USN

10ES34

Third Semester B.E. Degree Examination, June/July 2015

Network Analysis

Time: 3 hrs. Max. Marks: 100

Note: ***Answer FIVE full questions, selecting at least TWO questions from each part.***

PART – A

1 a. Derive expression for
i) Star to delta transformation ii) Delta to star transformation (10 Marks)

b. For the Network shown find the node voltages Vd and Vc Fig. Q No. 1 (b) (10 Marks)

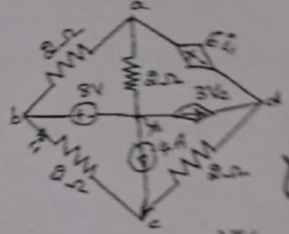


Fig.Q1(b)

2 a. Define the following with examples
i) Oriented graph ii) Tree iii) Fundamental cut set iv) Fundamental tie set (08 Marks)

b. For the network, Shown Fig. Q No.2 (b) write the tie set schedule, tie set matrix and obtain equilibrium equation in matrix form using KVL. Calculate branch currents and branch voltage. Follow the same orientation and branch numbers use 4, 5 and 6 as tree branches. (12 Marks)

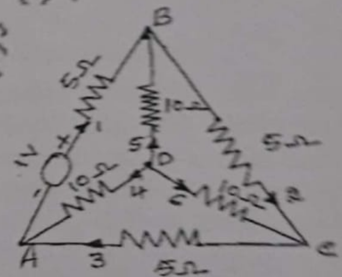


Fig.Q2(b)

3 a. State and prove Reciprocity theorem. (07 Marks)

b. Find the output voltage Eo of the Network shown Using Millman's theorem. Fig. Q No. 3(b)

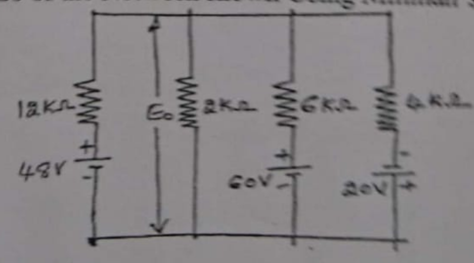
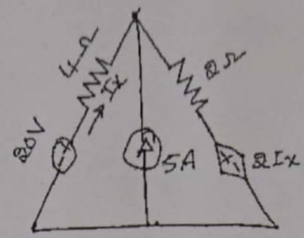


Fig.Q3(b)

(06 Marks)

c. Using superposition theorem, find the current IX the network shown in Fig. Q No.3(c)

Fig.Q3(c)

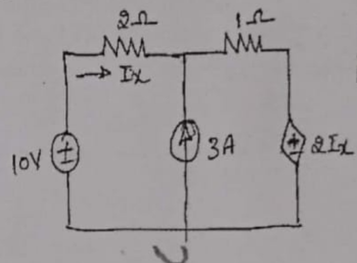


(07 Marks)

4 a. State Norton's theorem. Show that Thevenin's equivalent circuit is the dual of Norton's equalent circuit. (06 Marks)

b. Obtain the current I_x by using Thevenin's theorem for the network shown in Fig Q No.4(b)

Fig.Q4(b)



(08 Marks)

c. State maximum power transfer theorem. Prove that $Z_L = Z_o^*$ for Ac circuits. (06 Marks)

PART – B

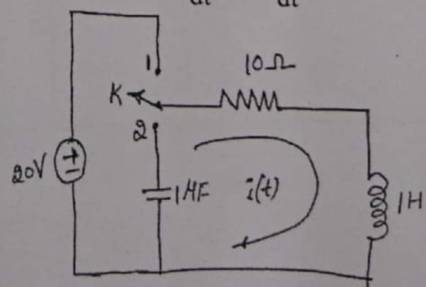
5 a. Show that $f_0 = \sqrt{f_1 f_2}$ fro series Resonance circuit. (06 Marks)

b. A voltage of 100 sin wt is applied to an RLC series circuit at resonant frequency. The voltage across a capacitor was found to be 400V. The bandwidth is 75Hz. The impedence at resonance is 100Ω. Find the resonant frequency and constants of the circuit. (06 Marks)

c. Derive an expression for the resonant frequency of a resonant frequency of a resonant circuit consisting of R_L L in parallel with R_c C. Draw the frequency response curve of the above circuit. (08 Marks)

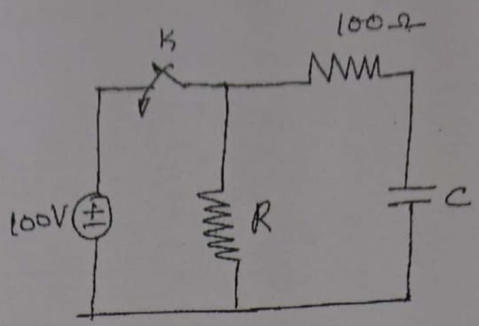
6 a. In the circuit shown, switch K is changed from 1 to 2 at t = 0, steady state having been attained in position 1. Find the values of i, $\frac{di}{dt}$ and $\frac{d^2i}{dt^2}$ at $t = 0^+$. (10 Marks)

Fig.Q6(a)



b. In the circuit shown, switch K is kept open for very long time, on closing K, after 10ms, Vc = 80V. Then the switch K is kept closed for a long time. When the switch is opened again, Vc = 90V after half second, calculate values of R and C. Fig. Q No.6 (b)

Fig.Q6(b)

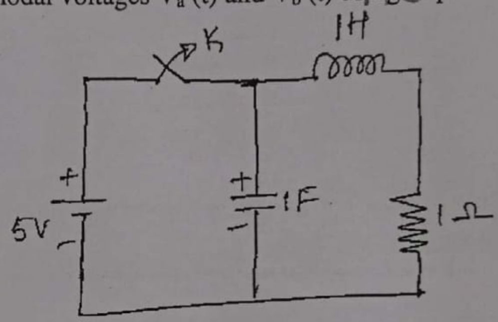


(10 Marks)

7 a. State and prove i) Initial value theorem ii) Final value theorem as applied to Laplace transform. What are the limitations of each theorem. (10 Marks)

b. In the circuit shown, in Fig.Q No.7 (b) switch is initially closed. After steady the switch is opened, Determine the nodal voltages V_a (t) and V_b (t) using Laplace transform method.

Fig.Q7(b)



(10 Marks)

8 a. Define z-parameters. Express z-parameters in terms of y – parameters. (10 Marks)

b. Find y parameters and z parameters for the circuit shown.

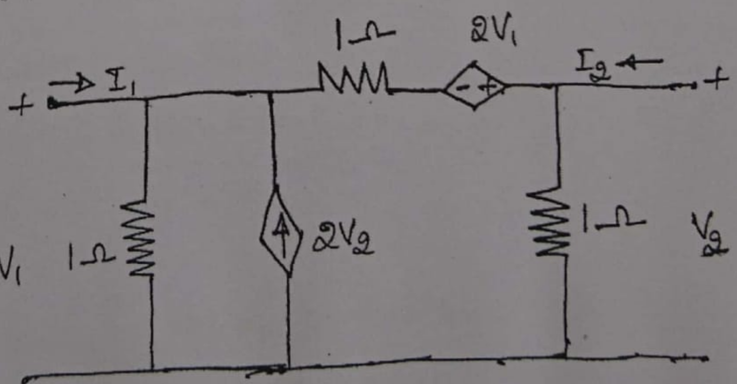


Fig.Q8(b)

10 Marks)

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Network Analysis June/July 2015.

Q1. Derive expression for i> Star to delta transformation [10M]
ii> Delta to star transformation.

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A:

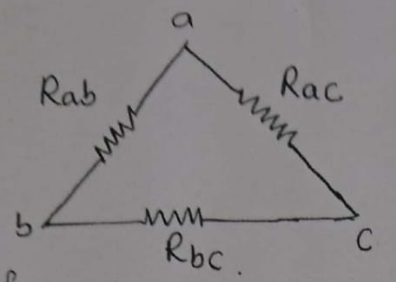


fig a> delta connection.

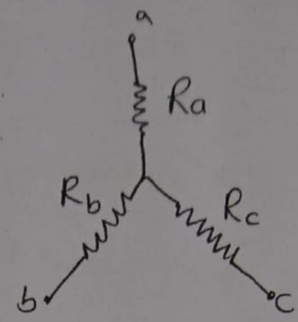


fig b: Star connection.

i> delta to star transformation:

Referring to figure (a), the resistance betn a & b is,

$$R_{ab} \parallel (R_{ac}+R_{bc}) = \frac{R_{ab}(R_{ac}+R_{bc})}{R_{ab}+R_{bc}+R_{ac}}$$

Refferring to fig (b), the resistance betn a & b is,

$R_a + R_b$, Since the two networks are equivalent,

$$R_a + R_b = \frac{R_{ab}(R_{ac}+R_{bc})}{R_{ab}+R_{bc}+R_{ac}} \quad \text{---} \; (1)$$

IIly. $$R_b + R_c = \frac{R_{bc}(R_{ab}+R_{ca})}{R_{ab}+R_{bc}+R_{ac}} \quad \text{---} \; (2)$$

& $$R_c + R_a = \frac{R_{ac}(R_{ab}+R_{bc})}{R_{ab}+R_{bc}+R_{ac}} \quad \text{---} \; (3)$$

Substracting (1) and (2),

$$R_a - R_c = \frac{R_{ab}R_{ac} + \cancel{R_{ab}R_{bc}} - \cancel{R_{ab}R_{bc}} - R_{bc}R_{ac}}{\Sigma R_{ab}}$$

$$R_a - R_c = \frac{R_{ab}R_{ac} - R_{bc}R_{ac}}{\Sigma R_{ab}} \quad \text{---} \; (4)$$

adding (3) & (4),

$$2R_a = \frac{R_{ab}R_{ac} + \cancel{R_{ac}R_{bc}} + R_{ab}R_{ac} - \cancel{R_{bc}R_{ac}}}{\Sigma R_{ab}}$$

$$R_a = \frac{R_{ab} R_{ac}}{\sum R_{ab}} \quad \text{——} (5)$$

$\therefore$ ||^{ly}

22 $$R_b = \frac{R_{bc} R_{ab}}{\sum R_{ab}} \quad \text{——} (6)$$

$$R_c = \frac{R_{ac} R_{bc}}{\sum R_{ab}} \quad \text{——} (7)$$

ii) Star to Delta Transformation:

Multiplying the above eqns we get.

$$R_a R_b = \frac{R_{ab} R_{ac} R_{bc} R_{ab}}{(\sum R_{ab})^2} \quad \text{——} (8)$$

$$R_b R_c = \frac{R_{bc} R_{ab} R_{ac} R_{bc}}{(\sum R_{ab})^2} \quad \text{——} (9)$$

$$R_a R_c = \frac{R_{ab} R_{ac} R_{ac} R_{bc}}{(\sum R_{ab})^2} \quad \text{——} (10)$$

Adding eqns (8) (9) & (10) we get,

$$R_a R_b + R_b R_c + R_a R_c = \frac{R_{ab}^2 R_{ac} R_{bc} + R_{bc}^2 R_{ab} R_{ac} + R_{ac}^2 R_{ab} R_{bc}}{\sum R_{ab} \cdot \sum R_{ab}}$$

$$= \frac{R_{ab} R_{bc} R_{ac} (R_{ab} + R_{bc} + R_{ac})}{\sum R_{ab} (R_{ab} + R_{bc} + R_{ac})}$$

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

From eqn (7), $R_{ab} \cdot R_{ac} = \frac{R_{ab} R_{ac} R_{bc}}{\sum R_{ab}} = R_a R_b + R_b R_c + R_a$

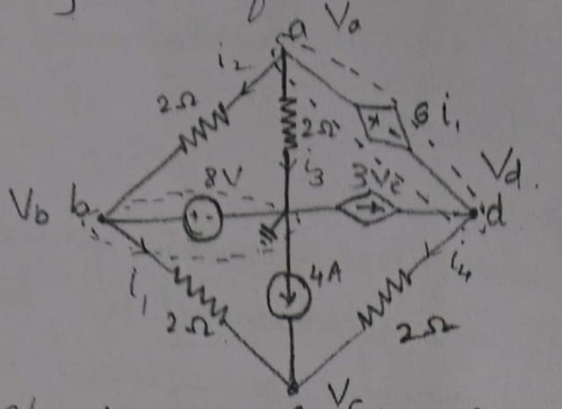
$$\therefore R_{ab} = \frac{R_a R_b + R_b R_c + R_a R_c}{R_c}$$

||^{ly},
$$R_{bc} = \frac{R_a R_b + R_b R_c + R_c R_a}{R_a}$$

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

For

For the network shown find the node voltages V_d and V_c [10M]



Writing KCL at supernode, $V_b = 8V$ — ①

KCL at a & d supernode,

$$V_a - V_d = 6i_1 \quad — ②$$

&

$$-i_2 - i_3 + 3V_c - i_4 = 0 \quad — ③$$

$$i_1 = \frac{V_b - V_c}{2}; \; i_2 = \frac{V_a - V_b}{2}; \; i_3 = \frac{V_a}{2}; \; i_4 = \frac{V_d - V_c}{2}$$

from ②, $V_a - V_d = 6\left(\frac{V_b - V_c}{2}\right) = 3V_b - 3V_c$.

$$\therefore V_a - 3V_b + 3V_c - V_d = 0.$$

$$V_a + 3V_c - V_d = 24 \quad — ④$$

$$\frac{V_a - V_b}{2} + \frac{V_a}{2} + \frac{V_d - V_c}{2} + -3V_c = 0$$

$$V_a - 4 + 0.5V_d - 3.5V_c = 0$$

$$V_a - 3.5V_c + 0.5V_d = 4 \quad — ⑤$$

KCL at c,

$$i_1 + i_4 + 4 = 0$$

$$\frac{V_b - V_c}{2} + \frac{V_d - V_c}{2} + 4 = 0$$

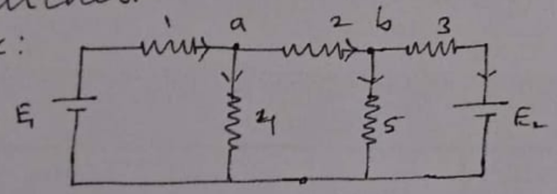
$$V_c - 0.5V_d = 8 \quad — ⑥$$

$V_a = 9.143V$ $\underline{V_c = -1.143V}$ $\underline{V_d = -18.28V}$

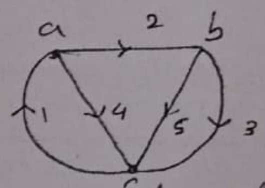
Q2) a) Define the following with examples.
24 i) Oriented graph ii) Tree iii) Fundamental Cut set
iv) Fundamental Tie set.

Sol2: i) Oriented graph.
The graph of a network is a geometric figure in which all passive elements are represented by line segments all the ideal voltage sources are replaced by S.C's and all the ideal current sources are replaced by open ckts. retaining all the nodes.
A graph is said to be oriented graph, when its all nodes are named and its branches are numbered and directions are assigned to these branches. The directions indicate the direction of current in the branches.

