Paper 1 Group A, TDC Part-1
Solved Question of Previous Year
Lecture-1

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2016

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Q 1(a) State and prove Superposition theorem.

Ans:- Statement of Superposition theorem:->

The theorem states that in any linear, bilateral, active network having more than one source (current or voltage), the response across any element is the sum of the responses obtained from each source considered seperately and all other sources are replaced by their internal resistance.

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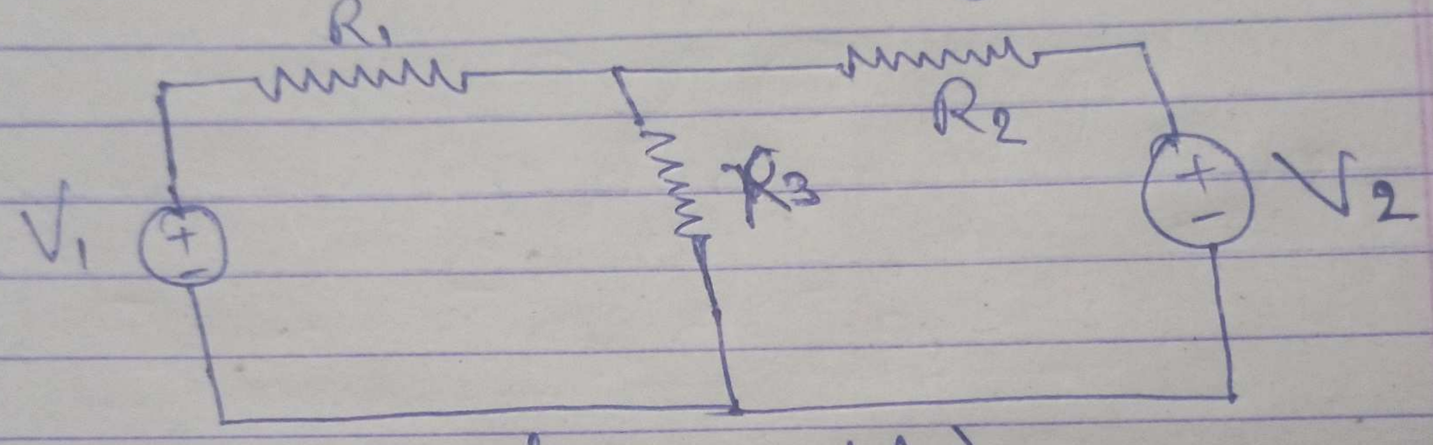
Proof :→

Let us consider a linear bilateral n/w as shown in figure 1(a).



figure→ 1(a)

To find the current through Resistance R_3 of figure 1(a), we will apply

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apply superposition theorem

So, first let us consider Voltage source V_1 and ~~sho~~ replace (remove) V_2 by short circuit

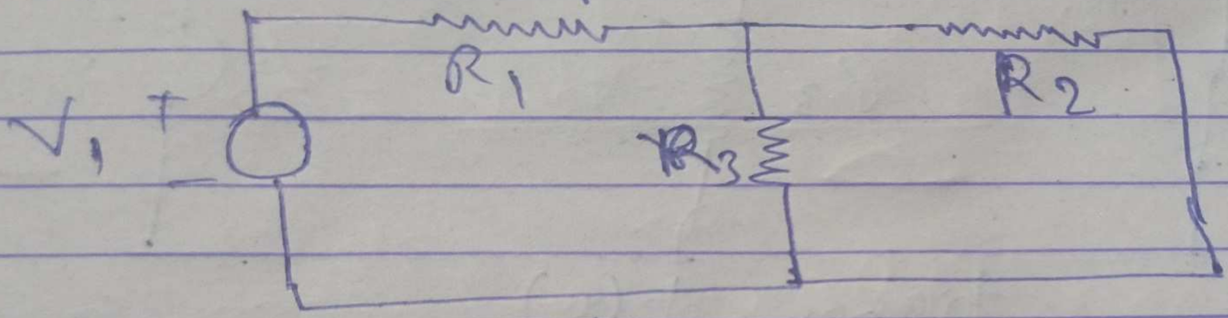

figure 1(b)

In above n/w R_2 & R_3 ~~will now be~~ is in ||rel combination and in series with R_1 so net resistance of n/w is,

$$R_1 + \frac{R_2 R_3}{(R_2+R_3)} = \frac{R_1R_2 + R_1R_3 + R_2R_3}{R_2 + R_3}$$

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So total current in the ckt is.

$$I_T' = \frac{V_1 \times (R_2 + R_3)}{R_1R_2 + R_1R_3 + R_2R_3}$$

Current through R_3 due to V_1 only is,

$$I_{R_3}' = \frac{I_T' \times R_2}{(R_2 + R_3)}$$

$$= \frac{V_1 \times R_2}{R_1R_2 + R_1R_3 + R_2R_3}$$ [Putting values of I_T'] ——— (i)

Now, We take another voltage source V_2

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and replace V_1 by short circuit as shown in figure 1(c) below.

