Paper 1, TDC Part-1
Chapter– 4, Circuit Theorems
Lecture - 4

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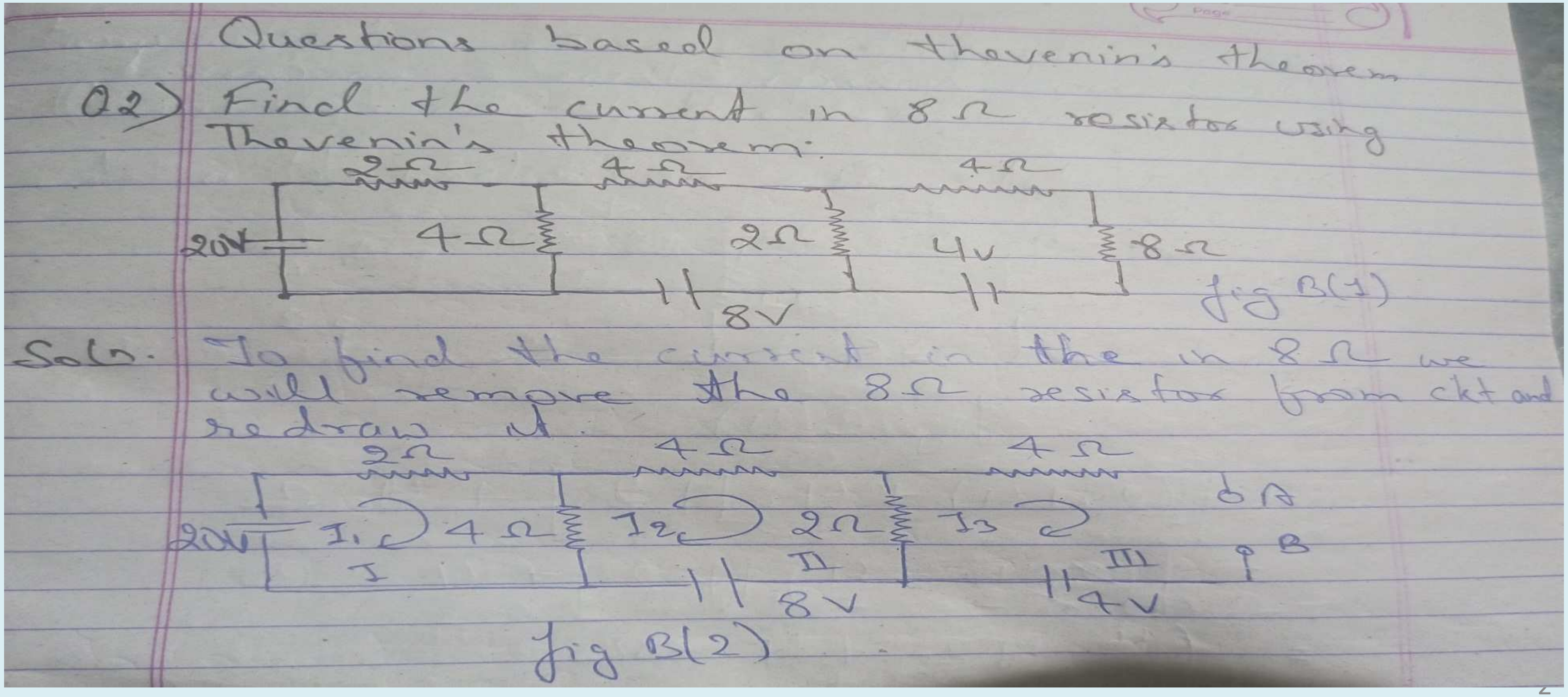
Circuit Theorem

- In previous lectures we have discussed “. Thevenin’s Theorem” and did one examples. Today we will see some problems based on Thevenin’s theorem


Questions based on thevenin's theorem

Q2) Find the current in 8 Ω resistor using Thevenin's theorem:

fig B(1)

Soln. To find the current in the in 8 Ω we will remove the 8 Ω resistor from ckt and redraw it.

fig B(2)

