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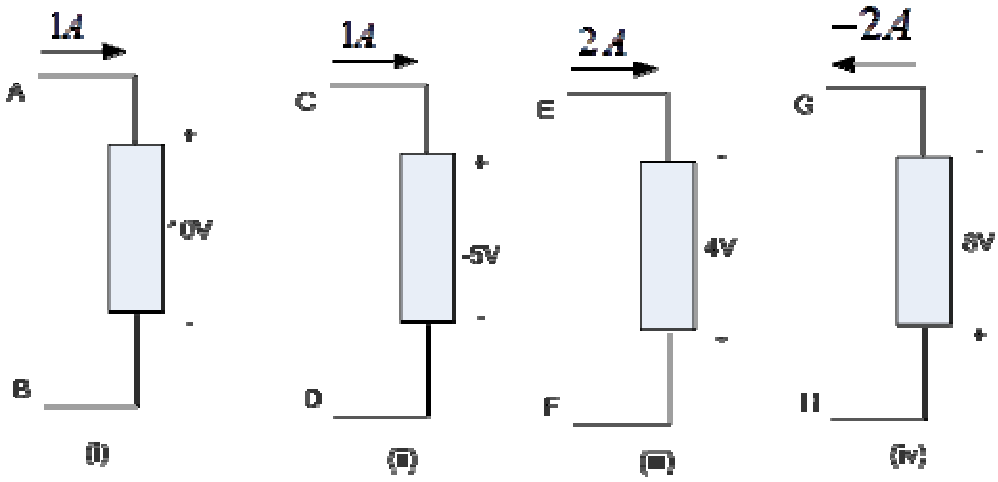
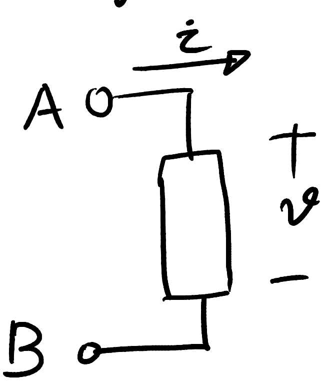
1) For the elements given below:



a) State for which elements is Passive sign convention followed?
b) Find the power associated with the each element.
c) Which elements are passive?
d) For each element, name the terminal that is at a higher voltage.

(a) Passive sign convention.



current is shown to enter into the +ve reference of the voltage.

When an arrow is put as the current direction along with the variable i, the arrow shows a reference direction only. It is not the actual direction of current. The actual direction of current will depend on the value of i.
That is to say if i has a +ve value (e.g. 2A), then current direction is same as the arrow.

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However if i has a negative value (e.g. -3 A), then actual current has a direction opposite to the arrow direction.

Similarly, when we put the + and − marks at the two ends of an element, along with a voltage variable v, it does not automatically mean that the terminal marked +ve is actually at a higher potential as compared to the terminal marked −ve.

Which terminal is at higher terminal will be decided by the value of v. If v has a positive value (e.g. 5 V), then the terminal marked +ve is 5V higher than the terminal marked −ve.

Again if $v = -10$V, then the terminal marked +ve is actually 10V lower than the −ve terminal.

(4) To note the reference current direction and reference voltage polarity <u>VS</u>. the actual current direction and actual voltage polarity.

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When current reference direction is shown to be entering into the +ve voltage polarity, it is said to be following the passive sign convention.

It's worth noting that for passive elements (which dissipate power), the actual current enters into the actual +ve (higher potential) terminal.

So, it is worth appreciating the difference between passive sign convention and a passive element.

To put it in other words, for an unknown element, we may or may not follow the passive sign convention while marking the reference current direction and reference voltage polarities. Then we solve the ckt (or make measurements) to find the values of i and v. When we calculate power p = v × i, it may be +ve or -ve.

If passive sign convention <u>was</u> followed, then +ve p ⇒ the element is passive and -ve p ⇒ element is <u>not</u> passive.

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However, if passive sign convention was not followed, then $p = +ve \Rightarrow$ the element is a source and $p = -ve \Rightarrow$ the element is a passive element.

So elements which follow the passive sign convention (i.e. current direction is shown to be entering into the +ve reference polarity of voltage) are:

(i), (ii) and (iv).

(b) power associated with each element

(i) $p = 10 \times 1 = 10\,W \Rightarrow$ passive

(ii) $p = -5 \times 1 = -5\,W \Rightarrow$ source

(iii) $p = 4 \times 2 = 8\,W \Rightarrow$ source (as not following passive sign convention)

(iv) $p = 8 \times (-2) = -16\,W \Rightarrow$ source.

