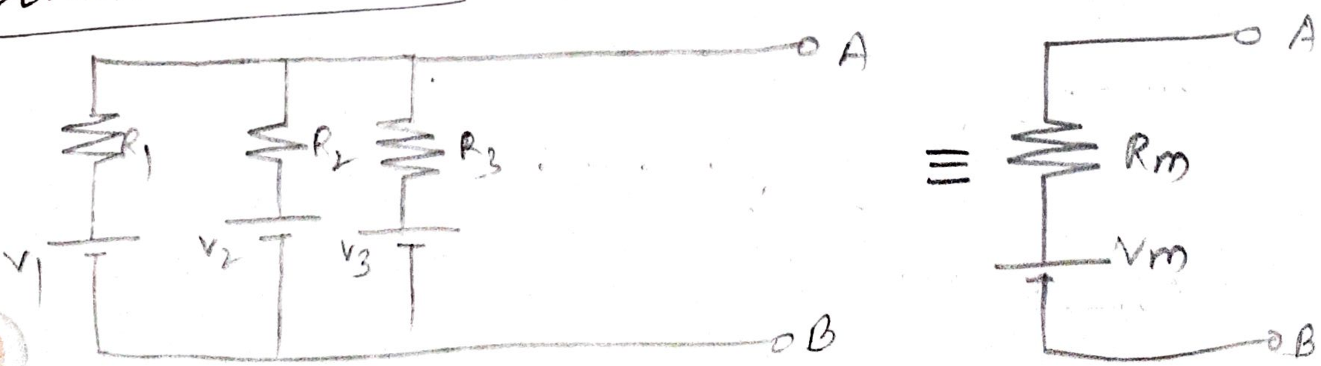


$$I_1 = \frac{V_1 - V_2}{R} = \frac{V_1}{R}\left[1 - \frac{V_2}{V_1}\right]$$

Let $\frac{V_2}{V_1} = K$

$$I_1 = \frac{V_1}{R}(1-K) = \frac{V_1}{\left(\frac{R}{1-K}\right)} = \frac{V_1}{R'}$$

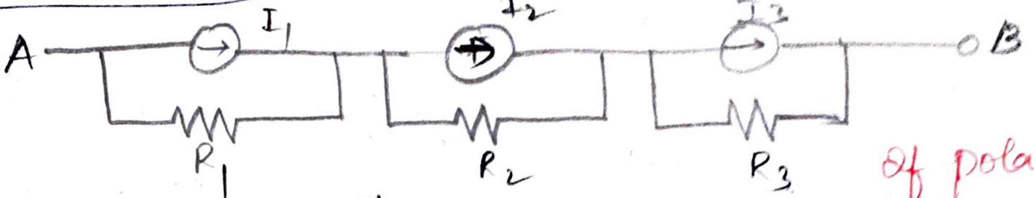
MILLMAN'S THEOREM:

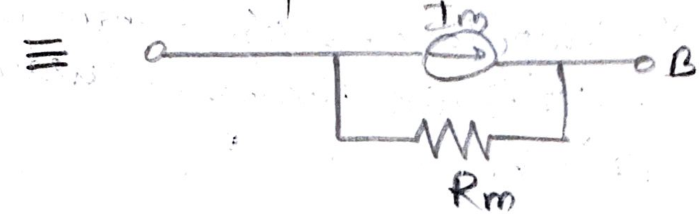


$$V_m = \frac{V_1 G_1 + V_2 G_2 + V_3 G_3 \cdots\cdots}{G_1 + G_2 + G_3 + \cdots\cdots} \qquad R_m = \frac{1}{G_1 + G_1 + G_3 + \cdots}$$

Source Transformation: VS → C.S. Add them → V.S.

Dual:



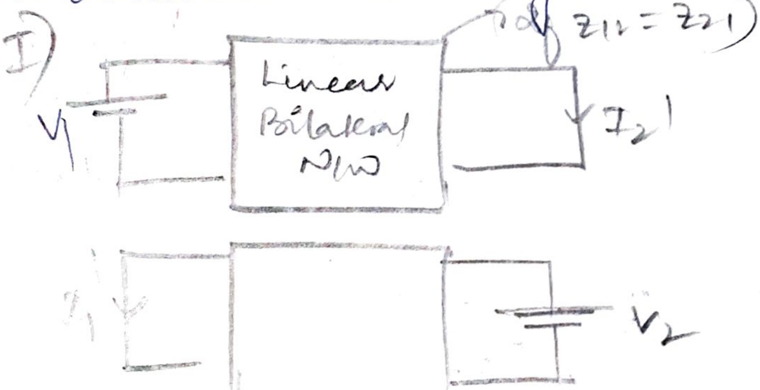


If polarities are changed, just change the sign to minus
$I_2 \leftarrow -I_2$

$$I_m = \frac{I_1 R_1 + I_2 R_2 + I_3 R_3 + \cdots}{R_1 + R_2 + R_3 + \cdots\cdots} \qquad R_m = R_1 + R_2 + R_3 + \cdots$$

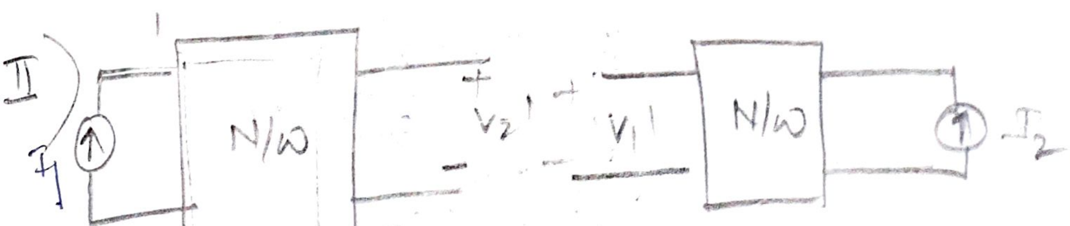
RECIPROCITY THEOREM: In Any linear bilateral network, the ratio of response to excitation is constant even if response and excitation interchange.