Circuit Theorem

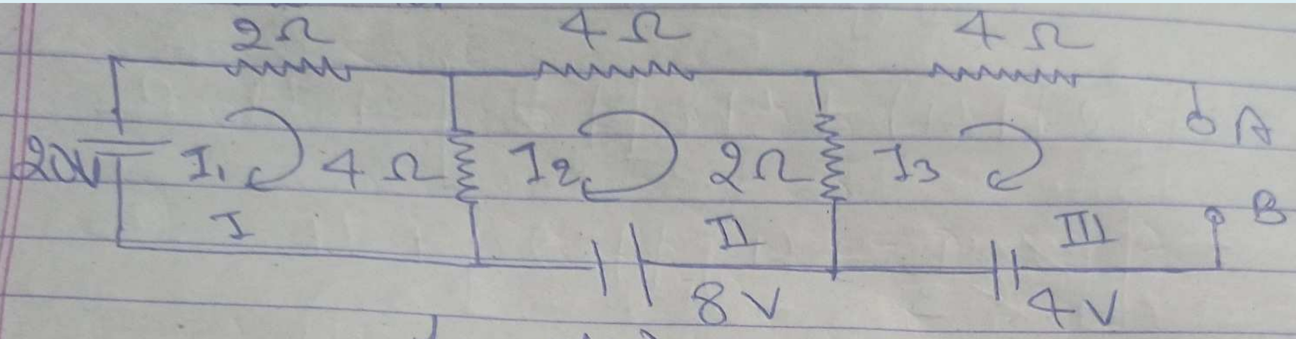


fig B(2)

Now the ckt of figure B(2) can be replaced or considered as thevenin's voltage in series with thevenins resistance as shown below

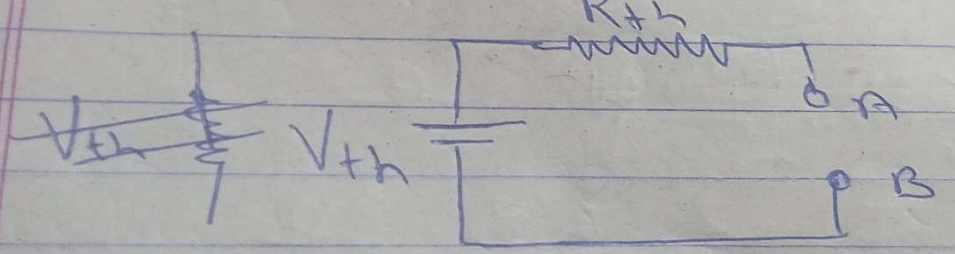


fig B(3)

To find the R_{th} we look into the from the terminals AB in figure B(2) and short

Circuit Theorem

circuit the all voltage sources and open circuit the current sources. (There is no current sources so there will be no open circuit).

To Calculate R_{th} we redraw ckt as below

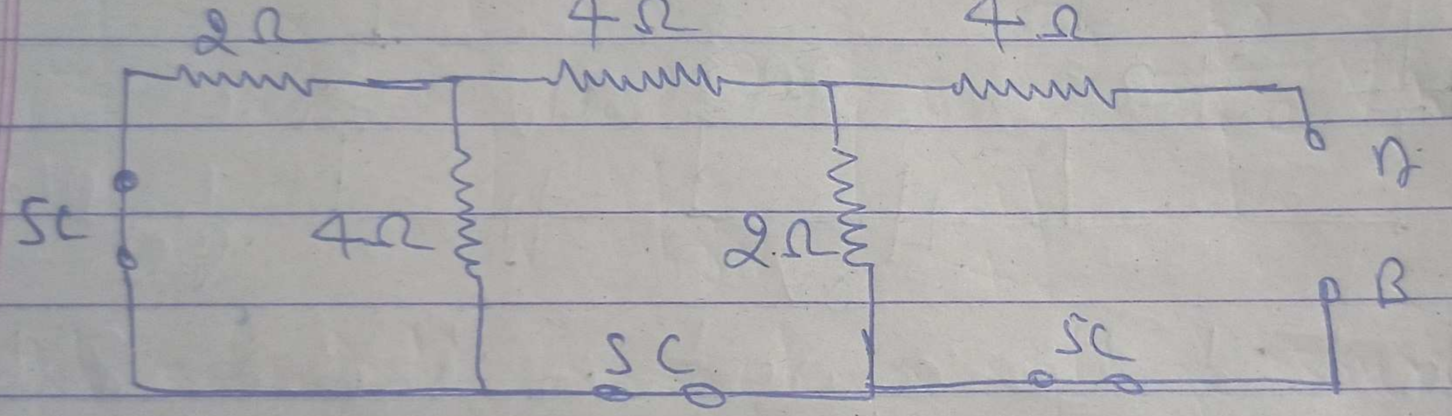


figure B(4)

