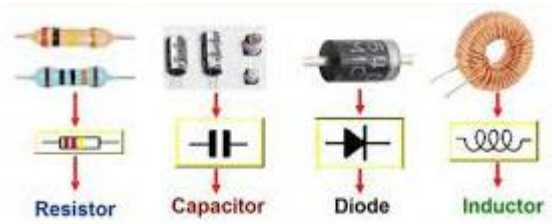
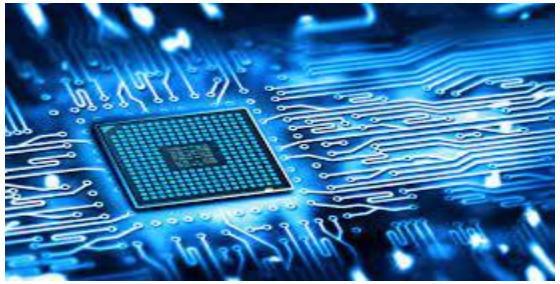
Electronics 1

BSC 113

Summer 2021-2022

Lecture 5





Mesh analysis & Superposition Methods

INSTRUCTOR

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➢ Contents

Terms of describing circuits

Name	Definitions
Node	A point where two or more circuit elements join
Essential node	A node where three or more circuit elements join
Branch	A path that connects two nodes
Essential branch	A path which connects two essential nodes without passing through an essential node
Loop	A path whose last node is the same as the starting node
mesh	A loop that does not enclose any other loops

Example 1

- For the circuit in the figure, identify

a) all nodes.

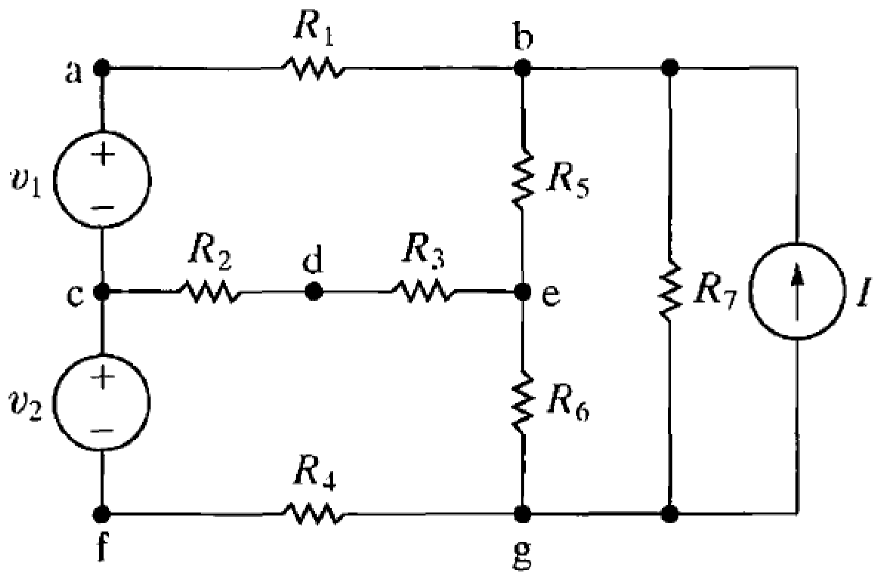
b) all essential nodes.

c) all branches.

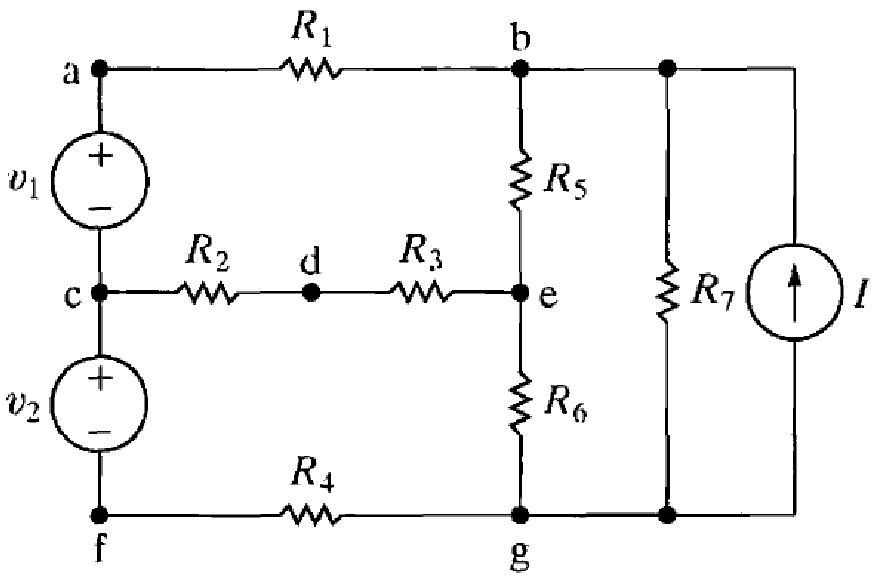
d) all essential branches.