Ex:

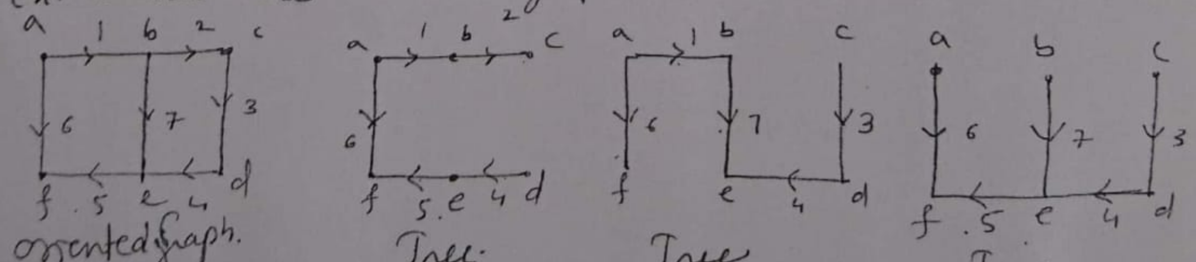


network



oriented graph.

ii) Tree: Tree is a subgraph of a graph which does not contain any loops. A network graph can have several trees.
Ex: Consider the oriented graph as shown.



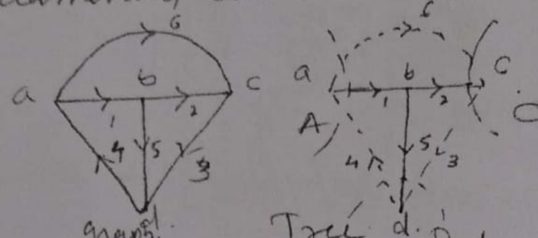
oriented graph.   Tree.   Tree.   Tree.

The tree branches are called as twigs and are given as.
Twigs = t = nodes − 1
For the above example, nodes = n = 6 ∴ $t = n-1 = 6-1 = 5$.

iii). Fundamental Cutset :

When a graph is given, first select a tree and note down its twigs. When a twig is remove from the tree, it separates a tree into two parts. Now all the branches connecting one part of the disconnected tree to the other along with the twig removed, constitute a cut set. This set of branches is called a fundamental cut set. or f-cut set.

Ex:



f-cut set A : {1, 4, 6}

f-cutset C : {2, 3, 6}

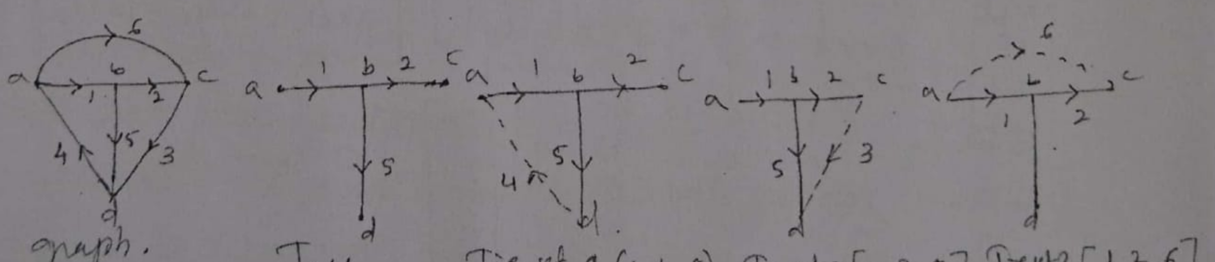
f-cutset D : {3, 4, 5}.

graph. Tree d.

The number of fundamental cut sets for graph is equal to number of twigs of the tree.

iv). Fundamental Tie set :

When a graph is given, first select a tree and remove all the links. When a link is replaced a closed loop is formed. The ckts formed this way are called fundamental ckts, or fundamental tie sets. The set of branches constituting a closed path is called a fundamental tie set. The following example is illustrated.



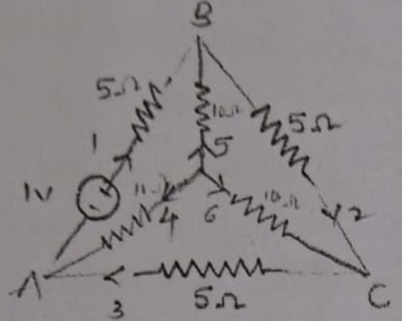
graph. Tree Tie-set 1 (1, 4, 5). Tie set 2 [2, 3, 5]. Tie set 3 [1, 2, 6].

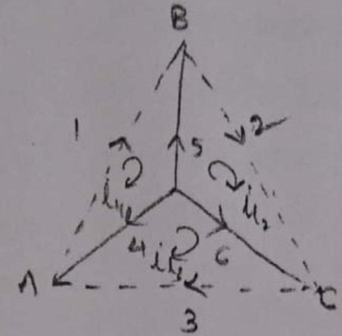
The number of tiesets for a graph is equal to the number of links. i.e $l = (b - n + 1)$ = Fundamental cutsets.

where b - number of branches in a graph.

n - number of node.

Q2 b). For the network shown, write the tie set schedule, tie set matrix and obtain equilibrium equations in matrix
2B. form using KVL. Calculate branch currents and branch voltages. Follow the same orientation and branch numbers use, 4, 5 & 6 as tree branches.





The equilibrium eq^ns with loop currents as variable are,

$$BZ_bB^T I_l = BZ_bI_g - BV_g \quad — ①$$

$$BZ_bB^T = \begin{array}{c|c} & \begin{array}{cccccc} 1 & 2 & 3 & 4 & 5 & 6 \end{array} \\ \begin{array}{c} i_{l_1} \\ i_{l_2} \\ i_{l_3} \end{array} & \begin{bmatrix} 1 & 0 & 0 & 1 & -1 & 0 \\ 0 & 1 & 0 & 0 & 1 & -1 \\ 0 & 0 & 1 & -1 & 0 & 1 \end{bmatrix} \end{array} \begin{bmatrix} 5 & 0 & 0 & 0 & 0 & 0 \\ 0 & 5 & 0 & 0 & 0 & 0 \\ 0 & 0 & 5 & 0 & 0 & 0 \\ 0 & 0 & 0 & 10 & 0 & 0 \\ 0 & 0 & 0 & 0 & 10 & 0 \\ 0 & 0 & 0 & 0 & 0 & 10 \end{bmatrix} B^T$$

$$= \begin{bmatrix} 5 & 0 & 0 & 10 & -10 & 0 \\ 0 & 5 & 0 & 0 & 10 & -10 \\ 0 & 0 & 5 & -10 & 0 & 10 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & -1 \\ -1 & 1 & 0 \\ 0 & -1 & 1 \end{bmatrix} = \begin{bmatrix} 5+10+10 & -10 & -10 \\ -10 & 5+10+10 & -10 \\ -10 & -10 & 5+10+10 \end{bmatrix}$$

$$BZ_bB^T I_l = \begin{bmatrix} 25 & -10 & -10 \\ -10 & 25 & -10 \\ -10 & -10 & 25 \end{bmatrix} \begin{bmatrix} i_{l_1} \\ i_{l_2} \\ i_{l_3} \end{bmatrix} = \begin{bmatrix} 25i_{l_1} - 10i_{l_2} - 10i_{l_3} \\ -10i_{l_1} + 25i_{l_2} - 10i_{l_3} \\ -10i_{l_1} - 10i_{l_2} + 25i_{l_3} \end{bmatrix} \quad — ②$$

$$BZ_bI_g = \begin{bmatrix} 5 & 0 & 0 & 10 & -10 & 0 \\ 0 & 5 & 0 & 0 & 10 & -10 \\ 0 & 0 & 5 & -10 & 0 & 10 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} = 0 \quad — ③$$

$$BV_g = \begin{bmatrix} 1 & 0 & 0 & 1 & -1 & 0 \\ 0 & 1 & 0 & 0 & 1 & -1 \\ 0 & 0 & 1 & -1 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} \quad — ④$$

Therefore substituting ② ③ & ④ in eqn ① we get,

$25 i_{l_1} - 10 i_{l_2} - 10 i_{l_3} = -1$

$-10 i_{l_1} + 25 i_{l_2} - 10 i_{l_3} = 0$

$-10 i_{l_1} - 10 i_{l_2} + 25 i_{l_3} = 0$

$i_{l_1} = 0.0857A$; $i_{l_2} = 0.05714A$; $i_{l_3} = 0.05714A$ 27

The various branch currents are,

$i_1 = 0.0857A$ $i_2 = 0.05714A$ $i_3 = 0.05714A$.

$$I_b = B^T I_l = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & -1 \\ -1 & 1 & 0 \\ 0 & -1 & 1 \end{bmatrix} \begin{bmatrix} 0.0857 \\ 0.05714 \\ 0.05714 \end{bmatrix} = \begin{bmatrix} 0.0857 \\ 0.05714 \\ 0.05714 \\ 0.02856 \\ -0.02856 \\ 0 \end{bmatrix} = \begin{bmatrix} i_1 \\ i_2 \\ i_3 \\ i_4 \\ i_5 \\ i_6 \end{bmatrix}$$

The various branch voltages are given by

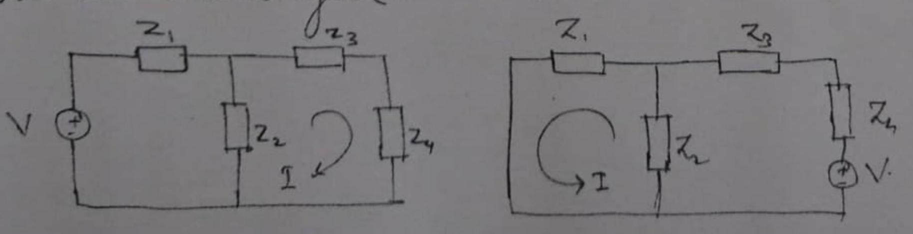
$E_b = E_g + Z_b(I_b - I_g)$ But $I_g = 0$.

$$E_b = E_g + Z_b I_b = \begin{bmatrix} 1 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} + \begin{bmatrix} 5 & 0 & 0 & 0 & 0 & 0 \\ 0 & 5 & 0 & 0 & 0 & 0 \\ 0 & 0 & 5 & 0 & 0 & 0 \\ 0 & 0 & 0 & 10 & 0 & 0 \\ 0 & 0 & 0 & 0 & 10 & 0 \\ 0 & 0 & 0 & 0 & 0 & 10 \end{bmatrix} \begin{bmatrix} 0.0857 \\ 0.05714 \\ 0.05714 \\ 0.02856 \\ -0.02856 \\ 0 \end{bmatrix}$$

$$= \begin{bmatrix} 1 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} + \begin{bmatrix} 0.4285 \\ 0.2857 \\ 0.2857 \\ 0.2856 \\ -0.2856 \\ 0 \end{bmatrix} = \begin{bmatrix} 1.4285 \\ 0.2857 \\ 0.2857 \\ 0.2856 \\ -0.2856 \\ 0 \end{bmatrix} = \begin{bmatrix} e_1 \\ e_2 \\ e_3 \\ e_4 \\ e_5 \\ e_6 \end{bmatrix}$$

Q7. State and prove reciprocity theorem.

A: Statement: If any linear, bilateral network containing only one independent source, the ratio of excitation to response remain constant, when their positions are interchanged.



Proof: Consider the network as shown in fig below.

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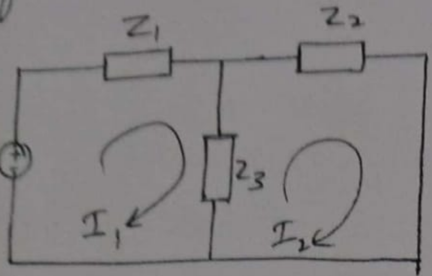


Let us calculate the ratio $\frac{V_1}{I_2}$

Applying KVL to two loops,

$$-I_1 Z_1 - I_1 Z_3 + I_2 Z_3 + V_1 = 0$$

$$\therefore I_1 (Z_1 + Z_3) - I_2 Z_3 = V_1 .$$

$$\& \; -I_2 Z_2 - I_2 Z_3 + I_1 Z_3 = 0 .$$

$$\therefore I_1 Z_3 - I_2 (Z_2 + Z_3) = 0$$

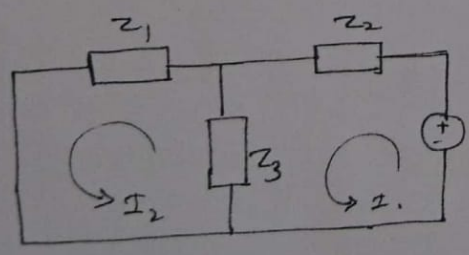
$$D = \begin{vmatrix} Z_1 + Z_2 & -Z_3 \\ +Z_3 & -Z_2 - Z_3 \end{vmatrix} = Z_1 Z_2 - Z_2 Z_3 - Z_1 Z_3 .$$

$$\& \; D_2 = \begin{vmatrix} Z_1 + Z_3 & V_1 \\ Z_3 & 0 \end{vmatrix} = -V_1 Z_3 .$$

$$\therefore I_2 = \frac{D_2}{D} = \frac{-V_1 Z_3}{-(Z_1 Z_2 + Z_2 Z_3 + Z_1 Z_3)}$$

$$\therefore \frac{V_1}{I_2} = \frac{Z_1 Z_2 + Z_2 Z_3 + Z_1 Z_3}{Z_3} \quad \text{——} \; (1).$$

Now, let us interchange the positions of V_1 & I_2.



Applying KVL,

$$-I_2 Z_1 - I_2 Z_3 + I_1 Z_3 = 0 .$$

$$\therefore I_1 Z_3 - I_2 (Z_1 + Z_3) = 0$$

$$\& \; -I_1 Z_2 - I_1 Z_3 + I_2 Z_3 + V_1 = 0$$

$$\therefore I_1 (Z_2 + Z_3) - I_2 Z_3 = V_1 .$$

$$\therefore D = \begin{vmatrix} Z_3 & -Z_2 - Z_3 \\ Z_1 + Z_3 & -Z_3 \end{vmatrix} = Z_1 Z_2 + Z_2 Z_3 + Z_3 Z_1 .$$

$$D_2 = \begin{vmatrix} Z_3 & 0 \\ Z_2 + Z_3 & V_1 \end{vmatrix} = Z_3 V_1 .$$

$$\therefore I_2 = \frac{D_2}{D} = \frac{Z_3 V_1}{Z_1 Z_2 + Z_2 Z_3 + Z_3 Z_1} .$$

$$\therefore \frac{V_1}{I_2} = \frac{Z_1 Z_2 + Z_2 Z_3 + Z_3 Z_1}{Z_3} \quad \text{——} \; (2).$$

eqns (1) & (2) show that the ratio V/I remain same.

. Find the output voltage E_o of the network shown using Millmans theorem. [06 M]

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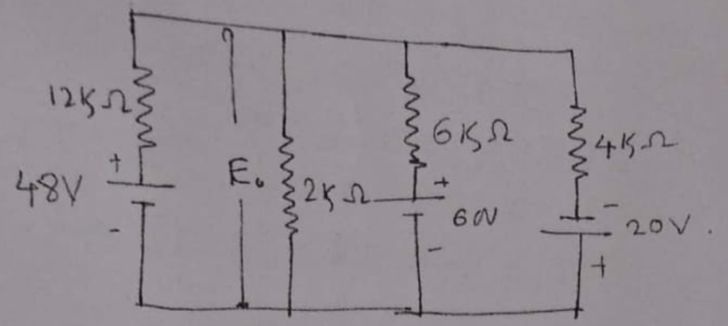
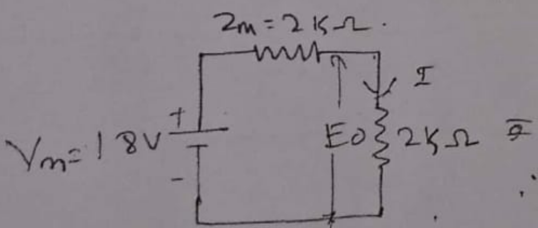


$$Z_3 = \frac{1}{\frac{1}{Z_1}+\frac{1}{Z_2}+\frac{1}{Z_3}} = \frac{1}{\frac{1}{12k}+\frac{1}{6k}+\frac{1}{4k}} = \frac{1}{0.5\times10^{-3}} = 2k\Omega.$$

$$V_m = \frac{\frac{V_1}{Z_1}+\frac{V_2}{Z_2}+\frac{V_3}{Z_3}}{\frac{1}{Z_1}+\frac{1}{Z_2}+\frac{1}{Z_3}} = \frac{\frac{48}{12k}+\frac{60}{6k}-\frac{20}{4k}}{0.5\times10^{-3}}$$

$V_m = 18V$.