Circuit Theorem

$$R_{th} = \left[\left\{(2 \,||\, 4) + 4\right\} \,||\, 2\right] + 4 \ \Omega$$

$$= \left[\left(\frac{\cancel{2}\times 4}{\cancel{6}\,3} + 4\right) \,||\, 2\right] + 4 \ \Omega$$

$$= \left(\frac{16}{3} \,||\, 2\right) + 4 \ \Omega$$

$$= \frac{\frac{(16\times 2)}{3}}{\frac{16}{3} + 2} + 4 \ \Omega$$

$$= \frac{16\,\cancel{32}/\cancel{3}}{11\,\cancel{22}/\cancel{3}} + 4 \ \Omega$$

$$= \frac{60}{11} \ \Omega$$

$$R_{th} = \frac{60}{11} \ \Omega$$

Circuit Theorem

Now we calculate V_{th}, for that we will find out different loop current or branch current of ckt shown in figure B(2).

As shown in figure B(2), current I_3 in loop 3 will be zero because the loop is open so no current flow in that loop.

$$I_3 = 0\,A.$$

Now considering loop 1 of figure B(2) we will write loop eqn. as per KVL.

$$-20V + 2I_1 + 4I_1 - 4I_2 = 0$$

$$6I_1 - 4I_2 = 20$$

$$3I_1 - 2I_2 = 10 \quad \text{———} (i)$$

Circuit Theorem

$$6I_1 - 4I_2 = 20$$

$$3I_1 - 2I_2 = 10 \quad \text{—— (i)}$$

Considering loop 2 now of figure B(2).

$$4I_2 + 2I_2 + 4I_2 - 4I_1 + 8 = 0$$

$$-4I_1 + 10I_2 = -8$$

$$-2I_1 + 5I_2 = -4 \quad \text{—— (ii)}$$

Solving eqn. (i) & (ii) as below.

$$\cancel{6I_1} - 4I_2 = 20$$

$$-\cancel{6I_1} + 15I_2 = -12$$

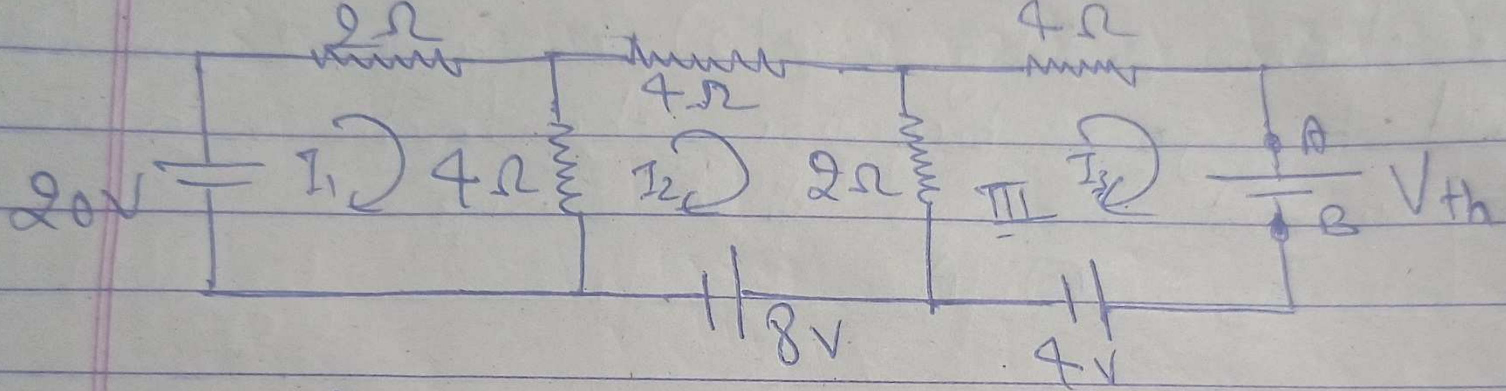
$$11I_2 = 8$$

$$I_2 = \frac{8}{11}\,A, \quad I_1 = \frac{10 + \left(2 \times \frac{8}{11}\right)}{3}$$

Circuit Theorem

$$I_1 = \frac{110+16}{11\times 3} = \frac{\overset{42}{\cancel{12.6}}}{11\times 3} = \frac{42}{11}\ A$$

Now we again redraw the ckt of figure B(2) to show V_{th}.



~~We calculate~~ connect a voltage source V_{th} at the terminal A and B solve the loop 3 Now to calculate V_{th}.