e) all meshes.

f) two loops that are not meshes.



Example 1



a) The nodes are a, b, c, d, e, f, and g.

b) The essential nodes are b, c, e, and g.

c) The branches are $v_1, v_2, R_1, R_2, R_3, R_4, R_5, R_6, R_7$ *and* I.

d) The essential branches are:

$v_1 - R_1$,

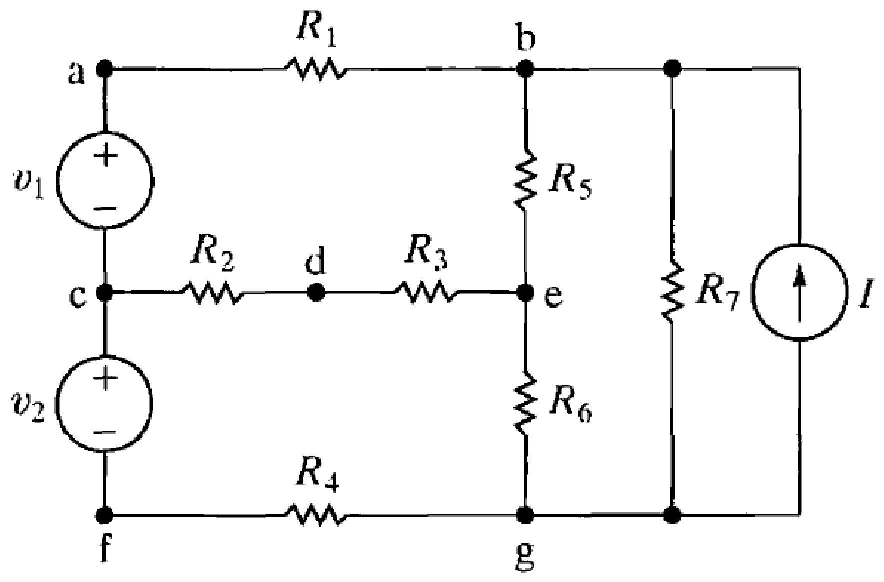
$R_2 - R_3$,

$v_2 - R_4$,

R_5, R_6, R_7 *and*

I

Example 1



e) The meshes are:

$v_1 - R_1 - R_5 - R_3 - R_2$,

$v_2 - R_2 - R_3 - R_6 - R_4$,

$R_5 - R_7 - R_6$ *and*

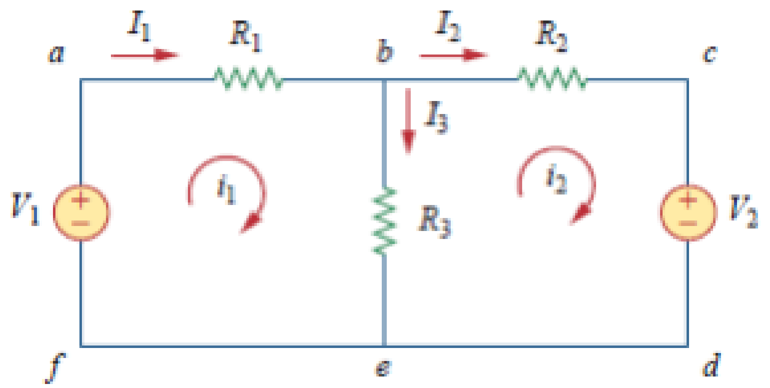
$R_7 - I$

f) The two loops that are not meshes are $v_1 — R_1 — R_5 - R_6$ - R_4 - v_2 and $I — R_5 — R_6$, because there are two loops within them.