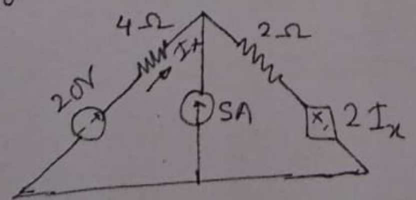
∴ The Millmann's equivalent cgt is .



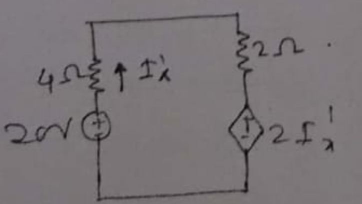
$$I = \frac{18}{4k} = 4.5\,mA.$$

$$\therefore E_o = 2I\times10^3 = 9V$$

). Using Superposition theorem find I_x. [07 M].



Considering only 20V source,

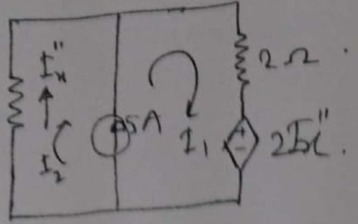


$$20 - 4I_x' - 2I_x' - 2I_x' = 0.$$

$$I_x' = \frac{20}{8} = 2.5A \quad \text{(1)}$$

Considering 5A source only.

30



$I_1 - I_2 = 5$. $I_1 = 5 + I_2$.

$-2I_2 - 2I_1 - 2I_x'' = 0$

$I_2 = I_x''$

$2I_1 + 4I_2 = 0$.

$2(5 + I_2) + 4I_2 = 0$.

$6I_2 + 10 = 0$ $I_2 = -1.66\,A$

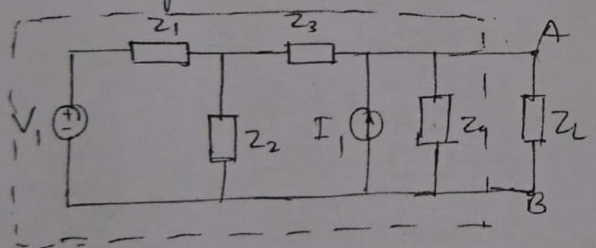
$I_1 = 5 - 1.66 = 3.33\,A$.

$\therefore I_x = I_x' + I_x'' = 2.5 - 1.66 = 0.84\,A$ //.

Q4a). State Norton's theorem. Show that Thevenin's equivalent ckt is the dual of Norton's equivalent ckt. 06.

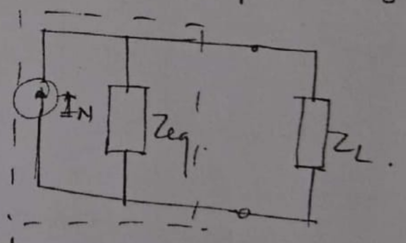
Sol2: Statement of Norton's theorem:
Any linear bilateral complex circuit can be replaced by an equivalent ckt consisting of a single current source of I_N amps and a single impedance Z_{eq} in parallel with it across the two terminals of the load Z_L.

Example.

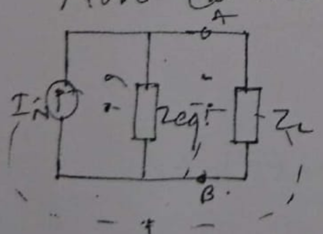


$\approx$

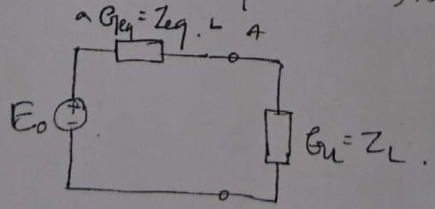
Norton's eqvlnt ckt.



Now consider the Norton's eqlnt ckt, Applying duality Princip



ckt (a).



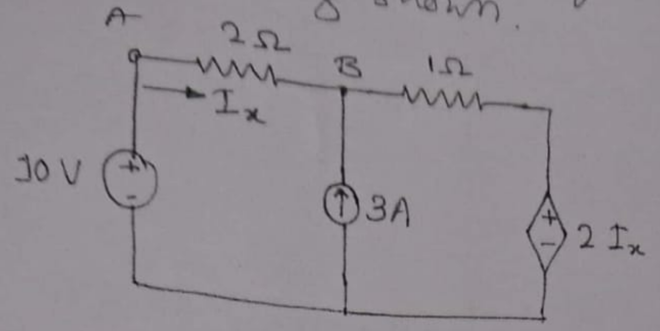
ckt (b).

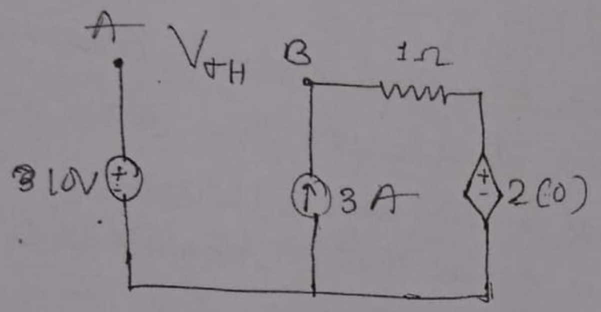
ckt(b) represents Thevenin's eqlnt n/w. Hence it is shown that Thevenin's eqlnt can be obtained by using Dual of Norton's n/w.

Obtain the current I_x for the network shown by using Thevenin's thm [8M].

25

Q/2:





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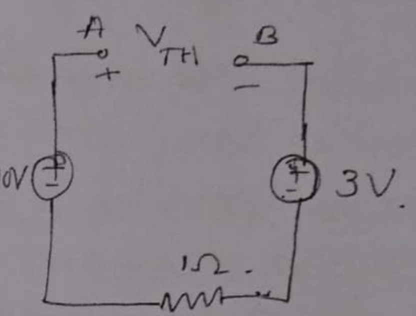
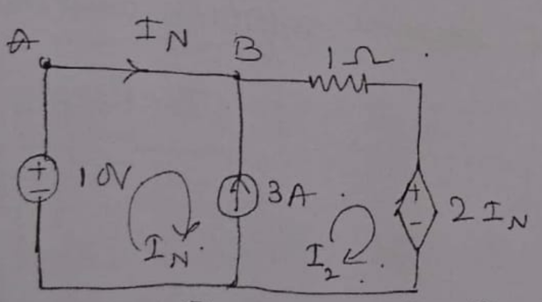


$$V_{TH} + 3 - 10 = 0 \qquad V_{TH} = 7\ V.$$

To find R_{TH} we have to find I_N first.



$$I_2 - I_N = 3 \quad \text{—(1)}. \quad I_2 = I_N + 3.$$

$$+10 - I_2 - 2 I_N = 0.$$

$$2 I_N + I_2 = 10.$$

$$2 I_N + I_N + 3 = 10$$

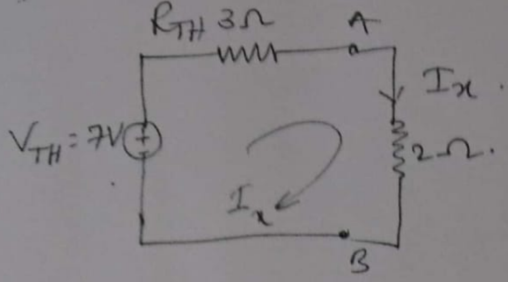
$$3 I_N + 3 = 10$$

$$3 I_N = 7.$$

$$I_N = 7/3.$$

$$\therefore R_{TH} = \frac{V_{TH}}{I_N} = \frac{7}{7/3} = 3\,\Omega.$$

26 $\therefore$ Thevenin's equivalent n/w is.



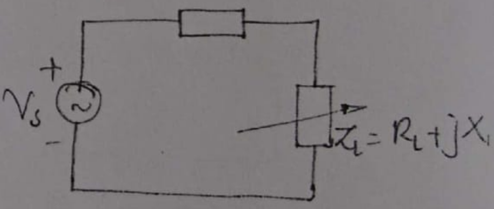
$$I_x = \frac{V_{TH}}{R_{TH}+2} = \frac{7}{5} A.$$

Q4 c). State Maximum power Transfer Theorem. Prove $Z_L = Z_0^*$ for AC ckts.

So/2: Statement: In any linear bilateral network, maximum power is transferred from source to the load when

1) Load resistance is equal to the source resistance.
2) the load resistance is equal to the magnitude of ~~load~~ source impedance.
3) the load impedance is the complex conjugate of the source impedance

To $Z_L = Z_0^*$ consider a network with load as a complex ~~resistance~~ impedance and variable resistance and variable reactance.



$$I_L = \frac{V_s}{Z_s + Z_L}$$

$$|I_L| = \frac{|V_s|}{\sqrt{(R_s+R_L)^2+(X_s+X_L)^2}}$$

The power delivered to the load is,

$$P_L = |I_L|^2 R_L = \frac{|V_s|^2 R_L}{(R_s+R_L)^2+(X_s+X_L)^2}$$

For the maximum value of P_L, the denominator of the eq2 must be small, i.e. $X_L = -X_s$.

$$\therefore \quad P_L = \frac{|V_s|^2 R_L}{(R_s+R_L)^2}$$

Differentiating the above eq^n w.r.t. R_L and equating to zero.

$$\frac{dP_L}{dR} = |V_s|^2 \left[\frac{(R_s+R_L)^2 - 2R_L(R_s+R_L)}{(R_s+R_L)^2} \right] = 0$$

$$(R_s+R_L)^2 - 2R_L(R_s+R_L) = 0.$$

$$R_s^2 - R_L^2 = 0 \quad \therefore R_s = R_L \text{ or } R_L = R_s.$$

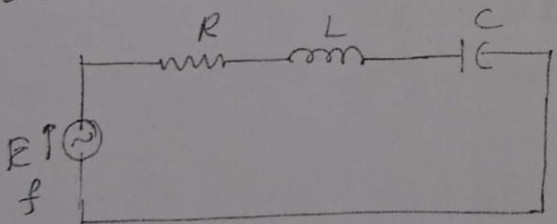
Hence, the load resistance R_L must be equal to R_s and load reactance X_L should be equal to $(-X_s)$ for maximum power transfer.

$$\therefore Z_L = R_L + jX_L = R_s - jX_s = Z_s^*.$$

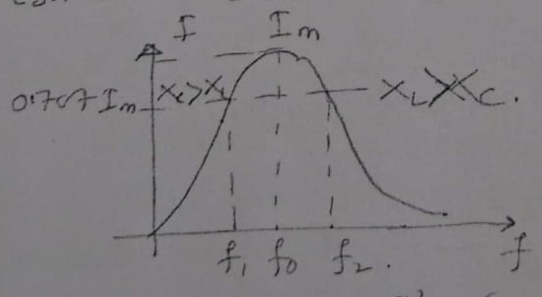
$$\therefore Z_L = Z_s^* \text{ or } Z_L = Z_0^* \quad \Big| \because Z_s = Z_0.$$

Part- B.

5.a). Show that $f_0 = \sqrt{f_1 f_2}$ for series resonance ckt. [6M]



Consider a series resonant ckt having, resistance R, inductance L and capacitance 'C'. With an ac supply source having emf E volts and frequency variable. Resonance curve is as shown below.



The impedances at f_1 & f_2 are given as.

$$Z_1 = \sqrt{R^2 + (X_{C_1} - X_{L_1})^2} \;\&.$$

$$Z_2 = \sqrt{R^2 + (X_{L_2} - X_{C_2})^2}.$$

But $Z_1 = Z_2 \quad \therefore R^2 + (X_{C_1} - X_{L_1})^2 = R^2 + (X_{L_2} - X_{C_2})^2.$

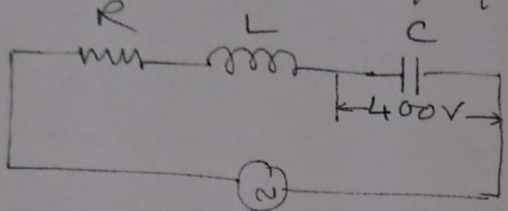
$$X_{C_1} - X_{L_1} = X_{L_2} - X_{C_2}. \quad X_{C_1} + X_{C_2} = X_{L_1} + X_{L_2}.$$

i.e. $\frac{1}{\omega_1 C} + \frac{1}{\omega_2 C} = \omega_1 L + \omega_2 L$ i.e. $\frac{1}{C}\left[\frac{\omega_1+\omega_2}{\omega_1\omega_2}\right] = L(\omega_1+\omega_2)$

i.e. $\omega_1\omega_2 = \frac{1}{LC} = \omega_0^2 \quad \therefore \omega_0 = \sqrt{\omega_1\omega_2}$ or $f_0 = \sqrt{f_1 f_2}$

Q 28 (5b). A voltage of 100 sin ωt is applied to an RLC series ckt at resonant frequency. The voltage across a capacitor was found to be 400V. The BW is 75Hz. The impedance at resonance is ~~75Hz~~ 100Ω. Find the resonant frequency and constants of the c [6

Sol:



$E = 100 \sin \omega t \, V.$

$B.W = 75 Hz.$

$Z_0 = 100\Omega = R = 100\Omega.$

Current at resonance,

$$I_m = \frac{E_m}{Z_0} = \frac{100}{100} = 1A.$$

$$V_{Cr} = I_m X_{Cr}. \quad X_{Cr} = \frac{V_{Cr}}{I_m} = \frac{400}{1} = 400\Omega.$$

$$Q_s = \frac{X_{Cr}}{R} = \frac{400}{100} = 4.$$

$$BW = f_2 - f_1 = \frac{f_r}{Q_s} = 75$$

$$\therefore f_r = 75 \times 4 = 300 Hz.$$

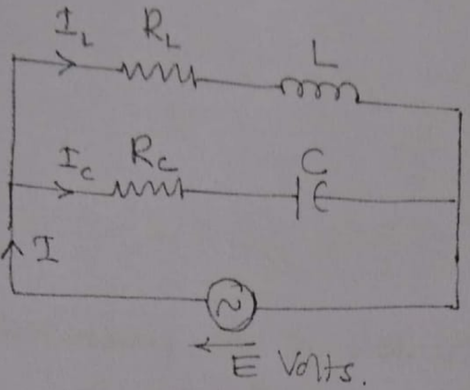
$$\frac{1}{2\pi f_r C} = 400 \quad \therefore C = \frac{1}{2\pi \times 300 \times 400} = 1.33 \mu F.$$

$$Q_s = \frac{X_{Lr}}{R} = \frac{2\pi f_r L}{R} = 4.$$

$$L = \frac{4 \times 100}{2\pi \times 300} = 0.212 H.$$

Desire an expression for the resonant frequency of a resonant ckt consisting of R_L L in parallel with R_c C. Draw the frequency response curve of the above circuit.

?:



$Z_L = R_L + j\omega L$ i.e. $Y_L = \frac{1}{R_L + j\omega L} = \frac{R_L - j\omega L}{R_L^2 + \omega^2 L^2}$.

||ly $Z_c = R_c - j\frac{1}{\omega C}$ i.e. $Y_c = \frac{1}{R_c - j\frac{1}{\omega c}} = \frac{R_c + j\frac{1}{\omega c}}{R_c^2 + \frac{1}{\omega^2 c^2}}$.