(c) Already mentioned in part (b).

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Terminals which are higher potential

(d) (i) A

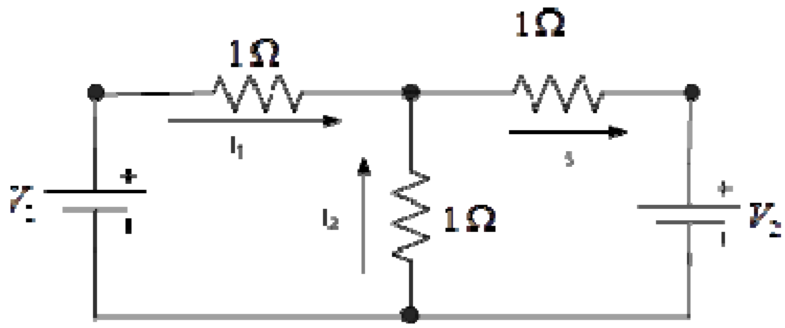
(ii) D

(iii) F

(iv) H

Q.2

For the figure,



a) Are the current directions for I2 and I3 correct?
b) Can we conclude if the voltage source V2 is taking power or giving power before solving the circuit?
c) If I1=-3A, I2=4A, find I3.
d) If V1=10V, find V2.

(a) The directions for I_1, I_2, I_3 are reference directions only. The actual current directions will be determined after solving the circuit.

(b) No, we can not say whether the DC sources are giving power or taking power, before we solve the circuit. When part of a circuit containing other sources, a source can even take (receive, absorb) power. Its physical interpretation can be a battery that is being charged.

(c) Apply KCL at the node.

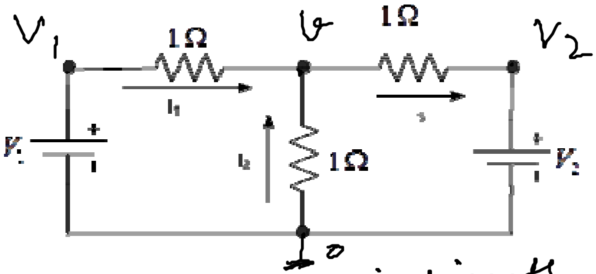
$-I_1 - I_2 + I_3 = 0$ (+ve for current leaving, -ve for current entering)

putting the actual values,

$-(-3) - 4 + I_3 = 0$

$\Rightarrow I_3 = 4 - 3 = 1$ A.

(d)



V_1 and V_2 are indirectly given by specifying the currents in part c.

KCL at v:

$$\frac{v - V_1}{1} = I_1 = -3$$

$$v - V_1 = -3 \quad \text{— (1)}$$

$$\frac{0 - v}{1} = I_2 = 4$$

$$v = -4 \quad \text{— (2)}$$

$$\frac{v - V_2}{1} = 1 \Rightarrow v - V_2 = 1 \quad \text{— (3)}$$

$$V_1 = v + 3 = -4 + 3 = -1$$

$$V_2 = v - 1 = -4 - 1 = -5$$

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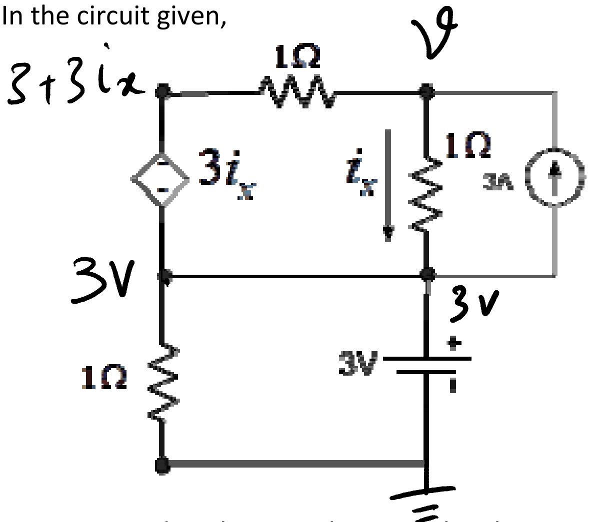
Q3 In the circuit given,



Use node voltage analysis to solve the circuit. Find the value of current i_x.

Note the reference node. (The -ve terminal of the voltage source 3V).

