NETWORK THEOREMS

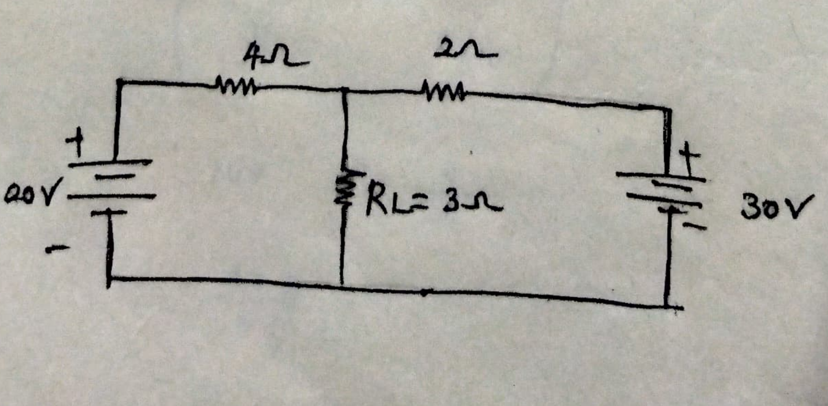
1. Superposition theorem
2. Thevinin theorem
3. Norton theorem
4. Maximum Power transfer theorem

Superposition theorem: states that in a linear circuit containing more than 1 sources, a current or voltage in any element is equal to the algebraic sum of current or voltage that would have been produced by individual sources acting separately.

Steps for working:

1. Removal of ideal voltage source means shortcircuiting.
2. Removal of practical voltage source means replacing by an internal resistance.
3. Removal of ideal current source means replacing by open circuit.

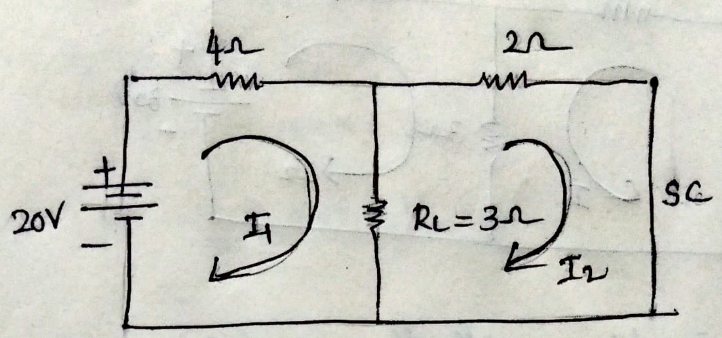
1. Find the current I_L, voltage V_L and power P_L in the following circuit using superposition theorem.



~~step 1~~ : Consider only the 20 V voltage source.

Step 1 :

Replacing 30V source by short circuiting the terminals and redraw the circuit.



$[R][I] = [V]$

By inspection :

$$\begin{pmatrix} 7 & -3 \\ -3 & 5 \end{pmatrix}\begin{pmatrix} I_1 \\ I_2 \end{pmatrix} = \begin{pmatrix} 20 \\ 0 \end{pmatrix}$$

$$\Delta = 35 - 9 = 26$$

$$\Delta_{I_1} = \begin{pmatrix} 20 & -3 \\ 0 & 5 \end{pmatrix} = 100$$

$$\Delta_{I_2} = \begin{pmatrix} 7 & 20 \\ -3 & 0 \end{pmatrix} = 60.$$

$$I_1 = \frac{\Delta I_1}{\Delta} = \frac{100}{26} = 3.846 \text{ A}$$

$$I_2 = \frac{\Delta I_2}{\Delta} = \frac{60}{26} = 2.307 \text{ A}$$

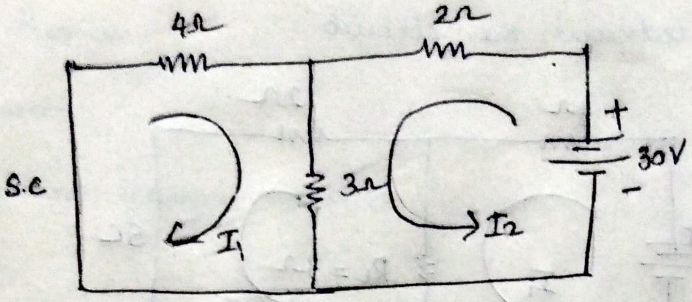
Current flow through 3Ω : $I_1 - I_2$

$= 3.846 - 2.307$

$I_{3\Omega} = \underline{1.539 \text{ A}}$

Consider 30 V voltage source only

Step 1: Replacing 20 V with short circuit & redraw



By inspection method

$$[R][I] = [V]$$

$$\Rightarrow \begin{pmatrix} 7 & +3 \\ +3 & 5 \end{pmatrix} \begin{pmatrix} I_1 \\ I_2 \end{pmatrix} = \begin{pmatrix} 0 \\ +30 \end{pmatrix}$$

$$\Rightarrow \quad \Delta = 35 - 9 = 26$$

$$\Delta_1 = \begin{pmatrix} 0 & 3 \\ +30 & 5 \end{pmatrix} = +90.$$

$$\Delta_2 = \begin{pmatrix} 7 & 0 \\ 3 & +30 \end{pmatrix} = +210$$

$$I_2 = \frac{\Delta I_2}{\Delta} = \frac{+210}{26} = +8.076\text{ A}.$$

$$I_1 = \frac{\Delta I_1}{\Delta} = \frac{-90}{26} = -3.46\text{ A}$$

Current through 3Ω = +8.076 + 3.46

= + 4.616 A

Step 3 : The resultant current flowing through $3\ \Omega$ Resistance (R_L)