The total admittance Y is given by,

$$Y = Y_L + Y_c = \frac{R_L - j\omega L}{R_L^2 + j\omega^2 L^2} + \frac{R_c + j\frac{1}{\omega c}}{R_c^2 + \frac{1}{\omega^2 c^2}}$$

$$Y = \left[\frac{R_L}{R_L^2 + \omega^2 L^2} + \frac{R_c}{R_c^2 + \frac{1}{\omega^2 c^2}}\right] + j\left[\frac{\frac{1}{\omega c}}{R_c^2 + \frac{1}{\omega^2 c^2}} - \frac{\omega L}{R_L^2 + \omega^2 L^2}\right]$$

At resonance admittance is purely conductive hence, the imaginary part is neglected equated to zero.

$$\therefore \frac{\frac{1}{\omega_r c}}{R_c^2 + \frac{1}{\omega_r^2 c^2}} = \frac{\omega_r L}{R_L^2 + \omega_r^2 L^2} \quad \text{i.e. } \frac{1}{\omega_r c}\left(R_L^2 + \omega_r^2 L^2\right) = \omega_r L\left(R_c^2 + \frac{1}{\omega_r^2 c^2}\right)$$

$$\text{i.e. } \frac{1}{LC}\left[R_L^2 + \omega_r^2 L^2\right] = \omega_r^2\left[R_c^2 + \frac{1}{\omega^2 c^2}\right]$$

$$\frac{R_L^2}{LC} + \omega_r^2 \frac{L}{C} = \omega_r^2 RC + \frac{1}{C^2}$$

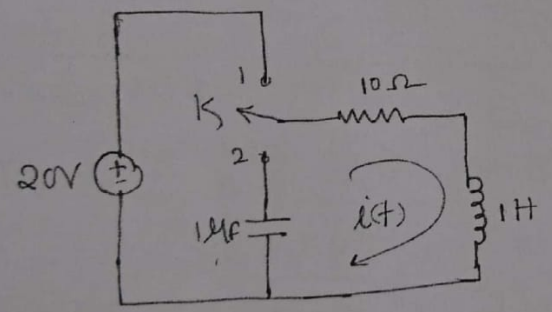
30 $$\omega_r^2\left[R_C^2 - \frac{L}{C}\right] = \frac{R_L^2}{LC} - \frac{1}{C^2} = \frac{1}{LC}\left[R_L^2 - \frac{L}{C}\right]$$

$$\therefore \omega_r^2 = \frac{\frac{1}{LC}\left[R_L^2 - \frac{L}{C}\right]}{R_C^2 - \frac{L}{C}}$$

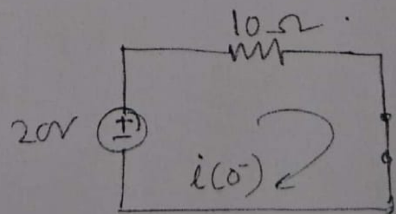
$$\therefore f_r = \frac{1}{2\pi\sqrt{LC}}\sqrt{\frac{R_L^2 - \frac{L}{C}}{R_C^2 - \frac{L}{C}}} \quad //.$$

Q6 a). In the ckt shown, switch K is changed from 1 to 2 at $t=0$, steady state having been attained in position 1. Find the values of i, $\frac{di}{dt}$ and $\frac{d^2i}{dt^2}$ at $t=0^+$.

S)



Sol 2: At $t=0^-$, the n/w attains steady state, Hence inductor ~~capacitor~~ acts as S.C.



$\therefore i(0^-) = \frac{20}{10} = 2A$

& $V_c(0^-) = 0$.

At $t=0^+$, the inductor acts as current source of 2 and capacitor acts at S.C.

$i(0^+) = 2A$

$V_c(0^+) = 0$.

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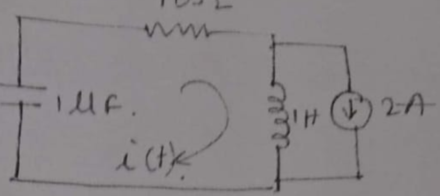
For $t>0$, the n/w is shown as below: 31

$$\frac{1}{1\times10^{-6}}\int_0^t i\,dt-10i-1\frac{di}{dt}=0 \quad \text{—}(1)$$



at $t=0^+$

$$0-10i(0^+)-\frac{di(0^+)}{dt}=0.$$

$$\frac{di(0^+)}{dt}=-10\times2=-20\,A/s$$

Differentiating eqn (1) we get,

$$\frac{1}{10^{-6}}i(t)-10\frac{di(t)}{dt}-\frac{d^2i(t)}{dt^2}=0.$$

at $t=0^+$

$$\frac{d^2i(0^+)}{dt^2}=\frac{10\,di(0^+)}{dt}-\frac{1}{10^{-6}}i(0^+).$$

$$\frac{d^2i(0^+)}{dt^2}=10\times(-20)-\frac{1}{10^{-6}}\times2.=200000002\,A/s^2$$

32 :

Q7). State and Prove Initial value theorem and final value theorem.

statement : Initial value theorem.

If f(t) and f'(t) are laplace transformable, then, the the behaviour of f(t) in the neighbourhood of $t=0^-$, corresponds to the behaviour of F(S), in the neighbourhood of $S=\infty$.

i.e. $f(0^-) = \underset{t\to 0}{Lt}\, f(t) = \underset{s\to\infty}{Lt}\, sF(s)$

Proof: W.K.T, $\mathcal{L}[f'(t)] = sF(s) - f(0^-)$

i.e. $\int_{0^-}^{\infty} f'(t)e^{-st}\,dt = sF(s) - f(0^-)$

i.e. $\underset{s\to\infty}{Lt} \int_{0^-}^{\infty} f'(t)e^{-st}\,dt = \underset{s\to\infty}{Lt}[sF(s) - f(0^-)]$

i.e. $0 = \underset{s\to\infty}{Lt}[sF(s) - f(0^-)]$ $\because \underset{s\to\infty}{Lt}\, e^{-st} = 0.$

$\therefore f(0^-) = \underset{s\to\infty}{Lt}\, sF(s).$

Final value theorem statement:

If f(t) and f'(t) are laplace transformable, then the behaviour of f(t) in the neighbourhood of $t=\infty$, corresponds to the behaviour of sF(s) in the neighbourhood of $s=0$.

i.e. $f(\infty) = \underset{t\to\infty}{Lt}\, f(t) = \underset{s\to 0}{Lt}\, sF(s).$

Proof: W.K.t $\mathcal{L}[f'(t)] = sF(s) - f(0^-)$.

i.e. $\int_{0^-}^{\infty} f'(t)e^{-st}\,dt = sF(s) - f(0^-)$.

$$\lim_{s \to 0} \int_{0^-}^{\infty} f'(t) e^{-st} dt = \lim_{s \to 0} [sF(s) - f(0^-)]$$ but $\lim_{s \to \infty} e^{-st} = 0$. 35

$$\therefore \int_{0^-}^{\infty} f'(t)\, dt = \lim_{s \to 0} [sF(s) - f(0^-)]$$

i.e. $$\lim_{t \to \infty} \int_{0^-}^{t} f'(t)\, dt = \lim_{s \to 0} [sF(s) - f(0^-)]$$

i.e. $$\lim_{t \to \infty} [f(t)]_{0^-}^{t} = \lim_{s \to 0} [sF(s) - f(0^-)]$$

i.e. $$\lim_{t \to \infty} [f(t) - f(0^-)] = \lim_{s \to 0} [sF(s) - f(0^-)]$$

$$\therefore f(\infty) - f(0^-) = \lim_{s \to 0} sF(s) - f(0^-)$$

$$\therefore f(\infty) = \lim_{s \to 0} sF(s).$$

Q. Define Z-parameters and obtain relation betn Z and Y parameters.

0/2 Z-parameters: These are also called open ckt parameters. Z-parameters are defined by,

$$V_1 = Z_{11} I_1 + Z_{12} I_2$$

$$V_2 = Z_{21} I_1 + Z_{22} I_2.$$

By putting $I_1 = 0$ & $I_2 = 0$, we get

$$Z_{11} = \left.\frac{V_1}{I_1}\right|_{I_2=0} \qquad Z_{22} = \left.\frac{V_2}{I_2}\right|_{I_1=0}$$

$$Z_{12} = \left.\frac{V_1}{I_2}\right|_{I_1=0} \qquad Z_{21} = \left.\frac{V_2}{I_1}\right|_{I_2=0}.$$

Relation betn Z and Y Parameters.

$I_1 = Y_{11}V_1 + Y_{12}V_2$ — ① $V_1 = Z_{11}I_1 + Z_{12}I_2$ — ③

$I_2 = Y_{21}V_1 + Y_{22}V_2$ — ② $V_2 = Z_{21}I_1 + Z_{22}I_2$ — ④

Substituting for V_2 from ② in ① we get,

$$I_1 = Y_{11}V_1 + Y_{12}\left[\frac{I_2 - Y_{21}V_1}{Y_{22}}\right] = V_1\left[Y_{11} - \frac{Y_{12}Y_{21}}{Y_{22}}\right] + \frac{Y_{12}}{Y_{22}}I_2$$

$$\therefore V_1 = \frac{Y_{22}}{Y_{11}Y_{22} - Y_{12}Y_{21}}I_1 - \frac{Y_{12}}{Y_{11}Y_{22} - Y_{12}Y_{21}}I_2$$

Comparing this eqn with eqn ③ we get,

$$Z_{11} = \frac{Y_{22}}{\Delta y} \quad \& \quad Z_{12} = -\frac{Y_{12}}{\Delta y}.$$

Substituting for V_1 from ② in ① we get,

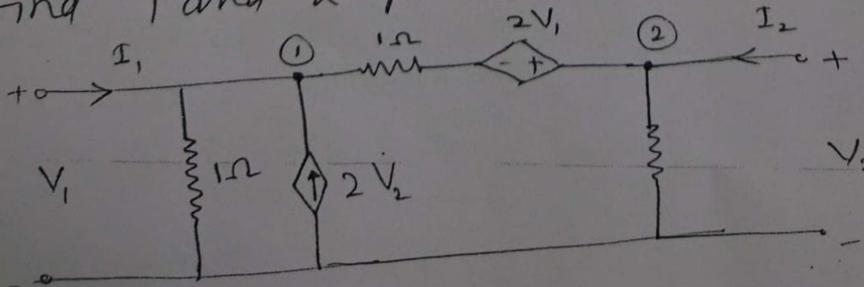
$$I_1 = Y_{11}\left[\frac{I_2 - Y_{22}V_2}{Y_{21}}\right] + Y_{12}V_2 \quad \text{or}$$

$$V_2 = -\frac{Y_{21}}{Y_{11}Y_{22} - Y_{12}Y_{21}}I_1 + \frac{Y_{11}}{Y_{11}Y_{22} - Y_{12}Y_{21}}I_2$$

Comparing this with eqn ④ we get

$$Z_{21} = \frac{-Y_{21}}{\Delta y} \quad \& \quad Z_{22} = \frac{Y_{11}}{\Delta y}.$$

38 b). Find Y and Z-parameters

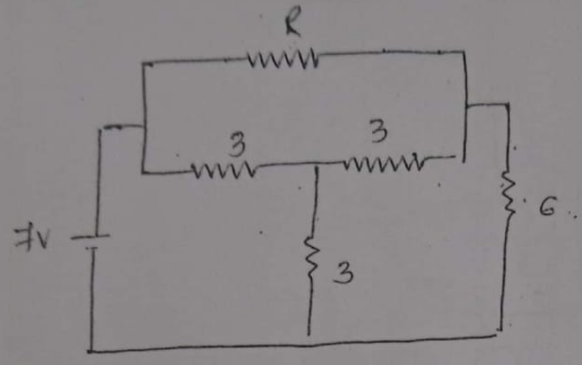


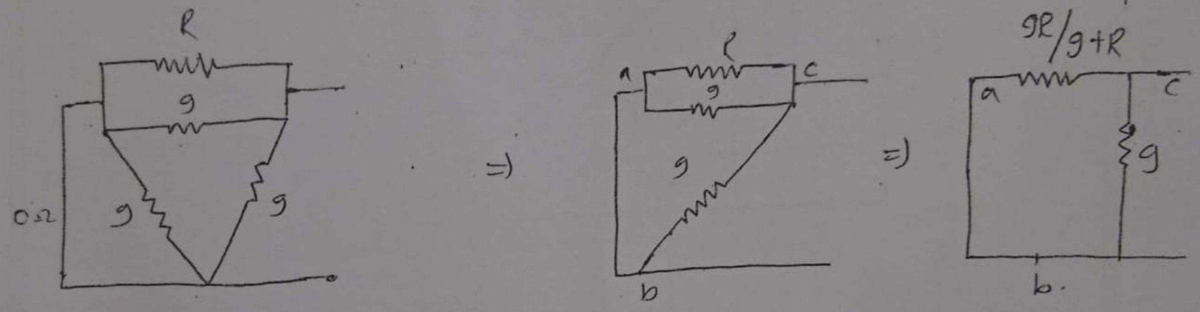
Dec 2014 / Jan 2015

Network Analysis.

10ES34

1) Determine the value of R, so that max power is consumed by $6\,\Omega$ resistor





$9 \| R$

$$\Rightarrow \frac{\frac{9R}{9+R} \times 9}{\frac{9R}{9+R} + 9} = 6$$

$$\Rightarrow \frac{\frac{81R}{\cancel{9+R}}}{\frac{9R+9(9+R)}{\cancel{9+R}}} = 6$$

$$\Rightarrow \frac{81R}{9R+81+9R} = 6$$

$$\Rightarrow 81R / 18R+81 = 6$$

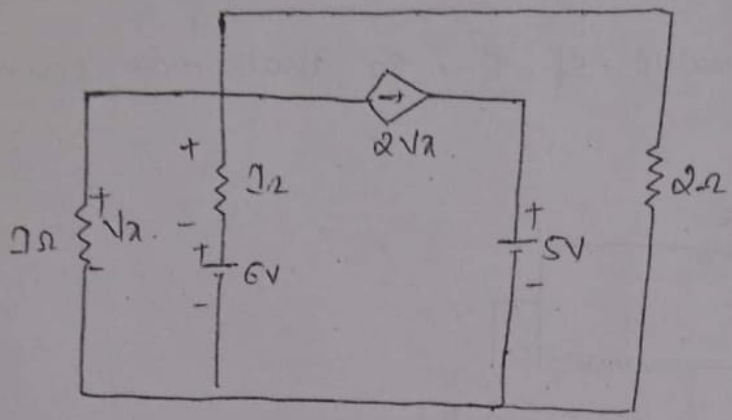
$81R = 6(18R+81)$

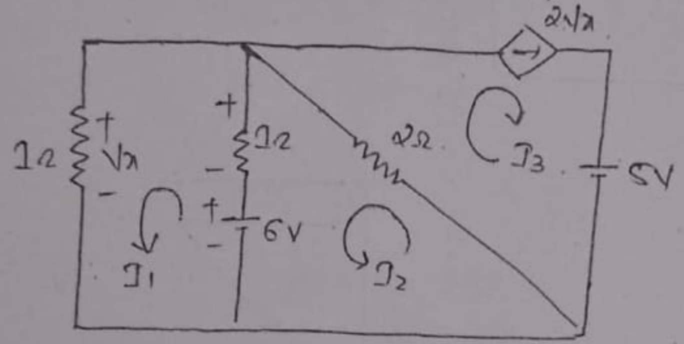
$81R = 108R + 486$

$27R = 486$

$\boxed{R = -18\,\Omega}$

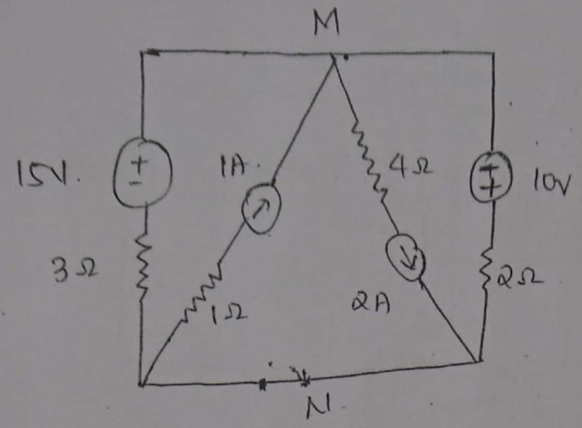
Find V_x using Mesh Analysis.