As $I_3 = 0$, $I_2 = \frac{8}{11}$ A so we

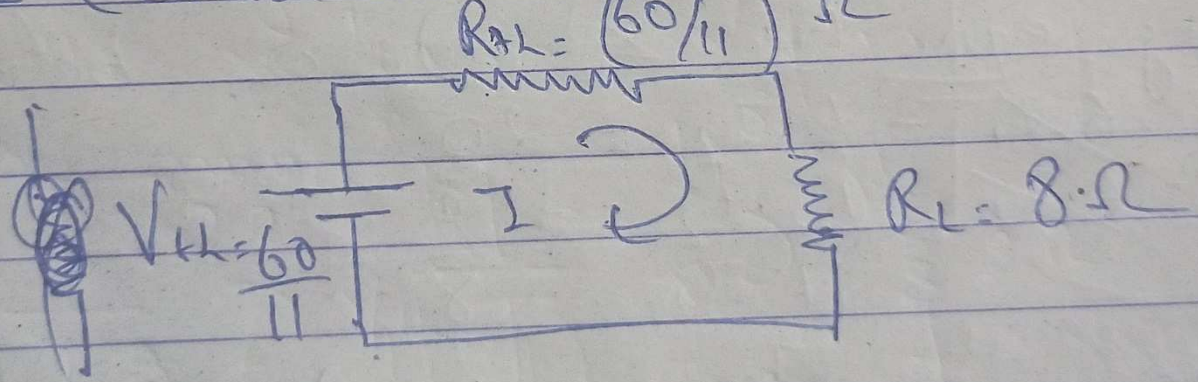
Circuit Theorem

can write KVL for loop 3 as below.

$$4\Omega \times 0 + V_{th} - 4V - 2 \times \frac{8}{11} = 0$$

$$V_{th} = 0 + 4 + \frac{16}{11} = \frac{60}{11} \text{ V}$$

So now the ckt of figure B(2) can be replaced by ckt of figure B(3) to find out current in 8Ω (load resistor).



Circuit Theorem

I_L i.e. current through load resistance R_L is

$$I_L = \frac{V_{th}}{(R_{th} + R_L)} = \frac{60/11}{\left(\frac{60}{11} + 8\right)} = \frac{60/\cancel{11}}{148/\cancel{11}} \text{ A}$$

$$= \frac{15}{37} \text{ A.}$$

So the current through $8\,\Omega$ resistor is $\frac{15}{37}$ A.

Circuit Theorem

Q3)

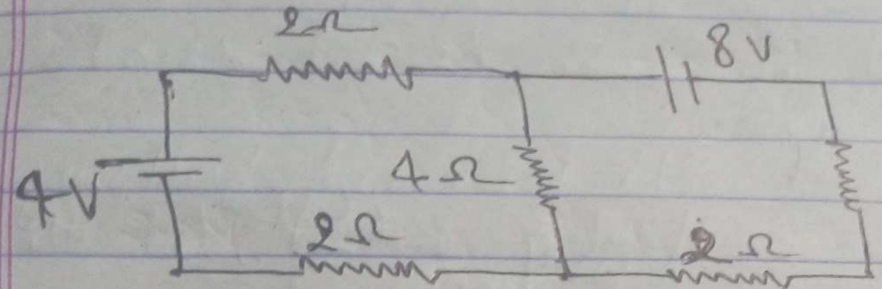


figure C(1)

Find current in 4Ω resistor using thevenin's theorem.

Soln. Here ~~8Ω~~ 4Ω resistor is load resistor because we have to find current in this resistor, we draw the ckt as per thevenin's theorem as below.

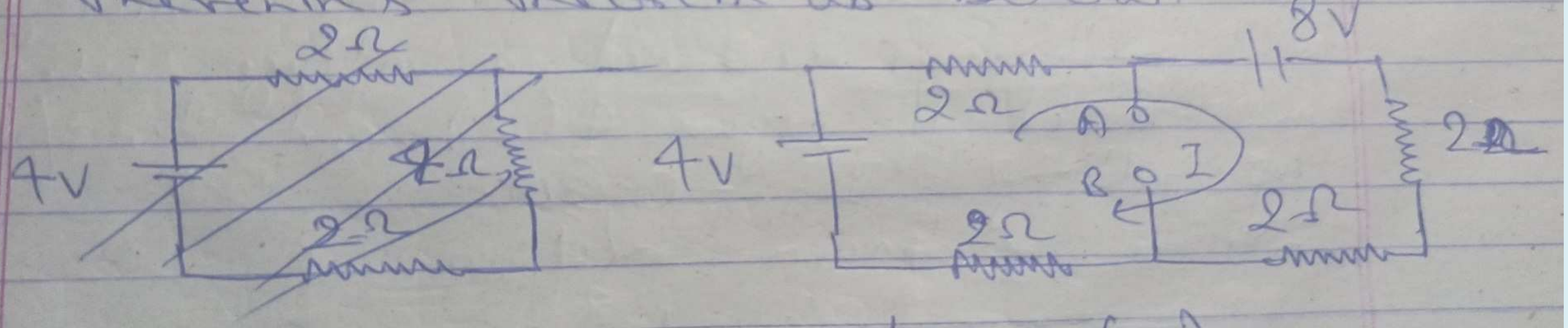


fig C(2)

Circuit Theorem

Soln. Here ~~8Ω~~ 4Ω resistor is load resistor because we have to find current in this resistor, we draw the ckt as per thevenin's theorem as below.