The other end of the 3V source is now known as 3V

Any two points in a circuit if 'shorted' through a conductor, are at same potential (voltage).

Next, there is a dependent voltage source. For any voltage source, if one end node's voltage is known, then the other end node voltage can be written (as in this case, the voltage at the other end of the dependent voltage source would be $(3 + 3i_x)$).

It's enough if we know the node voltage v, as we can then solve the complete ckt.

So our only unknown is v.

But there is a node voltage $(3+3i_x)$.

Now the 'control variable' i_x can be written as $i_x = \frac{v-3}{1} = v-3$.

So $3+3i_x = 3+3(v-3) = 3v-6$

We can now apply KCL at the node marked v.

Net sum of currents leaving $= 0$.

current leaving in the top 1Ω branch $=$

$$\frac{v-(3v-6)}{1} = -2v+6$$

As 3A current source shows current entering, its contribution is -3.

i_x is leaving and $i_x = \frac{v-3}{1} = v-3$

Adding these up

$$(-2v+6) + (-3) + v-3 = 0$$

or $-v+0=0 \Rightarrow v = 0V$, $\Rightarrow \underline{\underline{i_x = -3\,A}}$.

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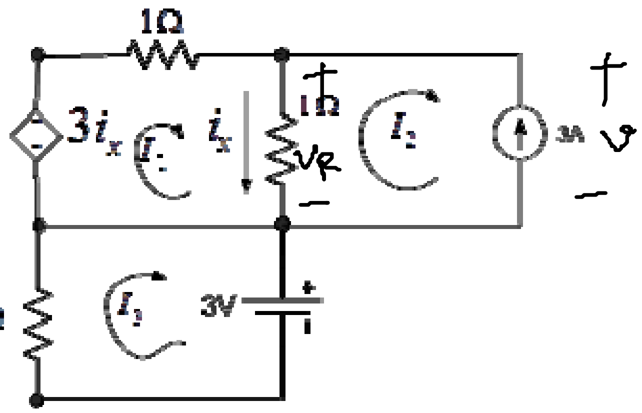
Q. 4

In the circuit given,



a) Find the values of I1, I2 an I3.
b) Find the value of .
c) What is the power associate with the current source?

Mesh current analysis.

There is one dependent voltage source:

3 i_x.

The control signal i_x has to be first written in terms of the mesh currents.

As i_x is in the direction of I_1 and opposite to the direction of I_2:

$$i_x = I_1 - I_2.$$

Then, dependent voltage source can be written as $3 i_x = 3(I_1 - I_2)$

Next, we write KVL equations around the meshes..

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Mesh 1

Again we stick to the convention of +ve for voltage fall and -ve for voltage rise as explained in qn. (2).

$$-3i_x + I_1 \times 1 + i_x \times 1 = 0$$

or $-2i_x + I_1 = 0$

Replacing i_x by $(I_1 - I_2)$

$$-2(I_1 - I_2) + I_1 = -I_1 + 2I_2 = 0 \quad \text{--- (1)}$$

Mesh 2

Mesh 2 has a current source in it. we can not write the voltage drop across the current source in terms of the mesh currents. Hence, we avoid this mesh.

Though we loose one equation in the process, we get it in another form. Please note that $I_2 = -3\,A$ (opposite to the current source)

So this is our 2nd eqn. $I_2 = -3\,A$ --- (2)

Mesh 3

$I_3 \times 1 - 3 = 0$ —③

$I_3 = 3$

The 3 equations are:

$-I_1 + 2I_2 = 0$ —①

$I_2 = -3$ —②

$I_3 = 3$ —③

Putting value of I_2 in eqn.①, we get:

$I_1 = 2 \times I_2 = 2 \times (-3) = -6A$

$I_2 = -3A$

$I_3 = 3A$.

(b) $\therefore \; i_x = I_1 - I_2 = -6 - (-3) = -3A$.

(c) To calculate the power associated with the current source.

We need the voltage across the current source.

Note the voltage v across the current source. It's not following the passive sign convention!