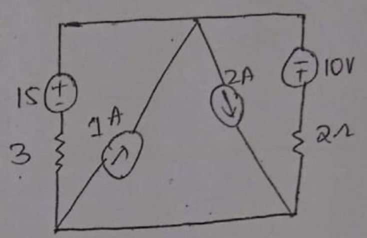


2a

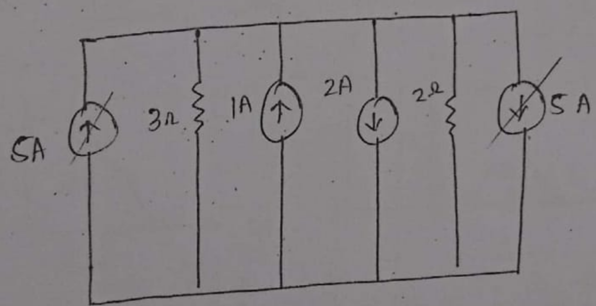
Find Potential difference between points M and N



false condition



Hence neglecting resistance



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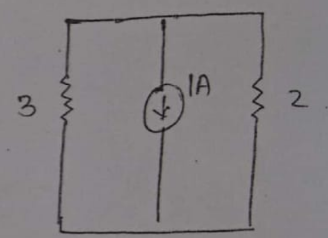
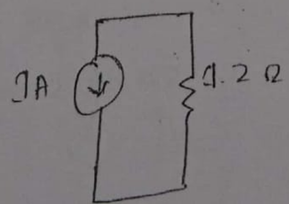


$3 \| 2 = 1.2\ \Omega$



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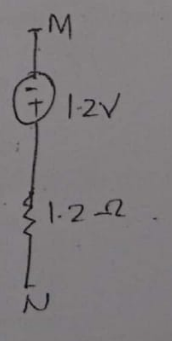
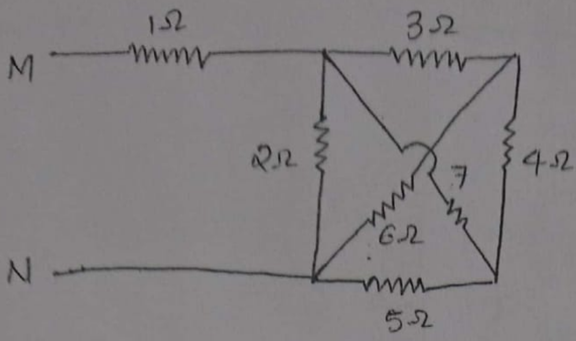
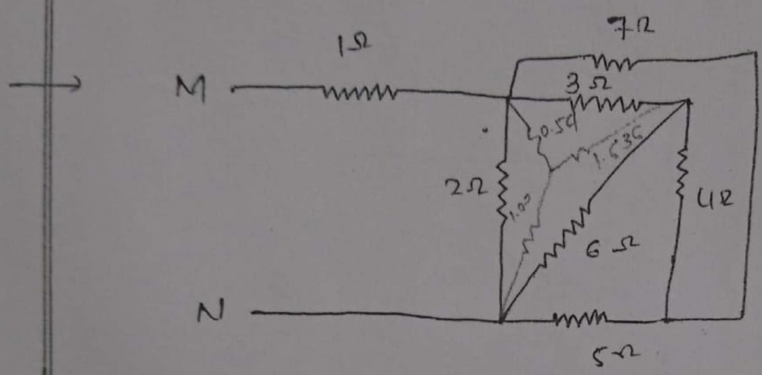


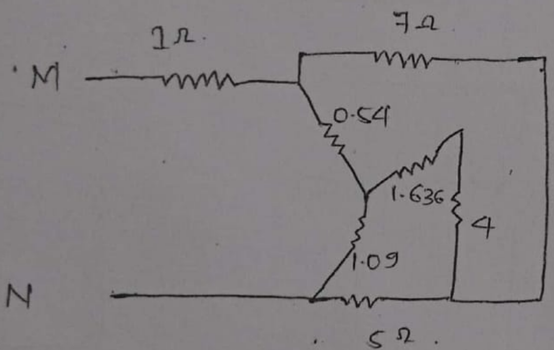
Hence the potential difference b/w M & N

$V_{MN} = -1.2V$

b find equivalent resistance between M and N.







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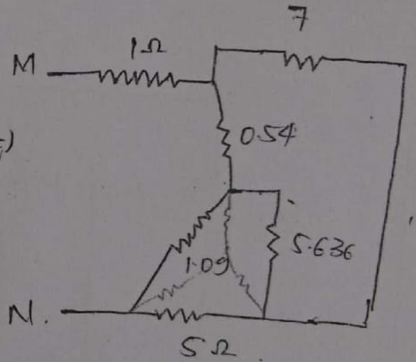

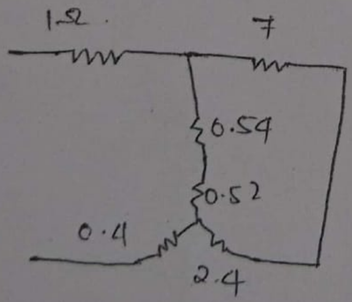

$7 + 2.4 = 9.4.$

$0.54 + 0.52 = 1.06.$

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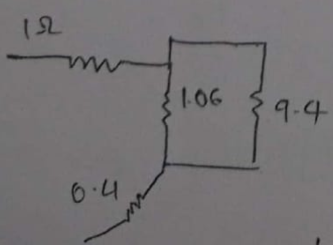

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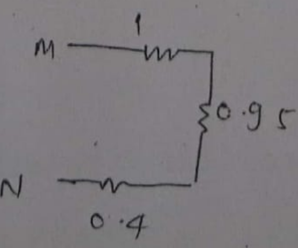
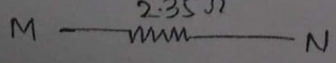
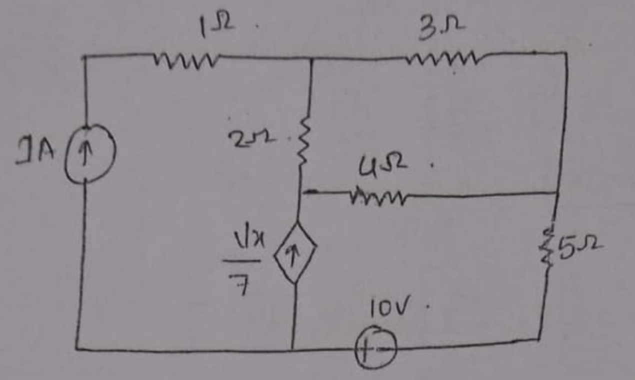
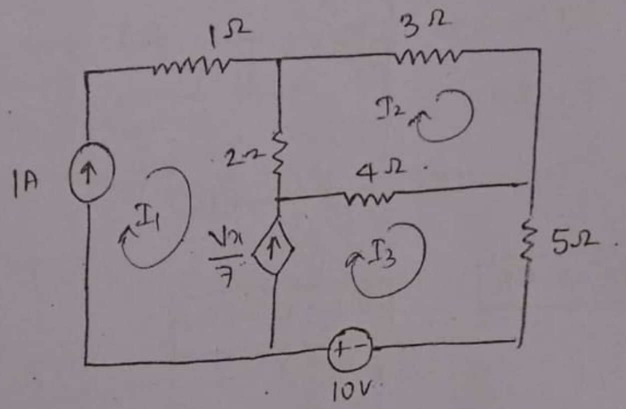


$1 + 0.95 + 0.4 = 2.35\Omega$

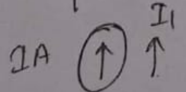


Find the power supplied by 10V source using mesh Analysis.



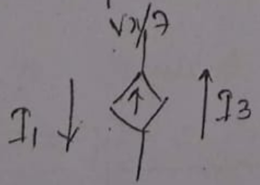


Equation for 1A c/n source

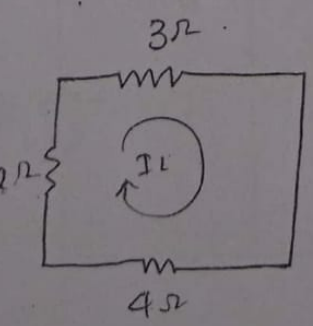


$\therefore \boxed{I_1 = 1A} \longrightarrow (1)$

Equation for $Vx/7$ c/n source.



$$\frac{Vx}{7} = I_3 - I_1 \longrightarrow (2)$$



KVL to mesh-2.

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

$-3I_2 - 4I_2 + 4I_3 - 2I_2 + 2I_1 = 0$

$-9I_2 + 2I_1 + 4I_3 = 0$

$\therefore \quad 9I_2 - 4I_3 = 2 \longrightarrow (3) \qquad \because I_1 = 1A$

$V_x = 4(I_2 - I_3)$

$$\frac{4(I_2 - I_3)}{7} = I_3 - I_1$$

$4I_2 - 4I_3 = 7I_3 - 7I_1$

$4I_2 - 4I_3 - 7I_3 + 7I_1 = 0$

$7I_1 + 4I_2 - 11I_3 = 0 \longrightarrow (4)$

$I_1 = 7A$

$\therefore \quad 4I_2 - 11I_3 = -7 \longrightarrow (5)$

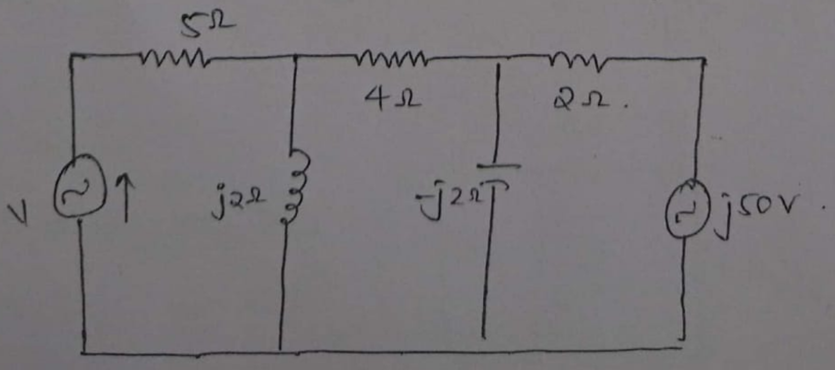
$\therefore \quad \boxed{I_2 = 0.6A} \qquad \boxed{I_3 = 0.855A}$

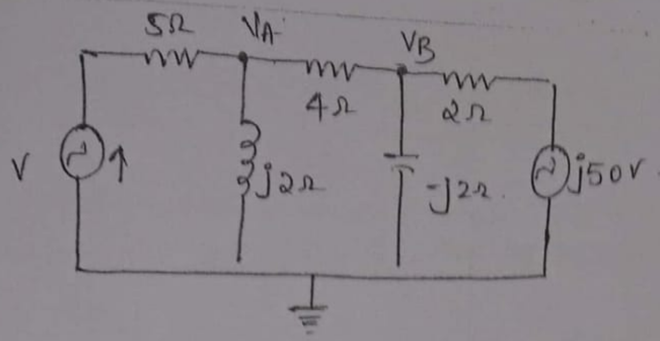
$P = V I_3$

$P = 10 \times 0.85$

$\boxed{P = 8.5W}$

d Find the magnitude of source voltage, so that current through 4Ω is 0. Using Node Analysis.





$$I = \frac{V_A - V_B}{4} = 0.$$

$$\therefore \boxed{V_A = V_B}$$

KCL at Node A.

$$V_A\left[\frac{1}{5} + \frac{1}{4} + \frac{1}{j2}\right] - \frac{V_B}{4} - \frac{V}{5} = 0.$$

$$V_A\,[0.45 - 0.5j] - 0.25V_A - 0.2V = 0 \qquad \because V_A = V_B$$

$$V_A\,[0.45 - 0.5j - 0.25] - 0.2V = 0.$$

$$V_A\,[0.2 - 0.5j] = 0.2V \longrightarrow (1)$$

KCL at Node B.

$$V_B\left[\frac{1}{2} + \frac{1}{4} - \frac{1}{2j}\right] - \frac{V_A}{4} - \frac{j50}{2} = 0.$$

$$V_B\,[0.75 + 0.5j] - 0.25V_A - 25j = 0.$$

$$V_B\,[0.75 - 0.25 + 0.5j] = 25j$$

$$V_B\,[0.5 + 0.5j] = 25j$$

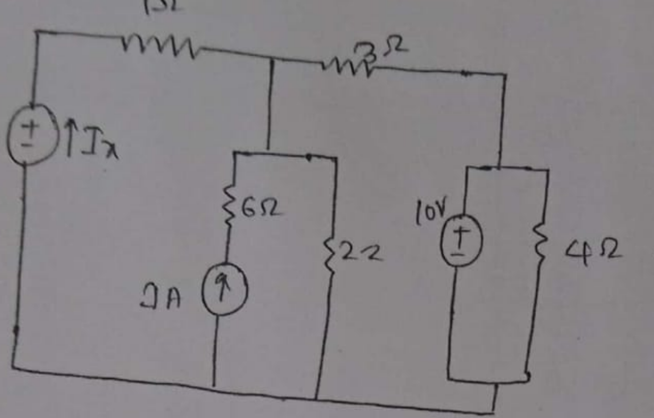
$$V_B = \frac{25j}{(0.5 + 0.5j)} = \frac{25\angle 90}{0.707\angle 45} = 35.36\angle 45.$$

$$\therefore 35.36\angle 45\,(0.2 - 0.5j) = 0.2V$$

$$V = \frac{35.36\angle 45\,(0.538\angle -68.1)}{0.2} = \frac{19.02\angle 73.1}{0.2}$$

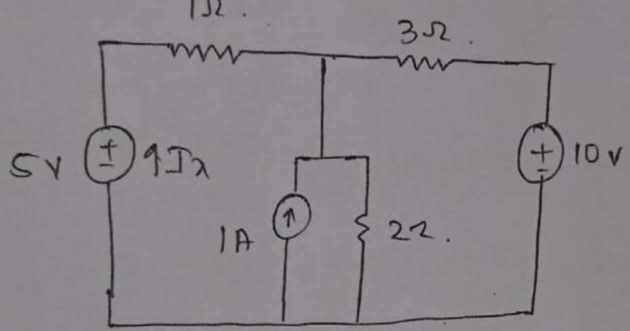
$$\boxed{V = 95.1 \angle -23.1 \text{ V}}$$

3a Use Superposition Theorem to find I_x.