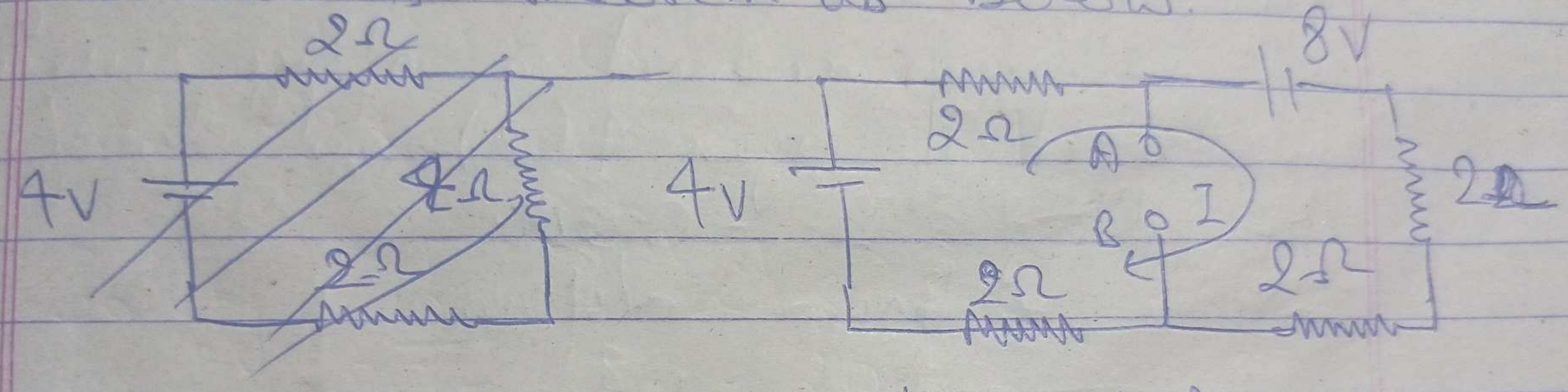


fig C(2)

find R_{th}, i.e. we will calculate R_{th} first. for that we will short the voltage sources of figure C(2) and redraw the ckt. as in figure (3).

Circuit Theorem

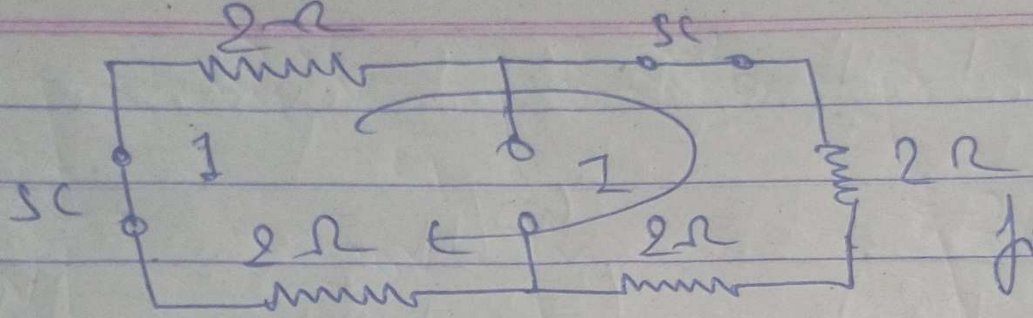


figure c(3)

$$R_{th} = \cancel{2 \parallel 2}\ [(2+2) \parallel (2+2)]\ \Omega$$

$$= (4 \parallel 4)\ \Omega$$

$$= \frac{4 \times 4}{4+4} = 2\ \Omega$$

$$R_{th} = 2\ \Omega$$

Now we will find the current following in the ckt as shown in figure c(2), let the current I flow in the ckt. then