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As can be seen in the figure:

$$v = v_R = i_x \times 1 = -3\,V$$

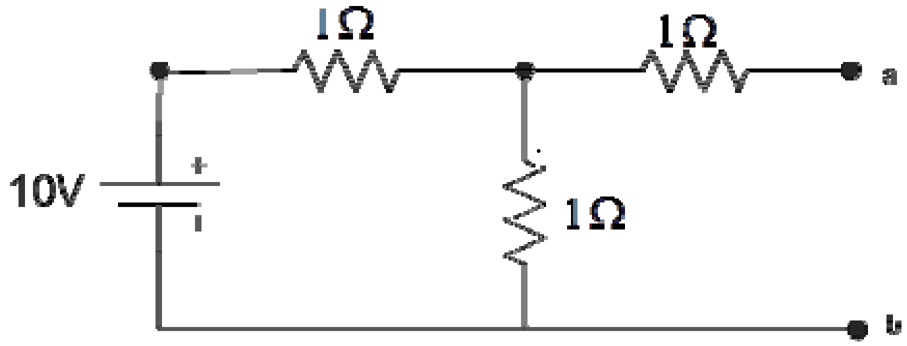
power in the current source $p = v \times i$

$$= -3 \times 3 = -9\,W.$$

As it is not following the passive sign convention, negative power means it's absorbing 9 W power.

Q5

In the circuit given, Find the Thevenin equivalent between terminals a and b.



To find the Thevenin equivalent, we need to find open circuit voltage and then the Thevenin resistance.

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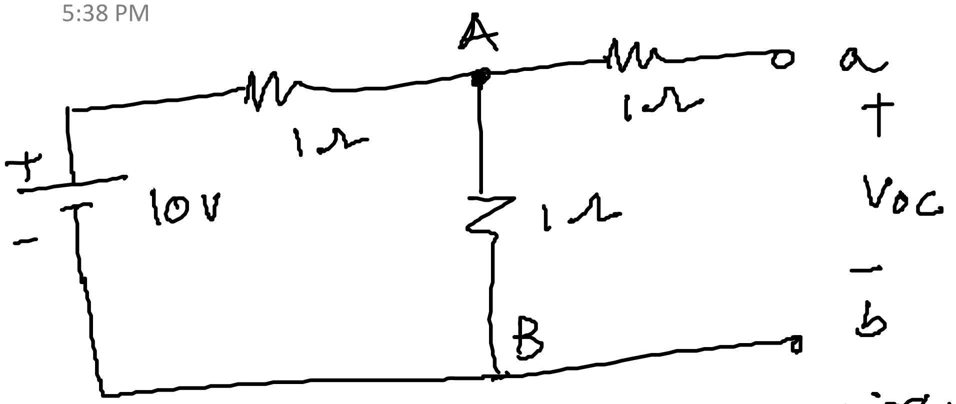
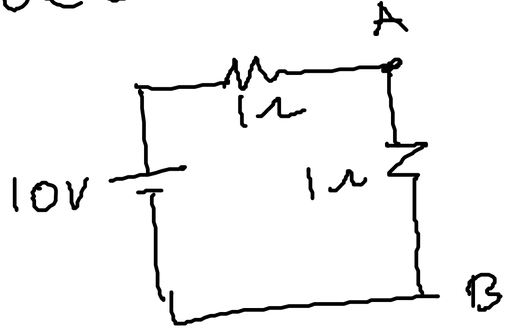


As a, b is already open circuited, no current will flow through branch Aa.
So no voltage across branch Aa.
We can use circuit:

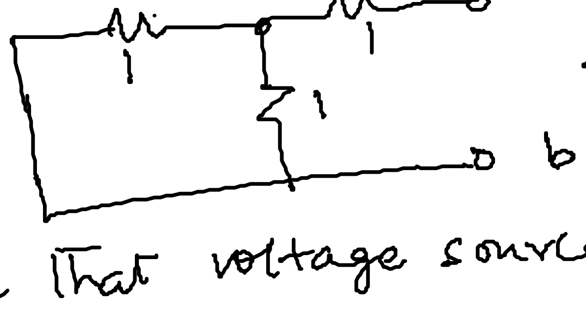


$V_{AB} = \frac{1}{1+1} \times 10 = 5V$
(From voltage divider principle)

Hence, $V_{oc} = 5\ V$.