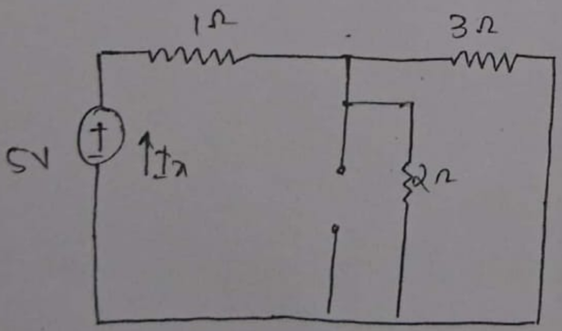


(false condition)

→)



* 5V Source acting alone.



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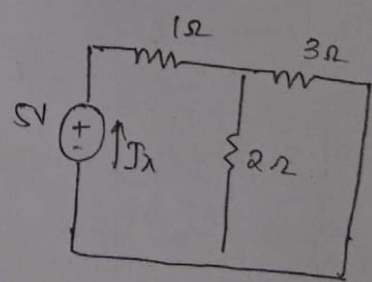

$3 \parallel 2 = 6/5 = 1.2\,\Omega$.

$R_{eq} = \underline{\underline{1.2 + 1 = 2.2\,\Omega}}$ ⇒ Equivalent Resistance.

$\therefore \quad I_x' = \dfrac{5V}{2.2} = 2.27\,A$

$$\boxed{I_x' = 2.27A}$$

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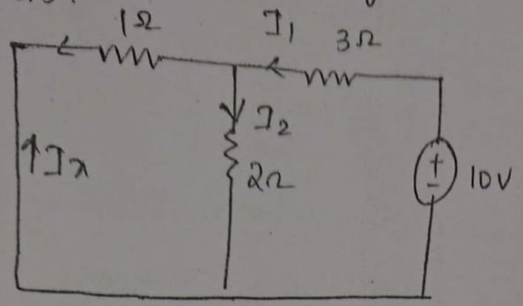
10 V source acting alone



$2 \parallel 1 = 0.66\ \Omega$.

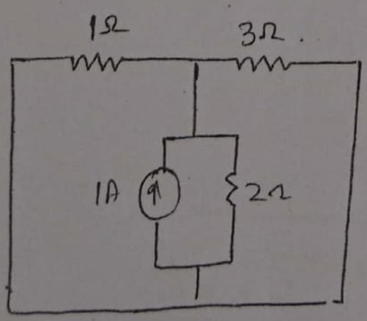
$R_{equ} = \underline{\underline{0.66 + 3 = 3.66\ \Omega}}$

$I_1'' = \frac{10}{3.66} = 2.732\ A$.

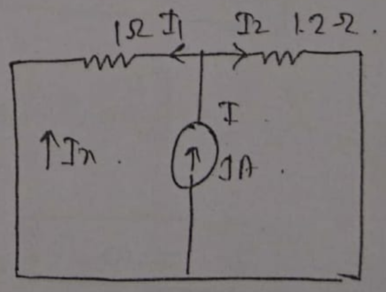
$\therefore\ I_x'' = -\left(\frac{I_1 \times 2}{1+2}\right) = -1.82133\ A$.

$\boxed{I_x'' = -1.8213\ A}$

1A current source acting alone.



$\Rightarrow$



$3 \parallel 2 = 1.2\ \Omega$.

$I_x''' = -I_1$

$I_x''' = \frac{1.2 \times 1}{1.2 + 1} = 0.54$

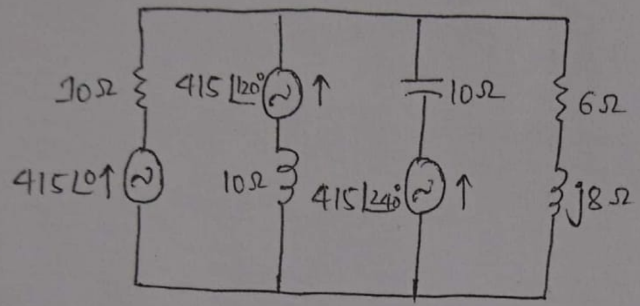
$\boxed{I_x''' = -0.54\ A}$

$\therefore \quad I_x = I_x' + I_x'' + I_x'''$

i.e., $I_x = 2.27 - 1.892 - 0.54$

$\boxed{I_x = -0.091A}$

b find the current I using Millman's Theorem



$$E = \frac{\left[\frac{415\angle 0^\circ}{10\Omega} + \frac{415\angle 120}{j10\Omega} + \frac{415\angle 240}{-j10\Omega}\right]}{\left[\frac{1}{10} + \frac{1}{10j} - \frac{1}{10j}\right]}$$

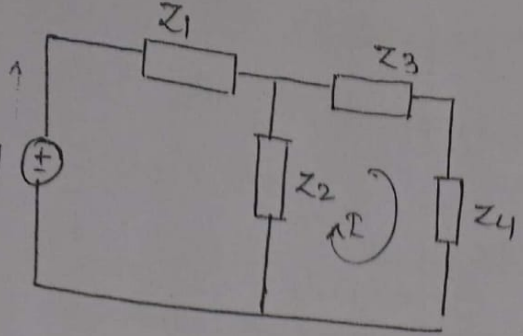
$\boxed{E = 1133.8V}$

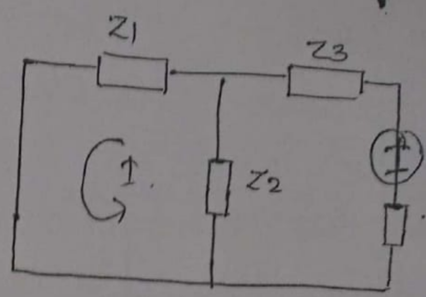
$$Z^{-1} = \frac{1}{Z} = \left[\frac{1}{10} + \frac{1}{10j} - \frac{1}{10j}\right]$$

$\boxed{Z = 10\,\Omega}$

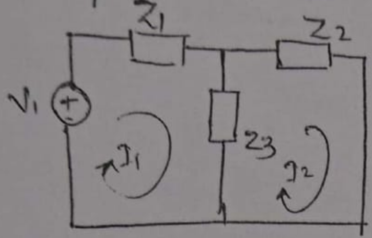
c State and Prove reciprocity Theorem

If any linear, bilateral network containing only one independent source, the ratio of excitation to response remain constant, when their positions are interchanged





Proof :- Consider the network as shown in fig below



Let us calculate the ratio V_1/I_2

Applying KVL to two loops

$$-I_1Z_1 - I_1Z_3 + I_2Z_3 + V_1 = 0.$$

$$\therefore I_1(Z_1+Z_3) - I_2Z_3 = V_1$$

$$\& \quad -I_2Z_2 - I_2Z_3 + I_1Z_3 = 0.$$

$$\therefore I_1Z_3 - I_2(Z_2+Z_3) = 0.$$

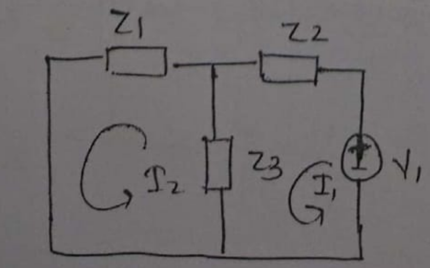
$$\Delta = \begin{vmatrix} Z_1+Z_2 & -Z_3 \\ +Z_3 & -Z_2-Z_3 \end{vmatrix} = Z_1Z_2 - Z_2Z_3 - Z_1Z_3.$$

$$\& \quad \Delta_2 = \begin{vmatrix} Z_1+Z_3 & V_1 \\ Z_3 & 0 \end{vmatrix} = -V_1Z_3.$$

$$I_2 = \frac{\Delta_2}{\Delta} = \frac{-V_1Z_3}{-(Z_1Z_2+Z_2Z_3+Z_1Z_3)}$$

$$\therefore \frac{V_1}{I_2} = \frac{Z_1Z_2+Z_2Z_3+Z_1Z_3}{Z_3} \longrightarrow (1)$$

Now let us interchange the position of V_1 & I_2



Applying KVL

$$-I_2Z_1 - I_2Z_3 + I_1Z_3 = 0$$

$$\therefore I_1Z_3 - I_2(Z_1+Z_3) = 0$$

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& $-I_1Z_2 - I_1Z_3 + I_2Z_3 + V_1 = 0$

$\therefore I_1(Z_2+Z_3) - I_2Z_3 = V_1$

$$\therefore \Delta = \begin{vmatrix} Z_3 & -Z_2-Z_3 \\ Z_2+Z_3 & -Z_3 \end{vmatrix} = Z_1Z_2 + Z_2Z_3 + Z_3Z_1$$

$$\Delta_2 = \begin{vmatrix} Z_3 & 0 \\ Z_2+Z_3 & V_1 \end{vmatrix} = Z_3V_1$$

$$\therefore I_2 = \frac{\Delta_2}{\Delta} = \frac{Z_3V_1}{Z_1Z_2+Z_2Z_3+Z_3Z_1}$$

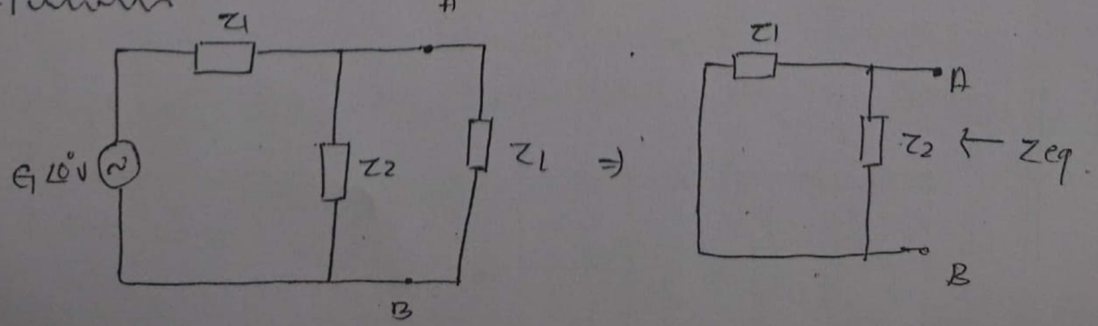
$$\therefore \frac{V_1}{I_2} = \frac{Z_1Z_2+Z_2Z_3+Z_3Z_1}{Z_3} \rightarrow (2)$$

equs (1) & (2) show that the ratio V/I remain same.

4a] State and explain maximum power Transfer Theorem when load impedance consisting of variable resistance and variable reactance.

→ The maximum power transfer theorem can be stated as, in an active ntw, maximum power transfer to the load takes place when the load impedance is the complex conjugate of an equivalent impedance of the network as viewed from the terminals of the load.

Explaination :-



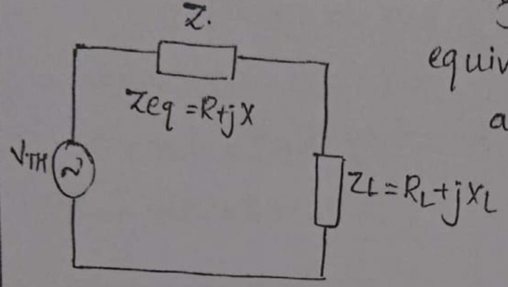
Let Z_{eq} be the equivalent impedance of the n/w as viewed from the terminals AB.

$\therefore Z_{eq} = R + jX$;

Then the maximum power will be transfered to the load, if Z_L is the complex conjugate of Z_{eq}.

$$\therefore \boxed{Z_L = Z^*_{eq} = R - jX}$$

Proof :- Let the given n/w is replaced by Thevinin's equivalent across the load terminals as shown in the fig.



Let $Z_{eq} = R + jX$.

& $Z_L = R_L + jX_L$

$\therefore I = V_{TH} / Z_{eq} + Z_L$.

$$I = \frac{V_{TH}}{R + jX_L + R_L + jX_L} = \frac{V_{TH}}{(R + R_L) + j(X + X_L)}$$

Power delievered to the load is $P_L = I^2 R_L$.

$$I = \frac{V_{TH}}{\sqrt{(R+R_L)^2 + (X+X_L)^2}} \qquad \therefore P_L = \frac{V^2_{TH}}{(R+R_L)^2 + (X+X_L)^2} \cdot R_L \rightarrow (1).$$

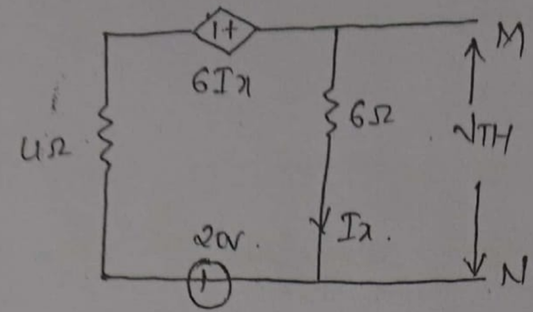
According to maximum Theorem we can write that for the maximum power transfer, with respect to variable X_L and fixed R_L.

$$\frac{\partial P_L}{\partial X_L} = 0.$$

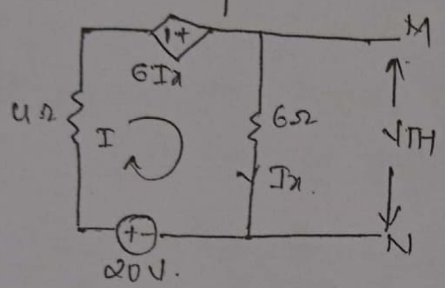
$$\therefore \frac{\partial}{\partial X_L}\left[\frac{V^2_{TH} R_L}{(R+R_L)^2 + (X+X_L)^2}\right] = 0.$$

$$\therefore \frac{-2 V^2_{TH} \cdot R_L (X + X_L)}{[(R+R_L)^2 + (X+X_L)^2]} = 0.$$

4 b] for the circuit shown below. Draw the Thevinin's equivalent circuit.



→ Calculation of VTH.



KVL to mesh-1.

$-4I + 6I_x - 6I + 20 = 0$

$-10I + 6I_x + 20 = 0$

$10I - 6I_x = 20 \longrightarrow (1)$

$10I - 6I = 20$

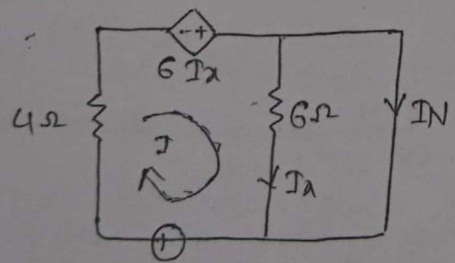
$4I = 20$

$\boxed{I = 5A}$

$\therefore \quad V_{TH} = V_{6\Omega}$

$= 6 \times 5$

$\boxed{V_{TH} = 30V}$



$-6(I - I_1) = 0$

$-6I + 6I_1 = 0$

$6I_1 - 6I = 0$

$-6(5) - 6I = 0$

$I = 5A$.

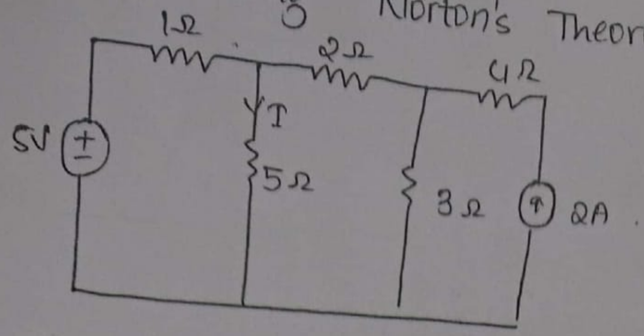
or $-4I_1 + 6\cancel{I_x} - 6\cancel{I_x} + 20 = 0$

$I_1 = 5A$

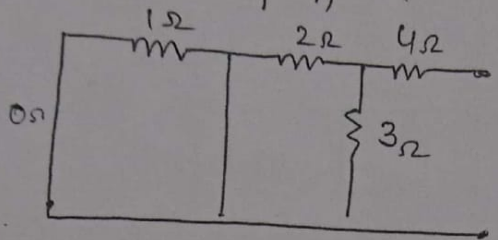
$I = I_N = 5A$.