Circuit Theorem

$$-4 + 2I + 8 + 2I + 2I + 2I = 0$$
$$8I + 4 = 0$$
$$I = \frac{-4}{8} = -0.5\ A$$

Now to find the ~~current~~ thevenin voltage we will ~~not~~ now connect a voltage source V_{th} in the ckt of figure c(2) and then find V_{th} by putting $I = -0.5A$.
so the redrawn n/w is

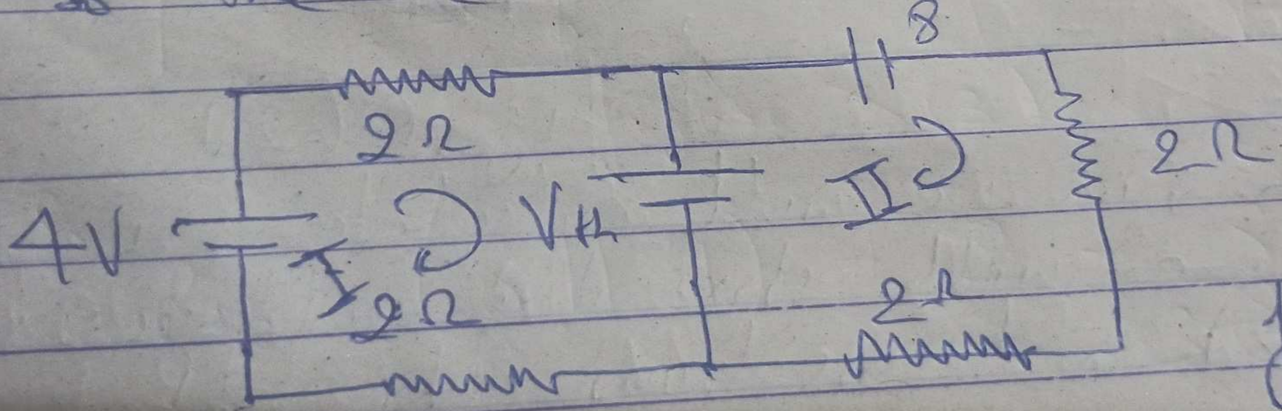


fig c(4)

Circuit Theorem

We can find V_{th} by taking any one of the loop because both loop contain V_{th}.
Let us consider loop 1, The writing KVL we will have.

In loop 1.

$$2 \times -0.5 + V_{th} + 2 \times -0.5 + -4 = 0$$

$$-1 + V_{th} + -1 - 4 = 0$$

$$V_{th} = 6\ V$$

Or,
through loop 2.

$$8 + 2 \times -0.5 + 2 \times -0.5 + -V_{th} = 0$$

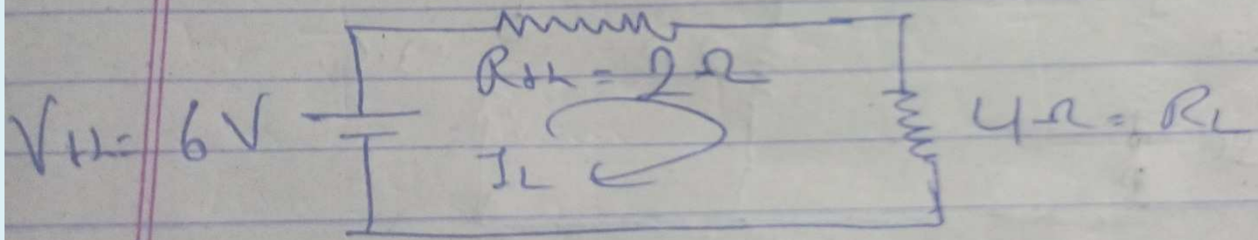
Circuit Theorem

$$8 - 1 - 1 - V_{th} = 0$$

$$V_{th} = 6\ V$$

So we see that value of V_{th} is same by taking any loop.

Now drawing thevenins equivalent ckt to find current through load resistor 4Ω



$$I_L = \frac{V_{th}}{(R_{th} + R_L)} = \frac{6}{(2+4)} = 1\ A$$

ans

Circuit Theorem

Q 4)