Thevenin's resistance

One way is to kill the independent sources (we can not kill any dependent source) and obtain a resistance only ckt as:



$\leftarrow R_{eq} = 1 + 1 || 1 = 1.5\Omega$

(Note that voltage source is replaced by a short)

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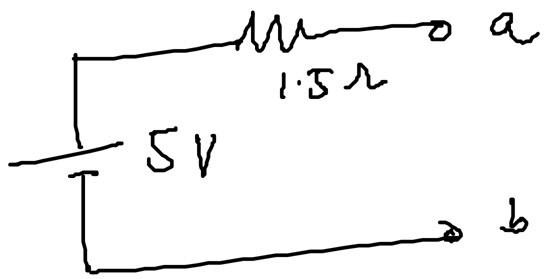
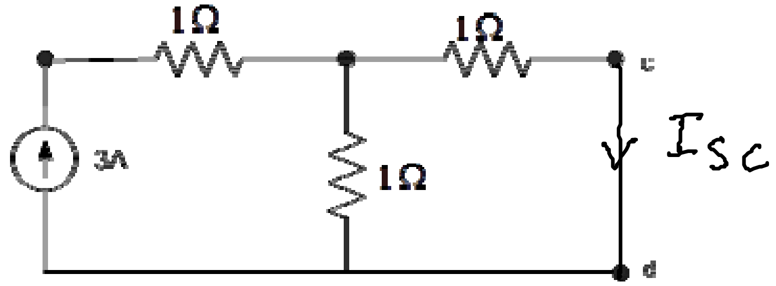
The Thevenin equivalent ckt is :

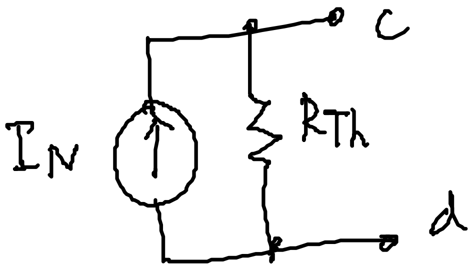


Q.6

Find the Norton equivalent of the circuit between points c and d.



Norton's equivalent of the ckt is



$I_N = I_{sc}$

If we short terminals c and d, we can apply the current divider principle,

So $I_{sc} = 3 \times \frac{1}{1+1} = 1.5\ A$.

Next we find the Thevenin's resistance.

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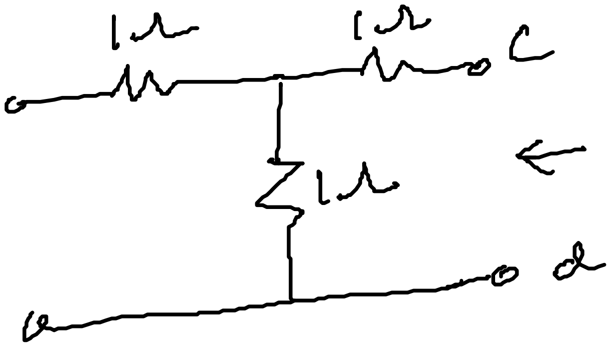
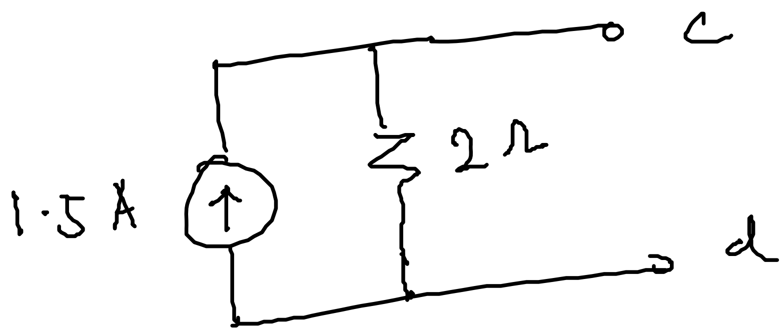
Again, because there is only an independent source in the circuit we can kill it and find its equivalent resistance.

Killing a current source means replacing the current source by an open circuit:

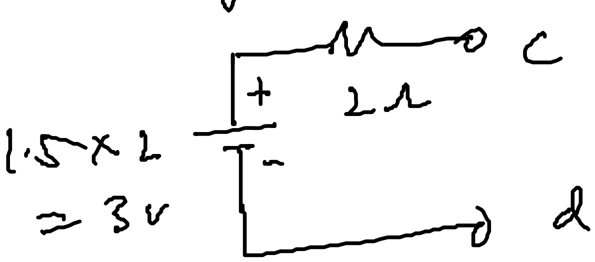


$\leftarrow R_{eq} = 1 + 1 = 2\,\Omega.$

Hence, Norton's equivalent ckt is:



We can find its Thevenin equivalent by using 'source transformation' rule:



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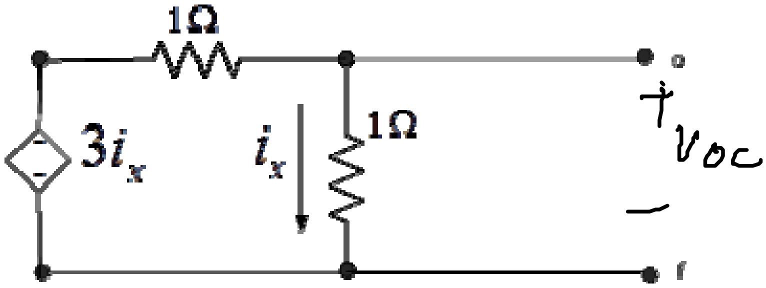
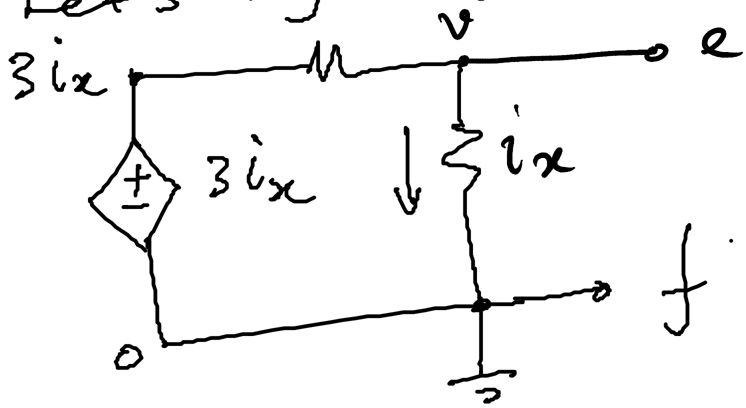
Q.7

Find the Thevein equivalent of the circuit between terminals e and f.



This circuit only has a dependent source and no independent source.

Let's try to find the open circuit voltage:



Node voltage analysis: Note the reference node and the unknown voltage v.

For the dependent voltage $3i_x$, let us express $i_x = \frac{v}{1} = v$

Then $3i_x = 3v$.

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KCL at the node voltage v:

$$\frac{v - 3i_x}{1} + \frac{v}{1} = 0$$

Replacing $i_x = v$

$$v - 3v + v = 0 \Rightarrow v = 0$$

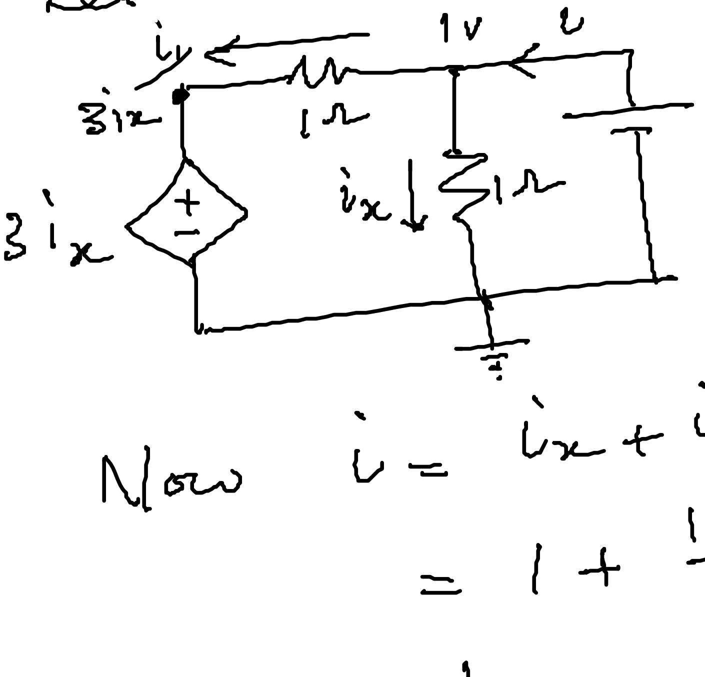
Hence, $v_{oc} = v_{Th} = 0$.

<u>Thevenin resistance</u>

We can not kill the dependent source!

We can not kill the dependent source! So we have use the 'Test source method'.

Let us connect a voltage source 1V!



$$i_x = \frac{1}{1} = 1\,A.$$

$$3i_x = 3$$

$$\text{Now } i = i_x + i_y = \frac{1}{1} + \frac{1 - 3i_x}{1}$$

$$= 1 + \frac{1 - 3\times 1}{1} = 1 - 2 = -1\,A.$$

$$R_{TH} = \frac{1}{-1} = -1\,\Omega.$$