$R_{TH} = \frac{V_{TH}}{I_N} = \frac{30}{5} = 6\,\Omega$.

c] Find I using Norton's Theorem.



→ Calculation of R_{NOR}



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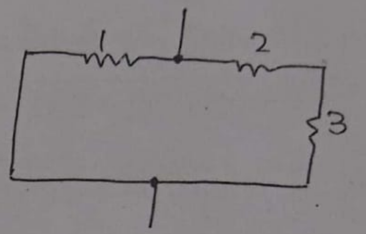
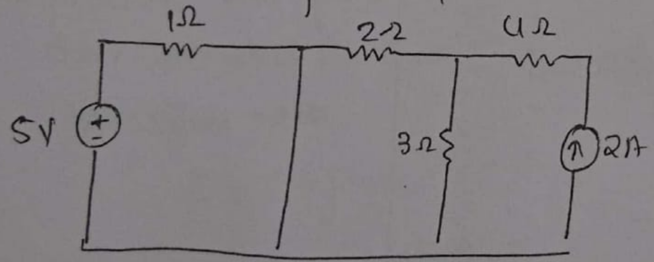


$3 \parallel 4 = \frac{3\times4}{3+4} = 1.714 A$

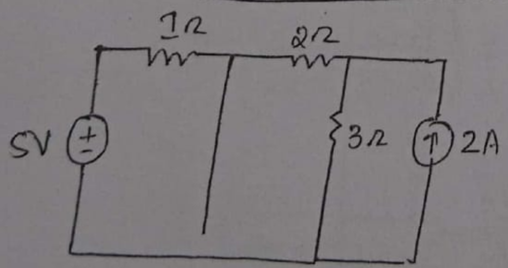
$3+2=5$

$R_{NOR} = \frac{5\times1}{5+1} = 0.833\,\Omega$

Calculation of I_{NOR}



(false condition)



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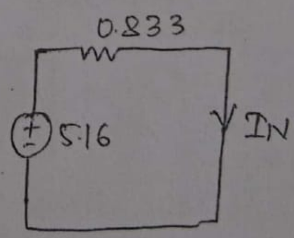

$I_N = \frac{5.16}{0.833}$ $\boxed{I_N = 6.2A}$

5a] What is resonance? Derive an expression for cut-off frequencies

→ Resonance is the phenomena which occurs in the ~~ex~~ ac ckt containing R, L & C elements in which voltage and current are in phase.

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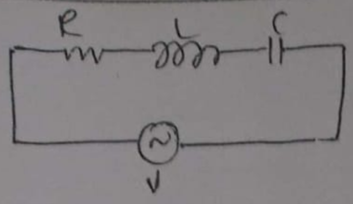
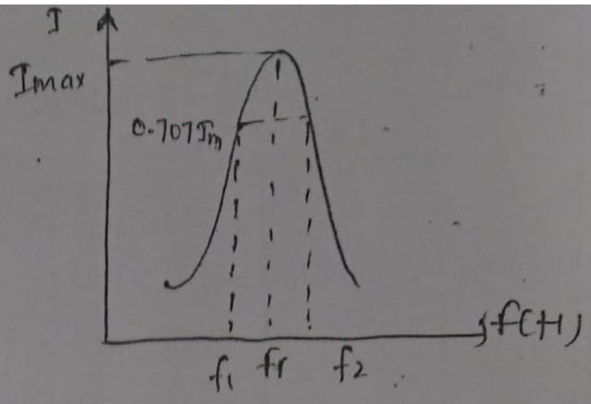




At f_1 & f_2 the cln is $I_m/\sqrt{2}$ and hence, the impedance is $\sqrt{2}$ times the value of impedance at f_r.

At $f=f_r$, $\boxed{Z_r = R}$ f_1 and f_2, $\boxed{Z=\sqrt{2}R}$

In General, impedance Z is

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

At f_1 & f_2, $\sqrt{2}R = \sqrt{R^2 + (X_L - X_C)^2}$

$$2R^2 = R^2 + (X_L - X_C)^2$$

$$R^2 = (X_L + X_C)^2$$

$$R = \pm (X_L + X_C)^2 \rightarrow (2)$$

At f_1 $X_C > X_L$ $\therefore$ equ (2) becomes

$$R = X_C - X_L \Rightarrow \frac{1}{\omega_1}C - \omega_1 L = R$$

$$R = \frac{1 - \omega_1^2 LC}{\omega_1 C} \Rightarrow \omega_1^2 LC + \omega_1 RC - 1 = 0$$

$$\omega_1^2 LC + \omega_1 R/L - 1/LC = 0$$

$$\therefore \omega_1 = \frac{-R}{2L} \pm \sqrt{(R/2L)^2 + 1/LC} \quad \because \text{By shridar Rule}$$

or $$f_1 = \frac{1}{2\pi}\left[-R/2L \pm \sqrt{(R/2L)^2 + 1/LC}\right]$$

At f_2 $X_L > X_C$, Hence equ (2) becomes

$$R = X_L - X_C = \omega_2 L - 1/\omega_2 C$$

$$R = \frac{\omega_1^2 LC - 1}{\omega_2 C} \Rightarrow \omega_2 RC = \omega_2^2 LC - 1$$

$$\omega_2^2 LC - \omega_2 RC + 1 = 0.$$

$$\therefore \omega_2 = \frac{R}{2L} \pm \sqrt{(R/2L)^2 + 1/LC} \quad \text{By shridar Rule.}$$

or $$f_2 = 1/2\pi\left[\frac{R}{2L} \pm \sqrt{(R/2L)^2 + 1/LC}\right]$$

Therefore,

$$f_1 = \frac{1}{2\pi}\left[-\frac{R}{2L} + \sqrt{\left(\frac{R}{2L}\right)^2 + \frac{1}{LC}}\right]$$

$$f_2 = \frac{1}{2\pi}\left[\frac{R}{2L} + \sqrt{(R/2L)^2 + 1/LC}\right]$$

Here we consider only one roots of f_1 & f_2 -ve roots are neglected.

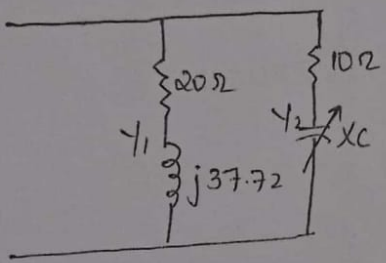
b] Calculate half power frequencies of series resonant circuit, where the resonance frequency is 150KHz, BW = 75KHz

Given :- BW = 75KHz   fr = 150KHz

$$f_1 = fr - \frac{BW}{2} \Rightarrow 150 - \frac{75}{2} = 112.5KHz$$

$$f_2 = fr + \frac{BW}{2} \Rightarrow 150 + \frac{75}{2} = 187.5KHz$$

c] for the circuit shown below. Find the values of capacitance for the resonance. Derive the formula used.



f = 50Hz.

$$Y = Y_1 + Y_2$$

Resonance occurs when $X_L = X_C$ or Imaginary terms must be zero.

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

$$Y = \left(\frac{1}{20 + j37.72}\right) + \left(\frac{1}{10 - jX_C}\right)$$

$$Y = \left(\frac{1}{20 + j37.72} \times \frac{20 - j37.72}{20 - j37.72}\right) + \left(\frac{1}{10 - jX_C} \times \frac{10 + jX_C}{10 + jX_C}\right)$$

$$Y = \frac{20 - j37.72}{(20^2 + 37.72^2)} + \frac{10 + jX_C}{(10^2 + X_C^2)}$$

$$Y = \frac{20}{20^2 + 37.72^2} + \frac{10}{10^2 + X_C^2} + j\left[\frac{X_C}{10^2 + X_C^2} - \frac{37.72}{20^2 + 37.72^2}\right]$$

At Resonance imaginary term = 0

$$\frac{X_C}{10^2+X_C^2} = \frac{37.72}{20^2+37.72}$$

$$10^2 \times 37.72 + 37.72 X_C^2 = 20^2 X_C + X_C\, 37.72$$

$$3772 + 37.72 X_C^2 = 400 X_C + 37.72 X_C$$

$$3772 + 37.72 X_C^2 - 437.72 X_C$$

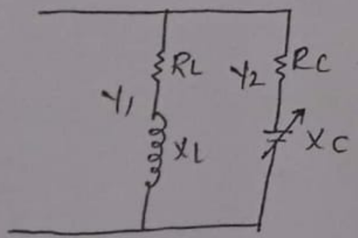
$$\boxed{X_C = 46.14\Omega} \qquad \boxed{X_C = 2.16\Omega}$$

$$X_C = \frac{1}{2\pi f c}$$

$$C = 1/2\pi X_C = 1/2\pi \times 46.1$$

$$C = 67\mu F \quad \& \quad C = 1.46\mu F.$$

Derivation



$$Y = Y_1 + Y_2$$

$$Y = \frac{1}{R_L + jX_L} + \frac{1}{R_C - jX_C}$$

$$Y = \frac{R_L - jX_L}{R_L^2 - X_L^2} + \frac{R_C + jX_C}{R_C^2 - X_C^2}$$

$$Y = \left[\frac{R_L}{R_L^2 - X_L^2} + \frac{R_C}{R_C^2 - X_C^2}\right] + j\left[\frac{X_C}{R_C^2 - X_C^2} - \frac{X_L}{R_L^2 - X_L^2}\right]$$

At Resonance imaginary terms are zero.

$$\frac{X_C}{R_C^2 + X_C^2} = \frac{X_L}{R_L^2 + X_L^2}$$

$$X_C(R_L^2 + X_L^2) = X_L(R_C^2 + X_C^2)$$

$$X_C R_L^2 + X_L^2 X_C = X_L R_C^2 + X_L X_C^2$$

$$X_C R_L^2 + X_L^2 X_C - X_L R_C^2 - X_L X_C^2 = 0$$

$$-X_L X_C^2 + X_C R_L^2 + X_L^2 X_C - X_L R_C^2 = 0$$

$$X_L X_C^2 - X_C (R_L^2 + X_L^2) + X_L R_C^2 = 0$$

$$X_C = \frac{(R_L^2 + X_L^2) \pm \sqrt{(R_L^2 + X_L^2)^2 - 4(-X_L)(-\cancel{X_L} - R_C)}}{2 \times (+X_L)}$$

$$X_C = \frac{(R_L^2 + X_L)^2 \pm \sqrt{(R_L^2 + X_L^2)^2 - 4X_L^2 R_C^2}}{2X_L}$$

8a Obtain transmission parameters in terms of hybrid Parameters

$$V_1 = h_{11} I_1 + h_{12} V_2 \longrightarrow (1)$$

$$I_2 = h_{21} I_1 + h_{22} V_2 \longrightarrow (2)$$

$$V_1 = AV_2 - BI_2 \longrightarrow (3)$$

$$I_1 = CV_2 - DI_2 \longrightarrow (4)$$

Substitute I_2 equ(2) in (1)

$$I_1 = \frac{I_2 - h_{22}V_2}{h_{21}}$$

$$V_1 = h_{11}\left[\frac{I_2 - h_{22}V_2}{h_{21}}\right] + h_{12}V_2$$

$$V_1 = \frac{h_{11}}{h_{21}} I_2 - \frac{h_{11}}{h_{21}} h_{22}V_2 + h_{12}V_2$$

$$V_1 = \frac{h_{11}}{h_{21}} I_2 - V_2\left[\frac{h_{11}h_{22}}{h_{21}} - h_{12}\right]$$

$$V_1 = \frac{h_{11}}{h_{21}} I_2 - \left[\frac{h_{11}h_{22} - h_{12}h_{21}}{h_{21}}\right] V_2$$

$$V_1 = \frac{h_{11}}{h_{21}} I_2 - \frac{\Delta h}{h_{21}} V_2$$

$$V_1 = \frac{-\Delta h}{h_{21}} + \frac{h_{11}}{h_{21}} I_2 \longrightarrow (5)$$

comparing equ (3) & (5)

$$A = \frac{\Delta h}{h_{21}} \qquad B = -\frac{h_{11}}{h_{21}}$$

Here $\Delta h = h_{11}h_{22} - h_{21}h_{12}$

from equ(2)

$I_2 = h_{21} I_1 + h_{22} V_2$

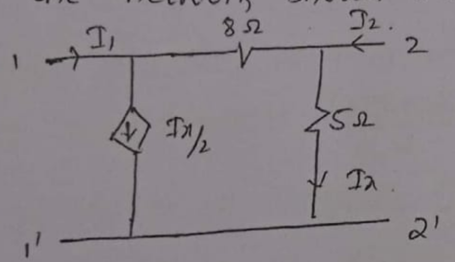
$$I_1 = \frac{I_2 - h_{22} V_2}{h_{21}}$$

$$I_1 = \frac{I_2}{h_{21}} - \frac{h_{22}}{h_{21}} V_2 \longrightarrow (6)$$

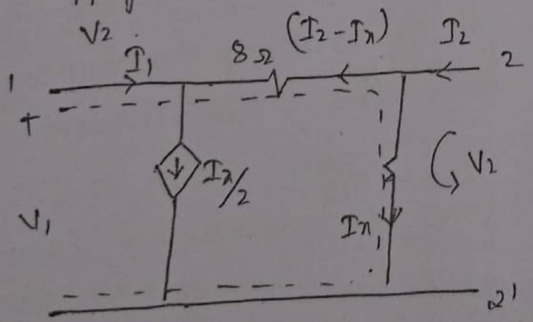
compare (6) & (4)

$C = 1/h_{21}$ $D = \frac{h_{22}}{h_{21}}$.

5] For the network shown below. find Z-Parameters



→ Apply KVL including V_1 and another KVL equ including V_2.



KVL to loop - I eliminating $I_x/2$.

$-V_1 - 8(I_1 - I_x) + 5I_x = 0.$

$-V_1 - 8I_1 + 8I_x + 5I_x = 0.$

$-V_1 - 8I_1 + 13I_x = 0$.

$V_1 = -8I_1 + 13I_x$.

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$I_\lambda/2$

$I_1 \downarrow \; \diamond \; \downarrow I_2 - I_\lambda$ $\qquad$ $\frac{I_\lambda}{2} = I_1 + I_2 - I_\lambda$.

$$I_\lambda = 2I_1 + 2I_2 - 2I_\lambda$$

$$3I_\lambda = 2I_1 + 2I_2$$

$$I_\lambda = \frac{2I_1 + 2I_2}{3}$$

$$V_1 = -8I_1 + \frac{13}{3}(2I_1 + 2I_2)$$

$$V_1 = -8I_1 + \frac{26}{3}I_1 + \frac{26}{3}I_2$$

$$V_1 = \frac{2}{3}I_1 + \frac{26}{3}I_1 \longrightarrow ①$$

$$V_2 = 5I_\lambda = 5\frac{(2I_1 + 2I_2)}{3}$$

$$V_2 = \frac{10I_1}{3} + \frac{10I_2}{3} \longrightarrow ②$$

from ① & ②

$Z_{11} = 2/3$ $\qquad$ $Z_{12} = 26/3$

$Z_{21} = 10/3$ $\qquad$ $Z_{22} = 10/3$.

c] following short circuit currents and voltage are obtained experimentaly for a two port network.

(i) with output short circuted ; $I_1 = 5mA$

$I_2 = 0.3mA$ & $V_1 = 25V$

(ii) with input short circuited ; $I_1 = -5mA$

$I_2 = 10mA$ $\quad$ $V_2 = 30V$.