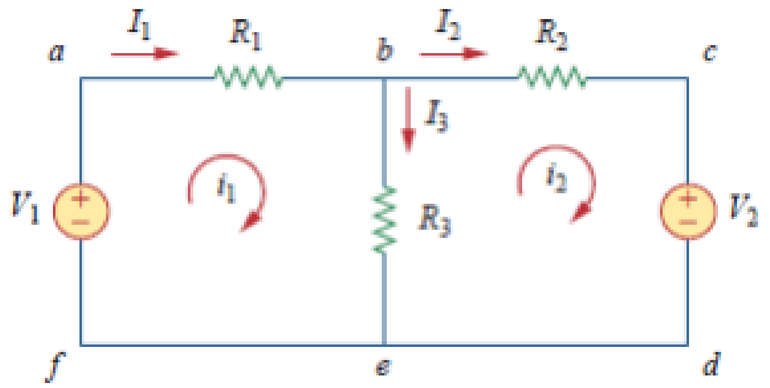
❑ Mesh analysis

➢ In the mesh analysis of a circuit with n meshes, we take the following three steps.

1. Assign mesh currents $i1, i2, \dots, in$ to the n meshes.
2. Apply KVL to each of the n meshes. Use Ohm's law to express the voltages in terms of the mesh currents.
3. Solve the resulting n simultaneous equations to get the mesh currents.



Mesh analysis



- As shown in figure 2.9,

loop 1:

$$-V_1 + R_1 i_1 + R_3(i_1 - i_2) = 0$$

loop 2:

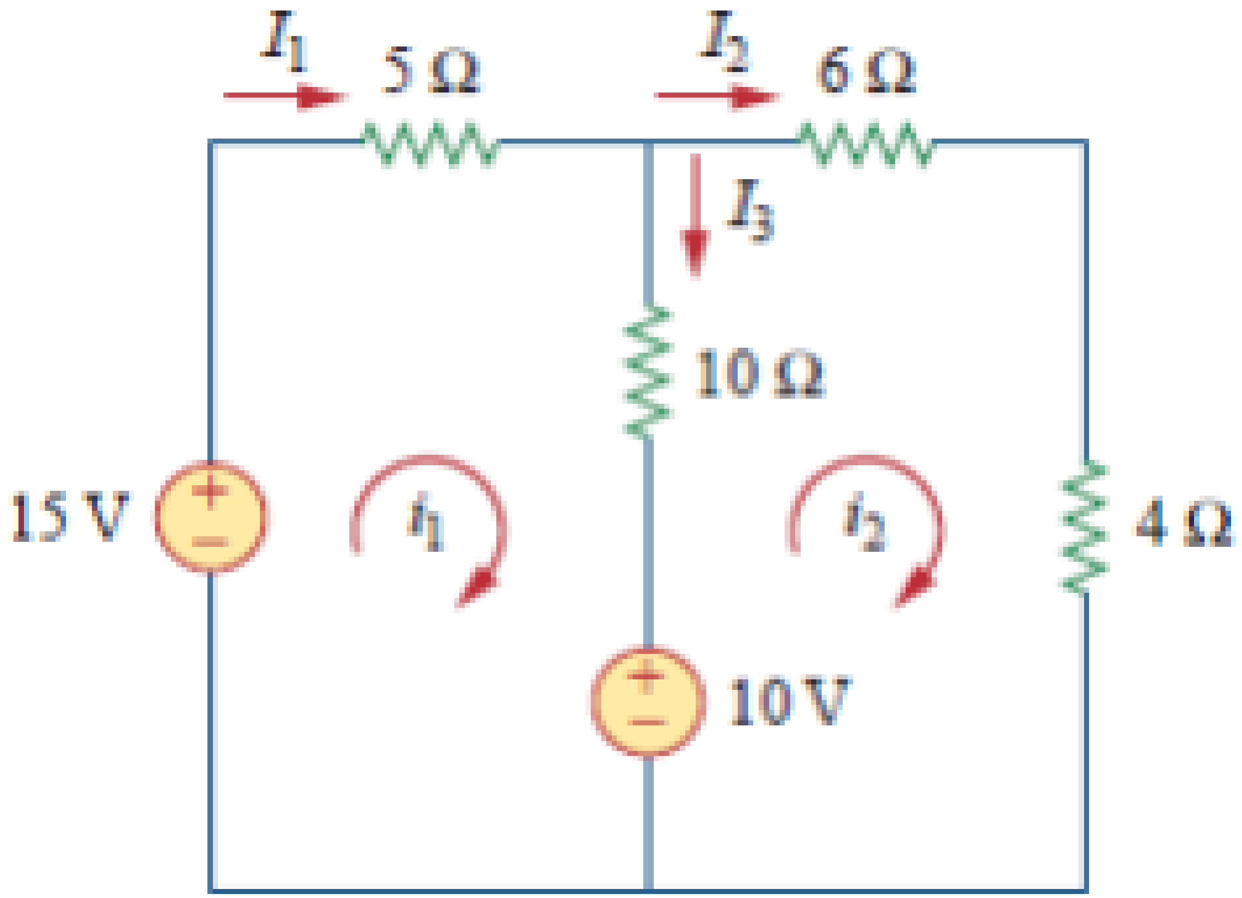
$$R_2 i_2 + V_2 + R_3(i_2 - i_1) = 0$$

After we will solve the two equation we can find:

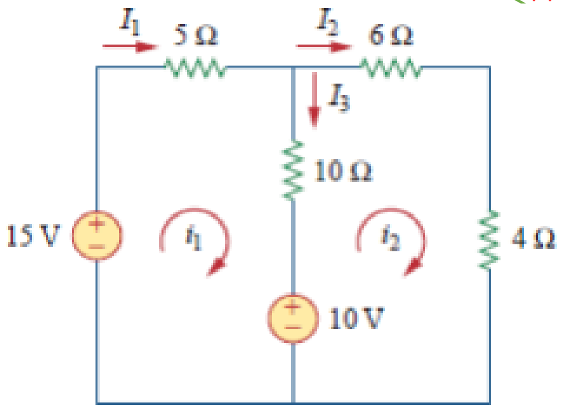
$$I_1 = i_1, \quad I_2 = i_2 \quad and\ I_3 = i_1 - i_2$$

❑ Example 2

➢ Find the branch currents I1, I2 and I3 using mesh analysis.



❑ Example 2 solution:



- Answer: We first obtain the mesh currents using KVL.

For mesh 1,

$$-15 + 5i_1 + 10(i_1 - i_2) + 10 = 0 \qquad (1)$$

and for mesh 2

$$6i_2 + 4i_2 + 10(i_2 - i_1) - 10 = 0 \qquad (2)$$

from (1) and (2)