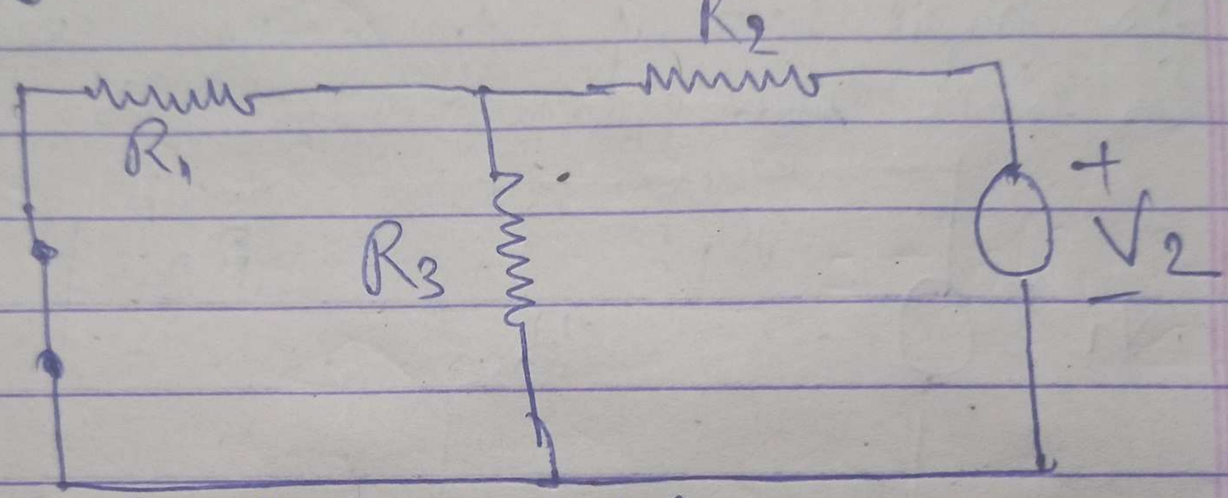

figure 1(c)

In above n/w, now, R_1 & R_3 are in ||el and then in series with R_2

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As we obtained the current I'_{R_3}, similarly we find current in R_3 due to source V_2 given as,

$$I''_{R_3} = \frac{V_2 \times R_1}{R_1 R_3 + R_1 R_2 + R_2 R_3} \quad \text{— (ii)}$$

Adding eqn. (i) & (ii) we get total current through R_3 due to V_1 & V_2

i.e., $I_{R_3} = I'_{R_3} + I''_{R_3}$

$$I_{R_3} = \frac{V_1 R_2 + V_2 R_1}{R_1 R_3 + R_1 R_2 + R_2 R_3} \quad \text{— (iii)}$$

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Now, let us find the current in R_3 of n/w of figure 1(a) without applying superposition theorem.

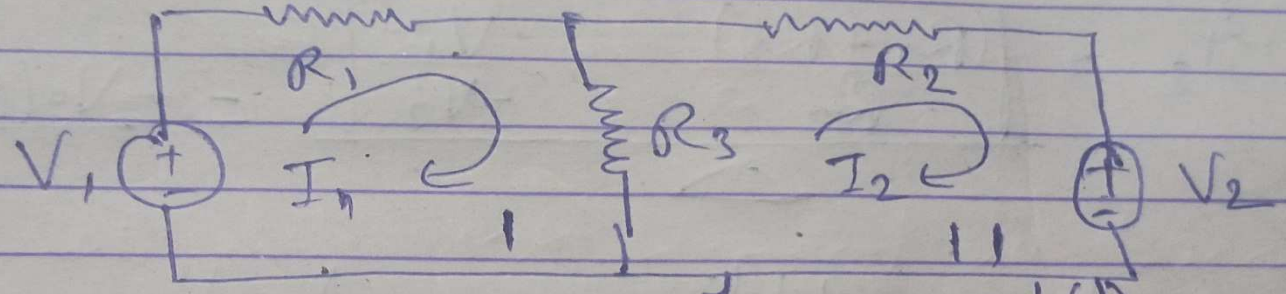

figure → 1(a)