I)



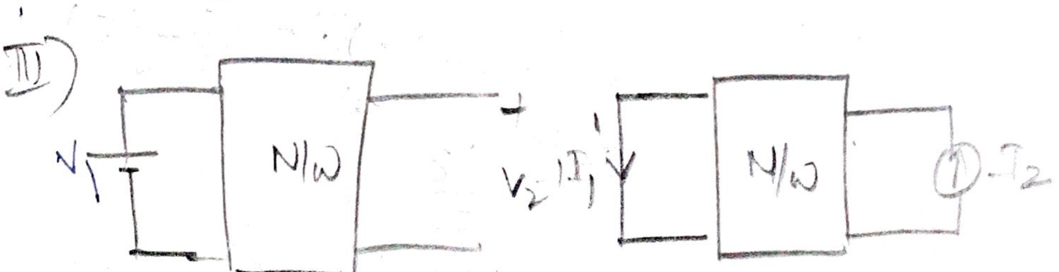
$$\boxed{\frac{I_2'}{V_1} = \frac{I_1'}{V_2}}$$

II)



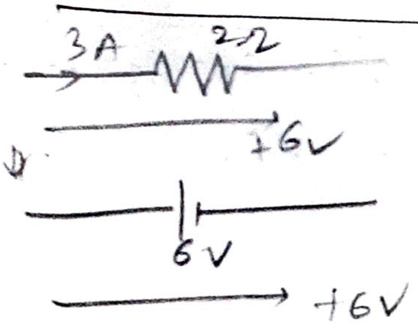
$$\boxed{\frac{V_2'}{I_1} = \frac{V_1'}{I_2}}$$

III)

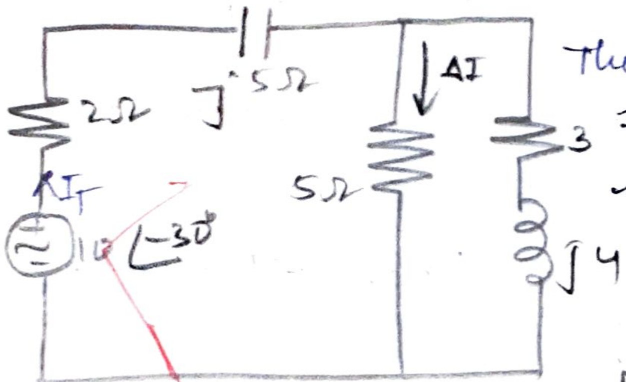


$$\boxed{\frac{V_2'}{V_1} = \frac{I_1'}{I_2}}$$

COMPENSATION THEOREM: / Substitution Theorem

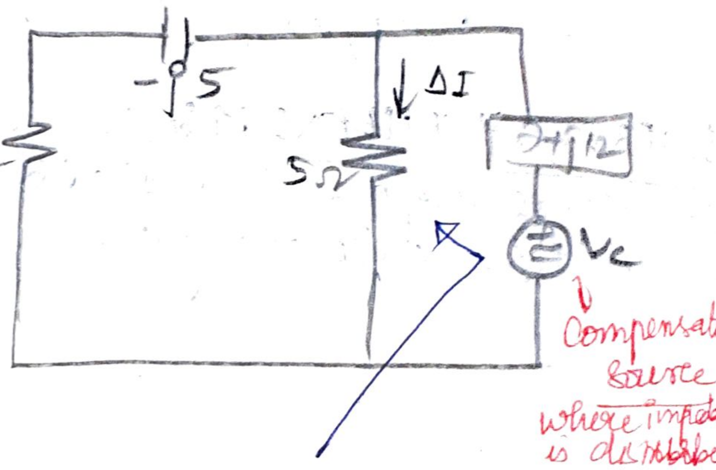


This theorem is useful to find change in current in any branch due to change in impedance in any one branch



The impedance 3+4j changed to 7+j12. Find change in current in 5V.

I is current before change where we want to find change in current.



(5) $V_C = I \delta Z$

$=$

$\delta Z = (7+j12) - (3+j4)$

$= (4+j8)$

(1) $Z_T = (2-j5) + (5 \| 3+j4)$ (looking from source)

(2) $I_T = \dfrac{10\angle{-30}}{Z_T}$

(3) $I = I_T \times \dfrac{(3+j4)}{5+(3+j4)}$

(4) Substitute in $V_C = I \delta Z$

$Z_T' = (7+j12) + 5 \| (2-j5)$

$I_T' = \dfrac{V_C}{Z_T'}$

$\Delta I = \dfrac{I_T'(2-j5)}{(2-j5)+(5)}$