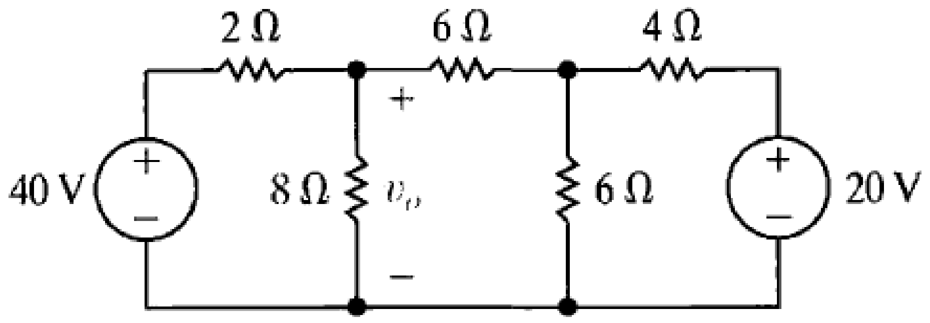
$$i_1 = i_2 = 1A$$

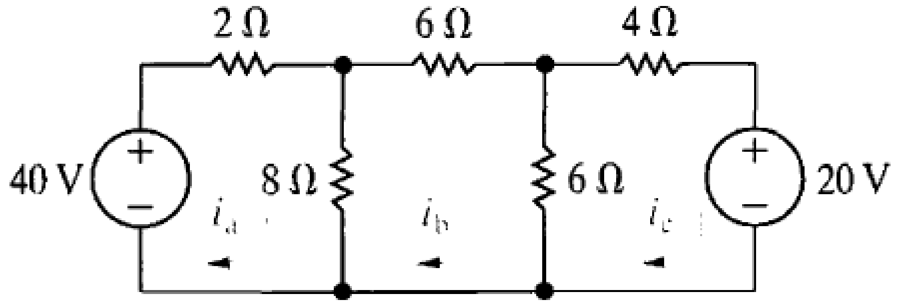
$$I_1 = i_1 = 1A, \quad I_2 = i_2 = 1A \quad and\ I_3 = i_1 - i_2 = 0A$$

Example 3

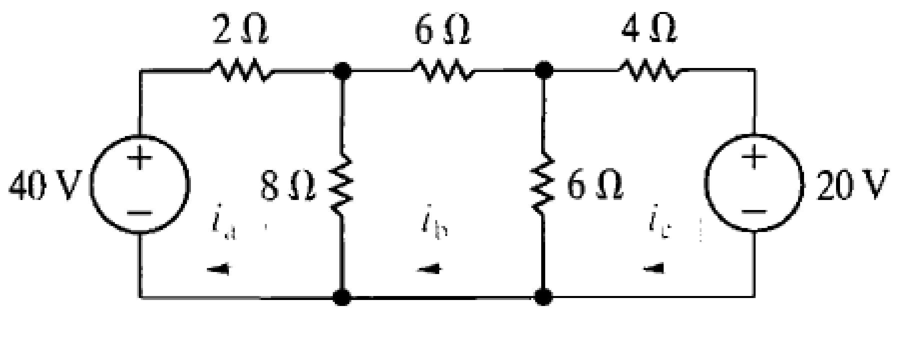
a) Use the mesh-current method to determine the power associated with each voltage source in the circuit shown.

b) Calculate the voltage v_o across the 8 Ω resistor.





Example 3



a) The three meshes equations are:

$$-40 + 2i_a + 8(i_a - i_b) = 0$$
$$8(i_b - i_a) + 6\,ib + 6(i_b - i_c) = 0$$
$$6(i_c - i_b) + 4\,i_c + 20 = 0$$

Therefore, the three mesh currents are

$i_a = 5.6$ A, $i_b = 2.0$ A, $i_c = -0.80$ A.

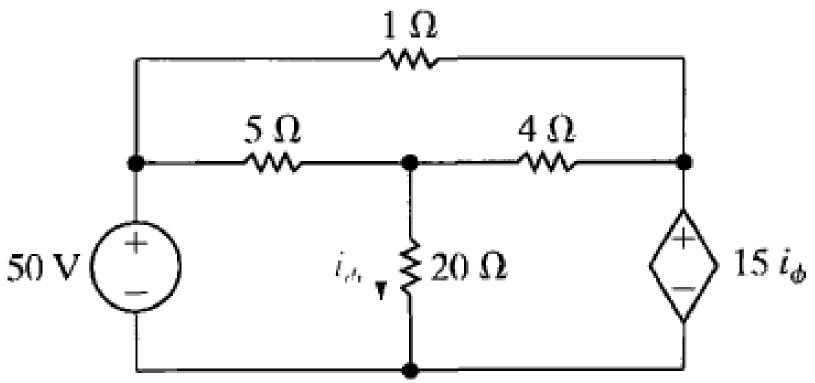
The power associated with each voltage source:

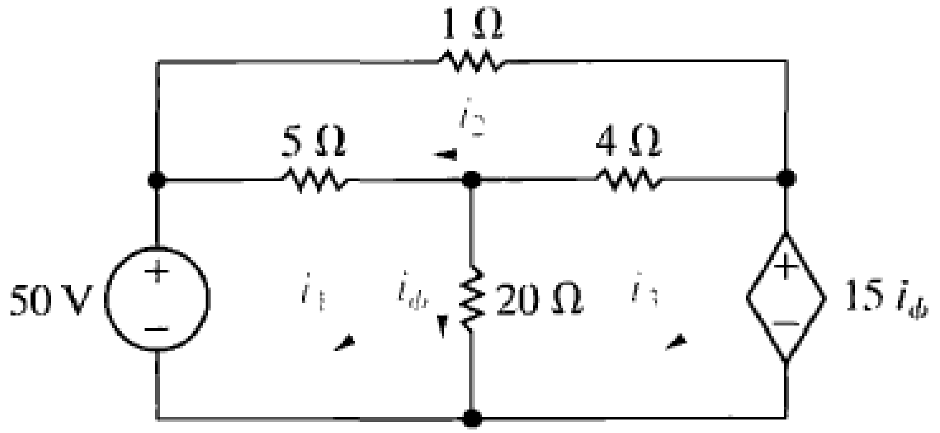
$P_{40V} = -40i_a = -224$ W, $P_{20V} = 20i_c = -16$ W.

b) $v_o = 8(i_a - i_b) = 8(3.6) = 28.8$ V.

Example 4

Use the mesh-current method of circuit analysis to determine the power dissipated in the 4Ω resistor in the circuit shown.





Example 4

- The three mesh-current equations are:

$$5(i_1 - i_2) + 20(i_1 - i_3) = 50$$

$$5(i_2 - i_1) + i_2 + 4(i_2 - i_3) = 0$$

$$20(i_3 - i_1) + 4(i_3 - i_2) + 15i_\Phi = 0$$

- We now express the branch current controlling the dependent voltage source in terms of the mesh currents as:

$$i_\Phi = i_1 - i_3$$

- Therefore, the mesh currents are:

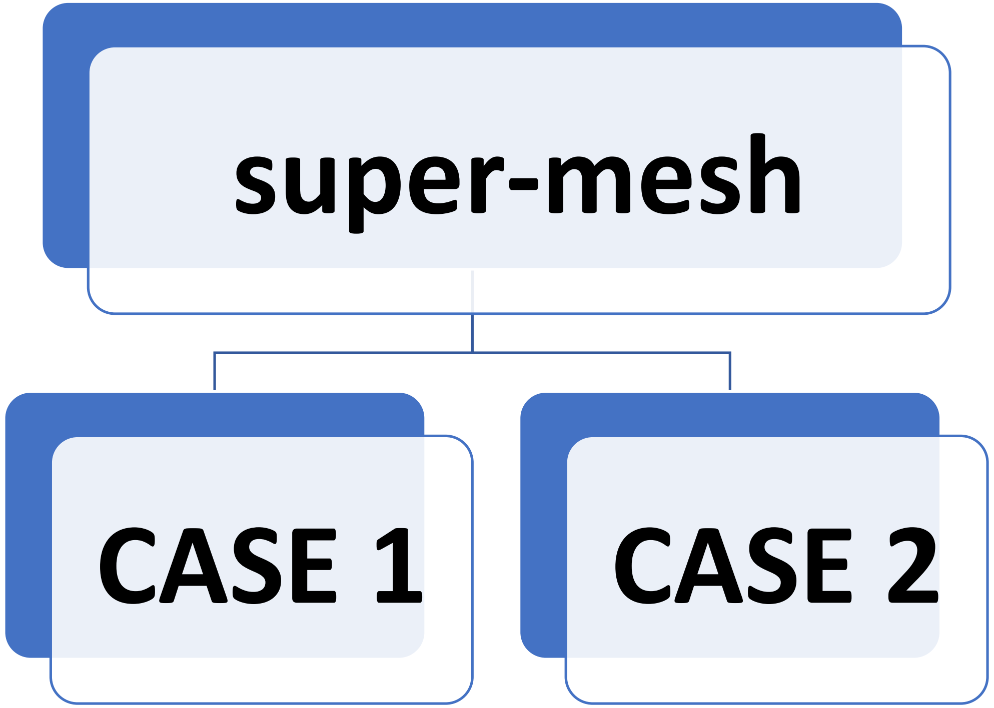
$i_1 = 29.6$ $\quad$ $i_2 = 26$ A $\quad$ $i_3 = 28$ A

and

$P_{4\Omega} = (i_3 - i_2)^2(4) = (2)^2(4) = 16$ W.