Let current I_1 flows in loop 1 and I_2 flow in loop 11. Now applying KVL in loop 1.

$$R_1 I_1 + R_3(I_1 - I_2) = V_1 \text{ ——}$$

$$(R_1 + R_3) I_1 - R_3 I_2 = V_1 \text{ ——— (iv)}$$

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Applying KVL in loop II, we get,

$$I_2R_2 + I_2R_3 - I_1R_3 = -V_2$$

$$-I_1R_3 + I_2(R_2+R_3) = -V_2 \quad \text{—— (V)}$$

Using Cramer's Rule, from eqn. (iv) & (V)

$$\Delta = \begin{vmatrix} (R_1+R_3) & -R_3 \\ -R_3 & (R_2+R_3) \end{vmatrix} = R_1R_2 + R_2R_3 + R_3R_1 \cancel{+R_3^2} \cancel{-R_3^2}$$

$$\Delta = R_1R_2 + R_2R_3 + R_3R_1$$

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So, $I_1 = \dfrac{\begin{vmatrix} V_1 & -R_3 \\ -V_2 & (R_2+R_3) \end{vmatrix}}{\Delta} = \dfrac{V_1(R_2+R_3) - V_2R_3}{\Delta}$ —(vi)

IIIly

$I_2 = \dfrac{\begin{vmatrix} (R_1+R_3) & V_1 \\ -R_3 & -V_2 \end{vmatrix}}{\Delta} = \dfrac{-V_2(R_1+R_3) + V_1R_3}{\Delta}$ —(vii)

from figure 1(d) current through R_3 is

$I_1 - I_2 = \dfrac{V_1R_2 + \cancel{V_1R_3} - \cancel{V_2R_3} + V_2R_1 + \cancel{V_2R_3} - \cancel{V_1R_3}}{\Delta}$

from eqn (vi) & (vii)

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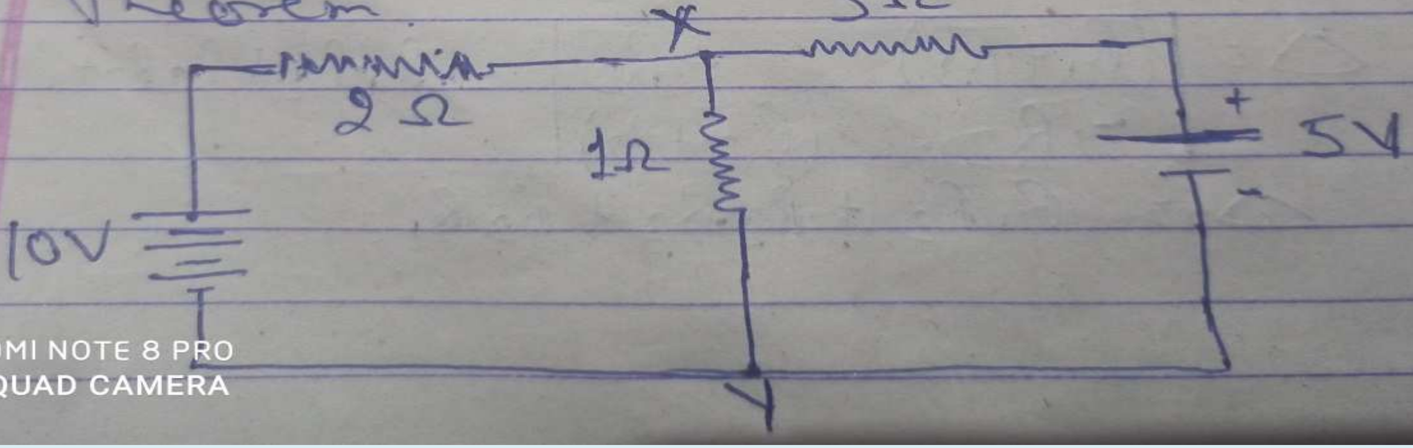
from eqn (vi) having

$$I_{R_3} = I_1 - I_2 = \frac{V_1 R_2 + V_2 R_1}{R_1 R_2 + R_2 R_3 + R_3 R_1} \quad \text{——} (ix)$$

So, from eqn. (iii) & (ix) we observe that current through resistor R_3 is same, this proves superposition theorem.