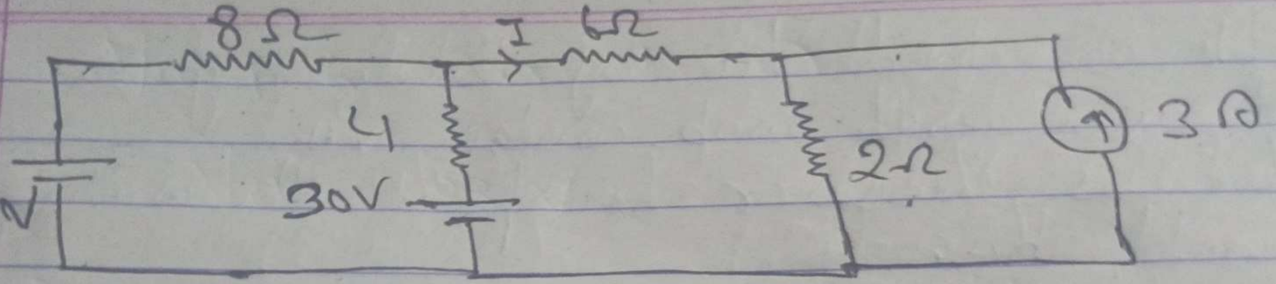


Fig D(1)

Find current in 6Ω resistor.

Soln - We will apply thevenins theorem in the above ckt: for that we will draw the ckt by removing load resistance (6Ω) resistor.

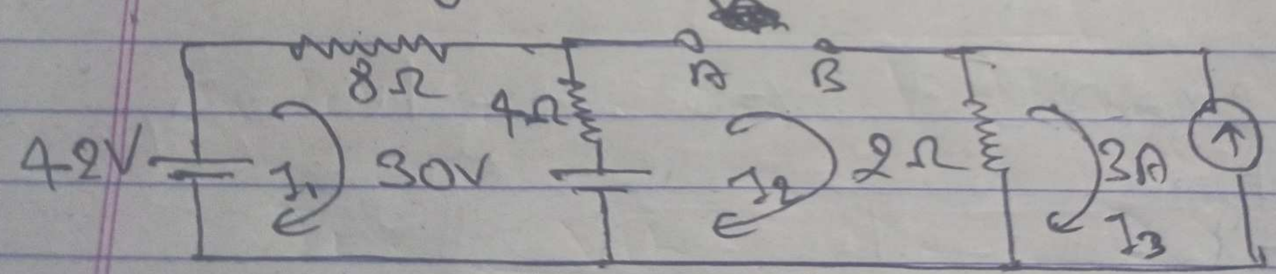


Fig D (2)

Circuit Theorem

We will calculate R_{th} first, for that short circuiting the voltage source and open circuit the current source. the drawing the ckt as shown in figure D (3).

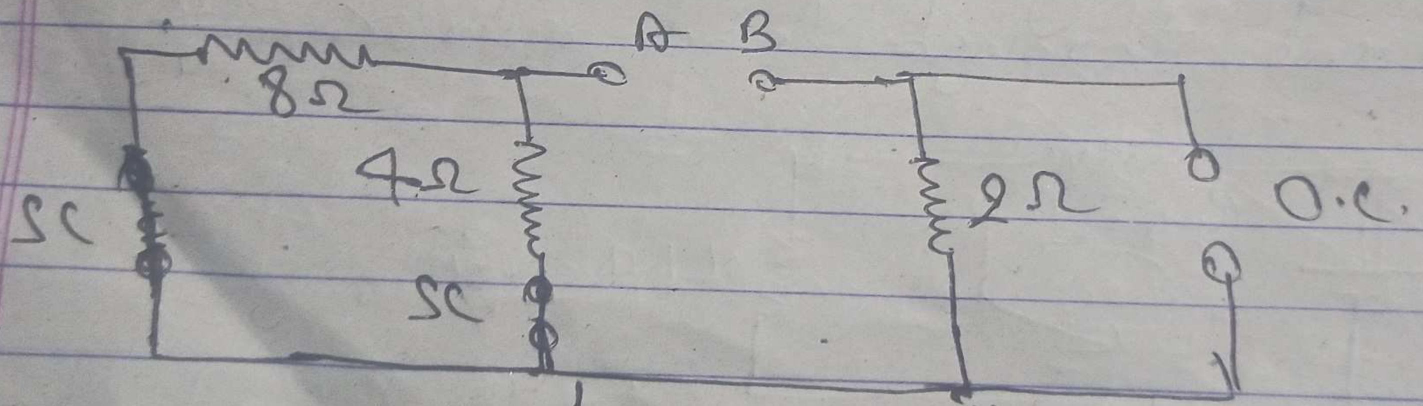


figure D (3)

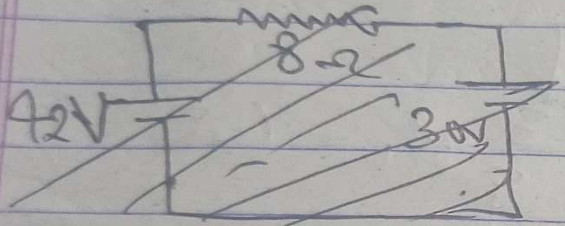
So

$$R_{th} = (8 \parallel 4) + 2 = \frac{8\times 4}{3\,\cancel{(8+4)}} + 2$$

Circuit Theorem

$$R_{th} = \frac{14}{3}\ \Omega$$

Now we will calculate V_{th} as below, first we will find current in different loop of ckt shown in figure D(2).