❑ super-mesh

- Mesh Analysis with Current Sources is called super-mesh (A super-mesh results when two meshes have a (dependent or independent) current source in common.) and considers as special case.

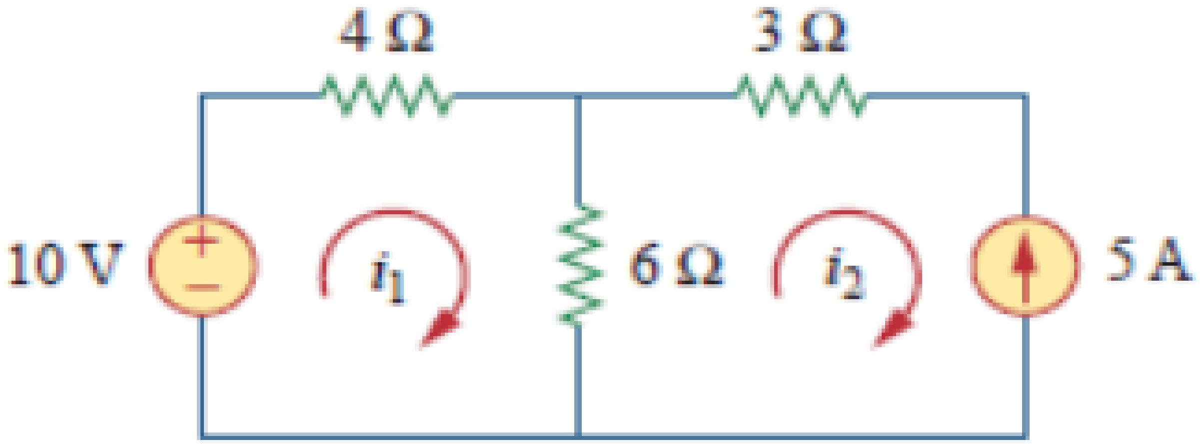


❑ CASE 1

- When a current source exists only in one mesh:
- Consider the circuit in next figure, for example. We set $i_2 = -5$ A and write a mesh equation for the other mesh in the usual way; that is,

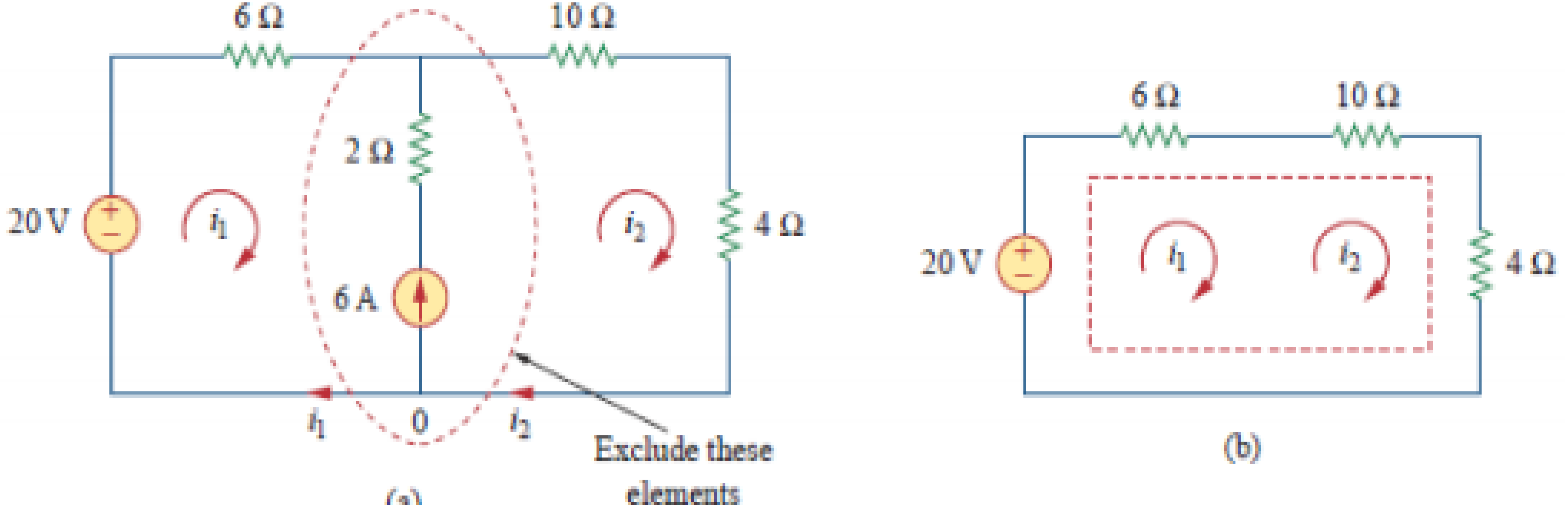
$$-10 + 4i_1 + 6\,(\,i_1 - (-5)\,) = 0 \quad \rightarrow i_1 = -2A$$