$$= 1.539 + 4.616\ A$$

$$I_L = \underline{\underline{6.155\ A}}$$

$$V_L = I_L R_L$$

$$= 6.155 \times 3$$

$$V_L = \underline{\underline{18.465\ V}}$$

$$\text{Power } (P_L) = V_L I_L$$

$$= 18.465 \times 6.155$$

$$= \underline{\underline{113.652\ \text{Watt}}}$$

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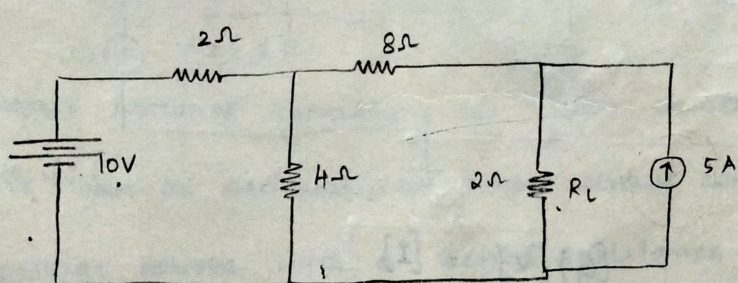
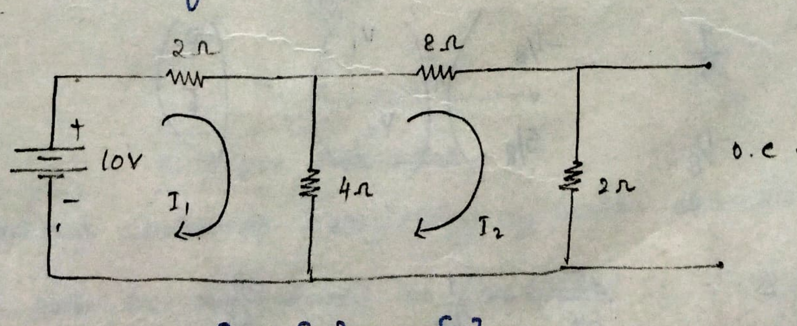
(2) Find current through resistance R_L using superposition theorem



Step 1:

Consider 10V voltage source only.

Replacing the 5A current source by an open circuit & redrawing.



$$[R][I] = [V]$$

$$\begin{pmatrix} 6 & -4 \\ -4 & 14 \end{pmatrix} \begin{pmatrix} I_1 \\ I_2 \end{pmatrix} = \begin{pmatrix} 10 \\ 0 \end{pmatrix}$$

$$\Delta = 84 - 16$$

$$= 68$$

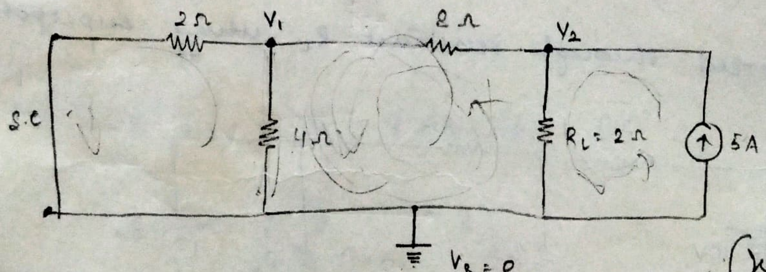
$$\Delta I_2 = \begin{pmatrix} 6 & 10 \\ -4 & 0 \end{pmatrix} = 40$$

$$I_2 = \frac{40}{68} = \underline{\underline{0.5882}}$$

Step 2 :

Consider the current source 5A only

Replacing the voltage source by short circuit & redraw the circuit.



(We should not convert into voltage source)

$$[G][V] = [I]$$

$$\begin{pmatrix} \frac{1}{2}+\frac{1}{8}+\frac{1}{4} & -1/8 \\ -1/8 & \frac{1}{2}+\frac{1}{8} \end{pmatrix} \begin{pmatrix} V_1 \\ V_2 \end{pmatrix} = \begin{pmatrix} 0 \\ 5 \end{pmatrix}$$

$$\Rightarrow \begin{pmatrix} \frac{7}{8} & -1/8 \\ -1/8 & 5/8 \end{pmatrix} \begin{pmatrix} V_1 \\ V_2 \end{pmatrix} = \begin{pmatrix} 0 \\ 5 \end{pmatrix}$$

$$\Delta = \frac{35}{64} - \frac{1}{64} = \frac{34}{64}$$

$$\Delta V_2 = \begin{pmatrix} 7/8 & 0 \\ -1/8 & 5 \end{pmatrix} = \frac{35}{8}$$

$$V_2 = \frac{35}{8} \times \frac{64}{\cancel{35}\,34}$$

$$\boxed{V_2 = 8.23}\ V$$

Current through $R_L = \frac{V_2}{R_L} = \frac{8.23}{2} = \cancel{4\Omega}\ \underline{\underline{4.117\,A}}$

Current $= \underline{\underline{4.117\ A}}$

<u>Step 3</u> :

Total current $I_L = \begin{array}{r} 4.1170 \\ +\ 0.5882 \\ \hline 4.7052 \end{array}$

$= \underline{\underline{4.7052\ A}}$.