Q1(b) Find the current in branch XY in the circuit shown below using superposition theorem.



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Soln:- Applying superposition theorem let us first consider source of 10V and removing 5V by the short circuit., then

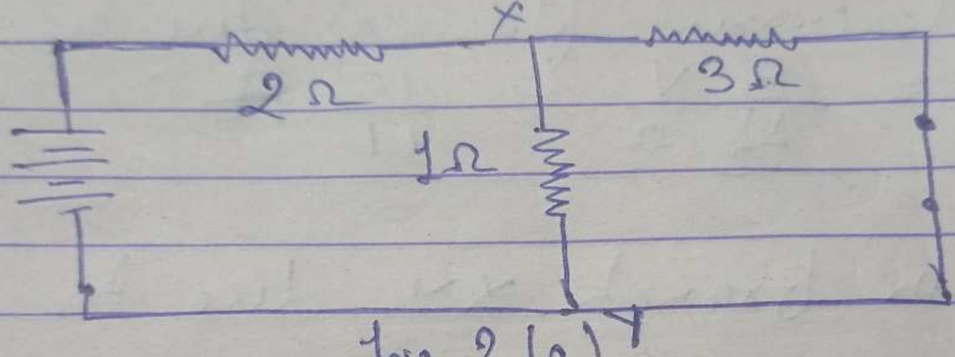

fig 2 (a)

In above ckt, 1Ω & 3Ω are in ||rl and then in series with 2Ω,

So, $R_{eq} = 2 + \frac{3 \times 1}{3+1} = 2 + \frac{3}{4} = \frac{11}{4}\,\Omega$

So current due to 10 V is,

$I_{10V} = \frac{10 \times 4}{11}\,A = \frac{40}{11}\,A$

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$$I_{10V} = \frac{10\times 4}{11}\ A = \frac{40}{11}\ A$$

Current in branch XY due to 10 V is,

$$I_{(x-y)10V} = \frac{40}{11} \times \frac{3}{(3+1)} = \frac{30}{11}\ A \quad \text{—— (i)}$$

Now, considering 5V source, and removing 10V by short ckt.

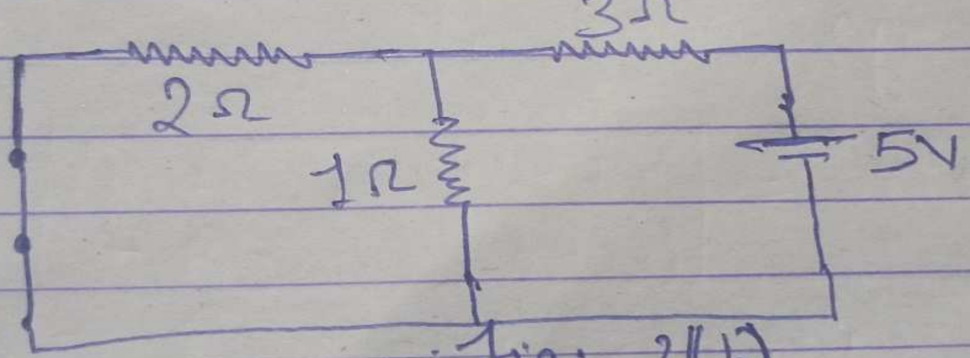

fig. 2(b)

In above ckt, 2Ω & 1Ω are ||al and then in series with 3Ω, So,

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$$R_{eq} = \frac{2 \times 1}{(2+1)} + 3 = \frac{2+9}{3} = \frac{11}{3}\ \Omega$$

So, total current flowing due to 5V source is

$$I_{5V} = \frac{5\ V}{\frac{11}{3}\ \Omega} = \frac{15}{11}\ A$$

Current in branch XY due to 5V source

$$I_{(x-y)5V} = \frac{\cancel{15}^{\,5} \times 2}{11 \times \cancel{(2+1)}} = \frac{10}{11}\ A \quad \text{— (ii)}$$

So current in branch XY is given by adding eqn. (i) & (ii)

$$I_{(x-y)} = I_{(x-y)10V} + I_{(x-y)5V}$$

$$= \left(\frac{30}{11} + \frac{10}{11}\right) A = \frac{40}{11}\ A$$

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Students are advised to see other theorems also. The lecture for those theorem available on college website.

Solution for other question will also be provided

For any query contact- 9771474020

Thank You