In loop 1, we have KVL

$$8I_1 + 4I_1 + 30 - 42 = 0$$

$$12 I_1 - 12 = 0$$

$$I_1 = \frac{\cancel{12}}{\cancel{12}} = 1\ A.$$

In loop 2, $I_2 = 0$ as it is open loop. and in loop 3,

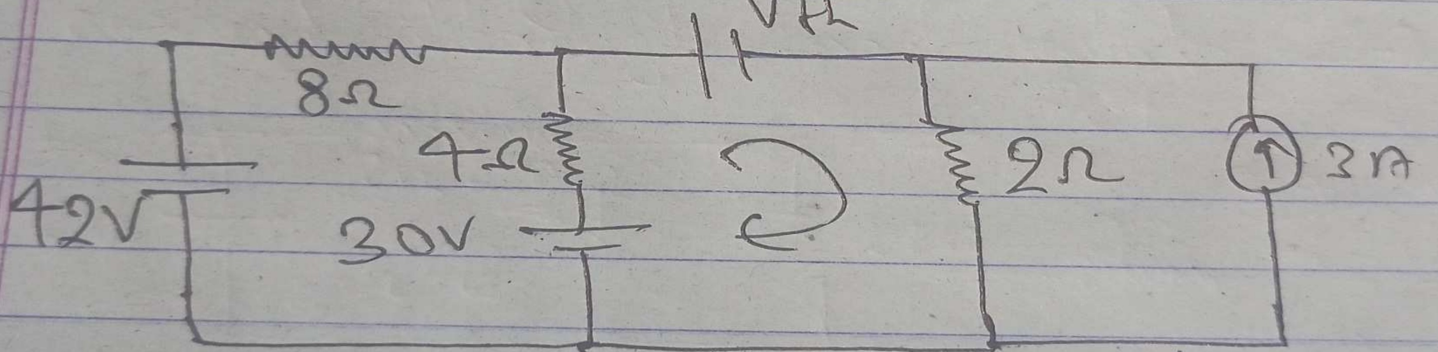
$$I_3 = -3A.$$

Circuit Theorem

In loop 2, $I_2 = 0$ as it is open loop.
and in loop 3,

$$I_3 = -3A.$$

Now redrawing the ckt of figure D (2) as below with V_{th} connected at terminal AB.



Applying KVL in loop 2 we have

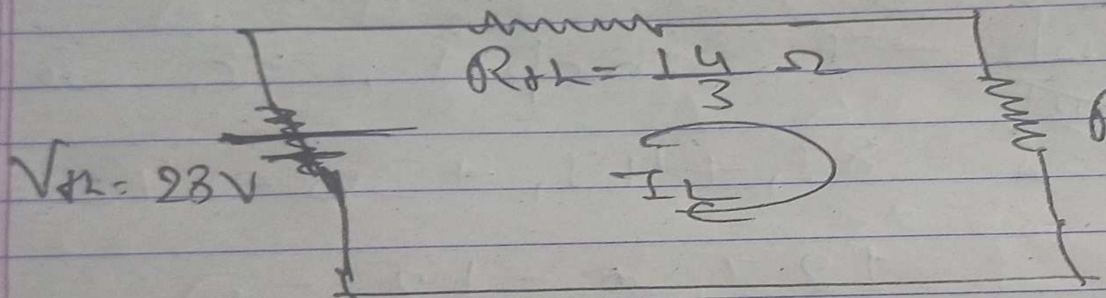
$$V_{th} + (2 \times 3) - 30V - (4 \times 1) = 0$$

Circuit Theorem

$$V_{th} + 6 - 30 - 4 = 0$$

$$V_{th} = 28\ V.$$

So thevenin's equivalent ckt is as below



So let I_L is current through 6Ω resistor

$$I_L = \frac{V_{th}}{(R_{th} + R_L)} = \frac{28}{\left(\frac{14}{3} + 6\right)}\ A$$

$$= \frac{28 \times 3}{(14 + 18)} = \frac{7}{8}\cancel{\frac{28}{32}} \times 3\ A$$

$$= \frac{21}{8}\ A.$$