Determine Y Parameters

$Y_{11} = I_1/V_1$ $Y_{12} = I_1/V_2$ $Y_{21} = I_2/V_1$ $Y_{22} = I_2/V_2$

$$Y_{11} = \frac{I_1}{V_1}\bigg|_{V_2=0} \qquad Y_{21} = \frac{I_2}{V_1}\bigg|_{V_2=0}$$

$$Y_{11} = \frac{5m}{25} = 0.2m\mho \qquad Y_{21} = \frac{-5m}{25} = -0.2m\mho$$

$$Y_{12} = \frac{I_1}{V_2}\bigg|_{V_1} = 0 \qquad Y_{22} = \frac{I_2}{V_2}\bigg|_{V_1=0}.$$

$$Y_{12} = 5/30 = 0.16m\mho \qquad Y_{22} = 10m/30 = 0.33m\mho.$$

2a Explain element - node incidence matrix with example. List the properties of element node incidence matrix.

Properties :- * Elements of column = zero

* Determinant of elements of a closed loop is zero

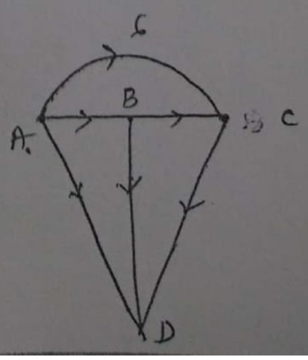
Incidence Matrix :- The incidence Matrix translates all the geometrical features of the graph into an algebraic expression. An incidence matrix is define to have an element A_{ij} in which column 'i' corresponds to number of nodes, row 'j' corresponds to number of branches, the elements are either +1 or -1.

If the orientation of branch j is away from node (i) then the element is +1, if the orientation of branch 'j' is toward node 'i' then the element is -1 and if branch 'j' doesnot touch the node 'i' then element is zero.

Ex:-

Nodes	1	2	3	4	5	6
A	1	1	0	0	0	1
B	-1	0	1	1	0	0
C	0	0	0	-1	1	-1
D	0	-1	-1	0	-1	0

Branches



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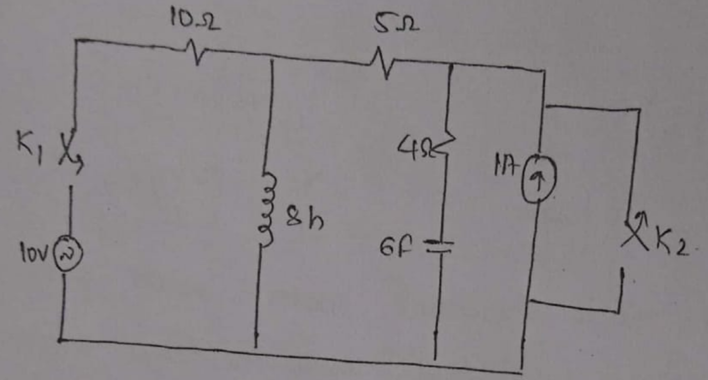
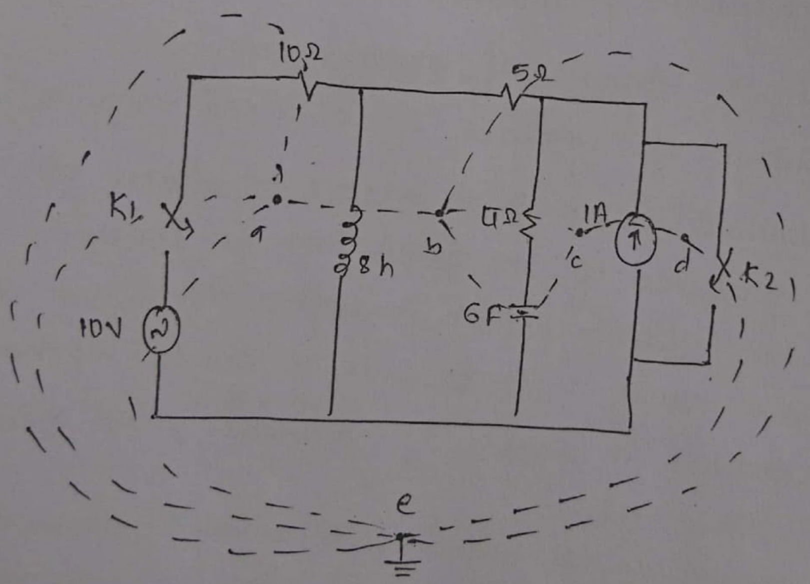
2c]

Write KVL equation for the network shown. Draw the dual of this and write KCL equation and show that these two networks are dual.



→)



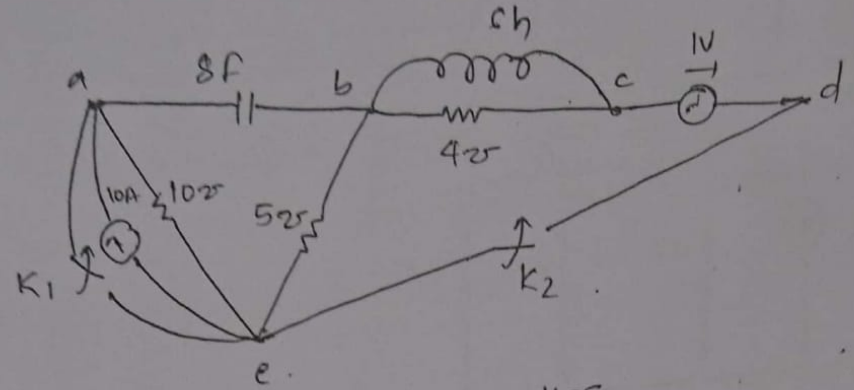
$$10 - 10i_1 - 8\frac{d}{dt}(i_1 - i_2) = 0.$$

$$10 + 8\frac{d}{dt}(i_1 - i_2) = 10 \longrightarrow (1)$$

$$-5i_2 - 4(i_2 - i_3) - \frac{1}{6}\int(i_2 - i_3)\,dt - 8\frac{d}{dt}(i_2 - i_1) = 0$$

$$5i_2 + 4(i_2 - i_3) + \frac{1}{6}\int (i_2 - i_3)\,dt + 8\frac{d}{dt}(i_2 - i_1) = 0 \rightarrow (2)$$

$$i_3 = -1A \rightarrow (3)$$



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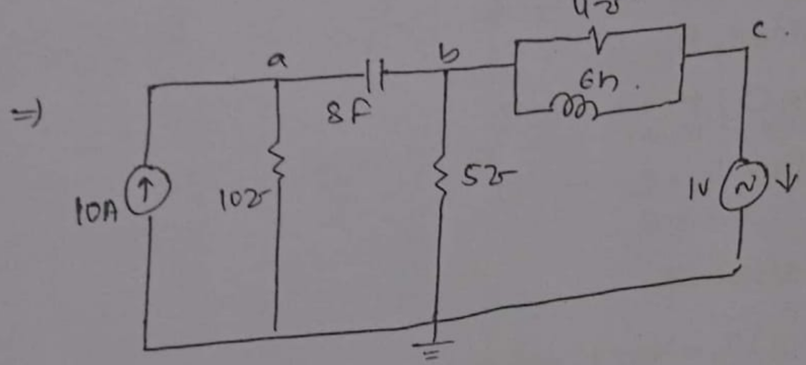


At Node a.

$$-10 + 10V_a + 8\frac{d}{dt}(V_a - V_b) = 0.$$

$$10V_a + 8\frac{d}{dt}(V_a - V_b) = 10 \longrightarrow (4)$$

At Node b.

$$8\frac{d}{dt}(V_a - V_b) + 5V_a + 4(V_b - V_c) + \frac{1}{6}\int (V_b - V_c) = 0.$$

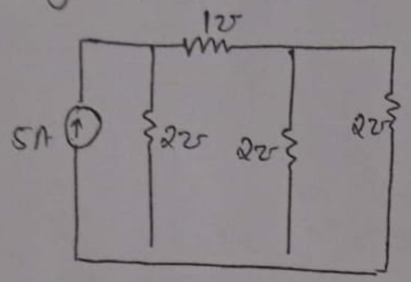
At Node c.

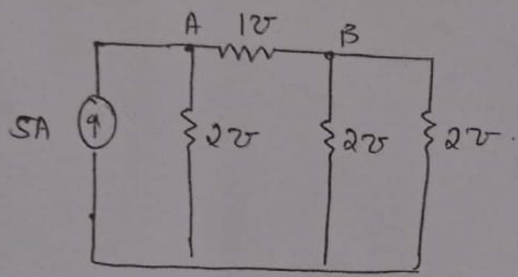
$$V_c + 0 = -1.$$

$$\therefore V_c = -1V \longrightarrow (3)$$

By observing the KVL and KCL of the networks (1) & (2) it is proved that the two networks are dual.

2b] For the network shown. Determine branch voltages. On voltage basis





At Node A,

$5 = V_A(2) + (V_A - V_B)1$

$3V_A - V_B = 5 \longrightarrow (1)$

At Node B,

$(V_A - V_B)1 = V_B(2) + V_B(2)$

$V_A - V_B = 2V_B + 2V_B$.

$V_A - 5V_B = 0 \longrightarrow (2)$

solving (1) & (2)

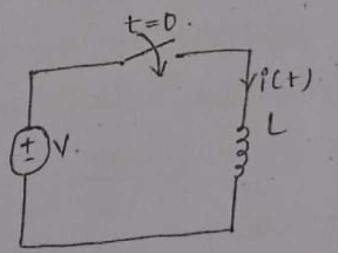
$V_A = 1.785\ V$

$V_B = 0.3571 V$

6a] What is the initial and final condition? Explain the behaviour of R, L and C for the initial condition.

→ Resistance :- The cause - effect relation for an ideal resistor is given by $V = Ri$, from this equation, we find that the current through a resistor will change instantaneously. Similarly, voltage also will change instantaneously, if current changes instantaneously.

* Inductors :- The switch is closed at $t=0$, Hence $t=0$ corresponds. To the instant when the switch is just open at $t=0^+$ corresponds to the instant when the switch is just closed.



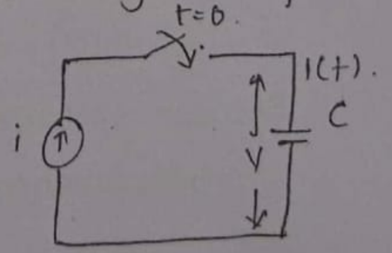
current through inductor is given by,

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

* Capacitors :- The switch is closed at $t=0$. Hence $t=0$ corresponds to the instant when the switches is just open at $t=0^+$ corresponding to the instant when the switch is just closed.

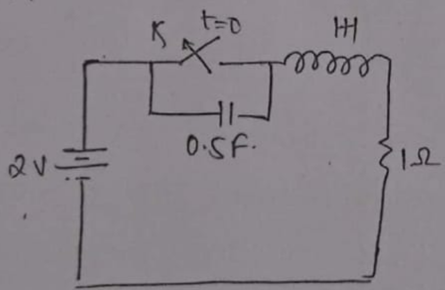
Voltage across capacitor is given by

$$V = \frac{1}{C}\int_{-\infty}^{t} i\,dt$$



Condition of element $t=0^-$ (Inital)	Condition of element $t=0^+$	condition of element at $t=\infty$ (final)
R	R	R
L No c/n	O.C	S.C
L $\rightarrow I_0$	I_0	S.C I_0
C	SC	O C.
C $-q_0+$	$V_0 = q_0/C$	O.C $V_0 = q_0/C$

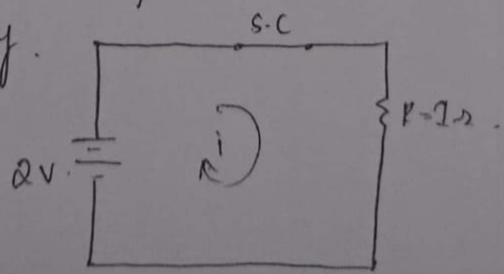
b] $R=1\Omega$, $L=1H$ and $C=1/2F$ are in series with a swith across C 2V is applied to the circuit. At $t=0^-$. The switch is in closed position. At $t=0$ the switch is opened. find at $t=0^+$, the voltage across the switch, its first



At $t=0^-$, switch K is closed, Thus shorting capacitor branch

ie, $V_C(0^-) = 0V = V_C(0^+) \rightarrow (1)$

Because voltage across capacitor can not change instantaneously.



$\therefore\ i = 2/1 = 2A$.

Thus $i_L(0^-) = 2A = i_L(0^+) \rightarrow (2)$.

Because current through inductor cannot change instantaneously.

At $t = 0^+$, from (1)

$$V_c(0^+) = V_c(0^-) = 0V.$$

But V_c, voltage across capacitor is given by

$$V_c = 1/c \int_0^t i\,dt \rightarrow (3)$$

Diff above equ wrt t.

$$\frac{dv_c}{dt} = \frac{1}{C} i. \Rightarrow (4)$$

$\therefore$ At $t = 0^+$, equation becomes,

$$\frac{dv(0^+)}{dt} = \frac{i(0^+)}{c}.$$

$$\frac{dv(0^+)}{dt} = \frac{2}{0.5} = 4v/sec.$$

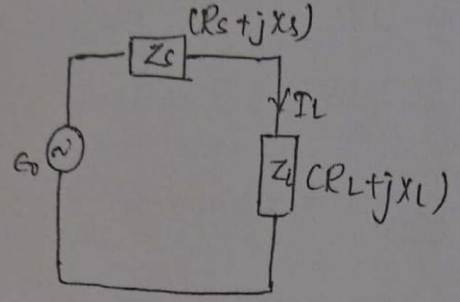
Diff (4) again wrt t

$$\frac{\partial^2 v_c}{dt} =$$

or branch

4(a) State and Explain maximum power Transfer Theorem. when load impedance consisting of variable resistance and variable reactance.

→



The load $I_L = \dfrac{E_0}{Z_s + Z_L}$.

The magnitude of I_L

$$I_L = \frac{E_0}{\sqrt{(R_s + R_L) + (X_s + X_L)^2}} \longrightarrow (1)$$

when $X_L = -X_s$

$$\therefore I_L = \frac{E_0}{\sqrt{(R_s + R_L)^2}} = \frac{E_0}{(R_s + R_L)} \longrightarrow (2)$$

For this condition the current is maximum hence the power transferred is given by

$$P = \frac{E_0^2 R_L}{(R_s + R_L)^2} \longrightarrow (3)$$

Differentiating equ (3)

$$\frac{dP}{dR_L} = \frac{d}{dR_L}\left\{\frac{E_0^2 R_L}{(R_s + R_L)^2}\right\}$$

WKT $dP/dR_L = 0 \longrightarrow (4)$

$$\therefore \quad 0 = \frac{(R_S+R_L)^2 G_0^2 - G_0^2 R_L \, 2 (R_S+R_L)}{[(R_S+R_L)^2]^2}$$

$$[(R_S+R_L)^2 - 2R_L(R_S+R_L)] G_0^2 = 0.$$

$$R_S^2 + R_L^2 + \cancel{2R_S R_L} - \cancel{2R_S R_L} - 2R_L^2 = 0.$$

$$R_S^2 - R_L^2 = 0.$$

$$R_L^2 = R_S^2$$

$\boxed{R_L = R_S}$ $\Rightarrow$ for which the gain is maxima.

Now the load impedance is given as

$Z_L = R_L - jX_S$. and also $R_L = R_S$

$Z_L = [R_S - jX_S]$, source impedance is

$Z_S = [R_S + jX_S]$

$$\therefore \boxed{Z_L = Z_S^*}$$