- Thus, our analysis is somewhat simplified by this knowledge of the voltage at this node.

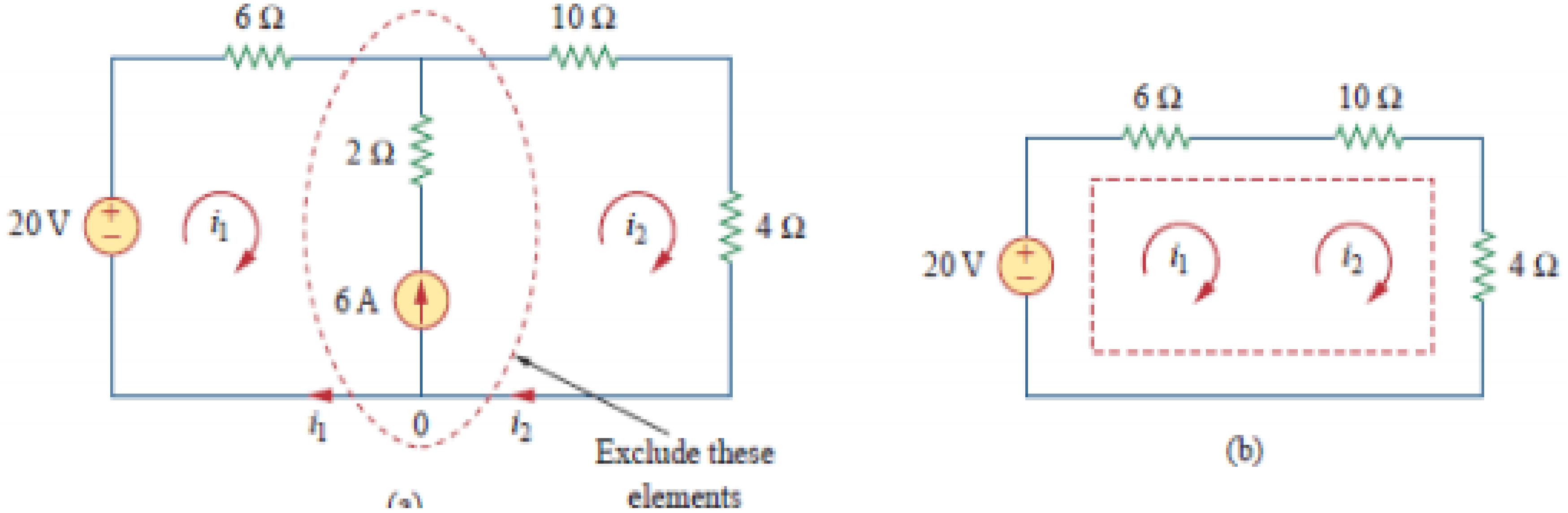


❑ CASE 2

- When a current source exists between two meshes:
- Consider the circuit in next figure, for example. We create a super-mesh by excluding the current source and any elements connected in series with it.



❑ CASE 2



$i_2 - i_1 = 6$ (1)

$-20 + 6\,i_1 + 10\,i_2 + 4\,i_2 = 0$ (2)

from (1) and (2)

$i_1 = -3.2$ A, $i_2 = 2.8$ A

Superposition Method

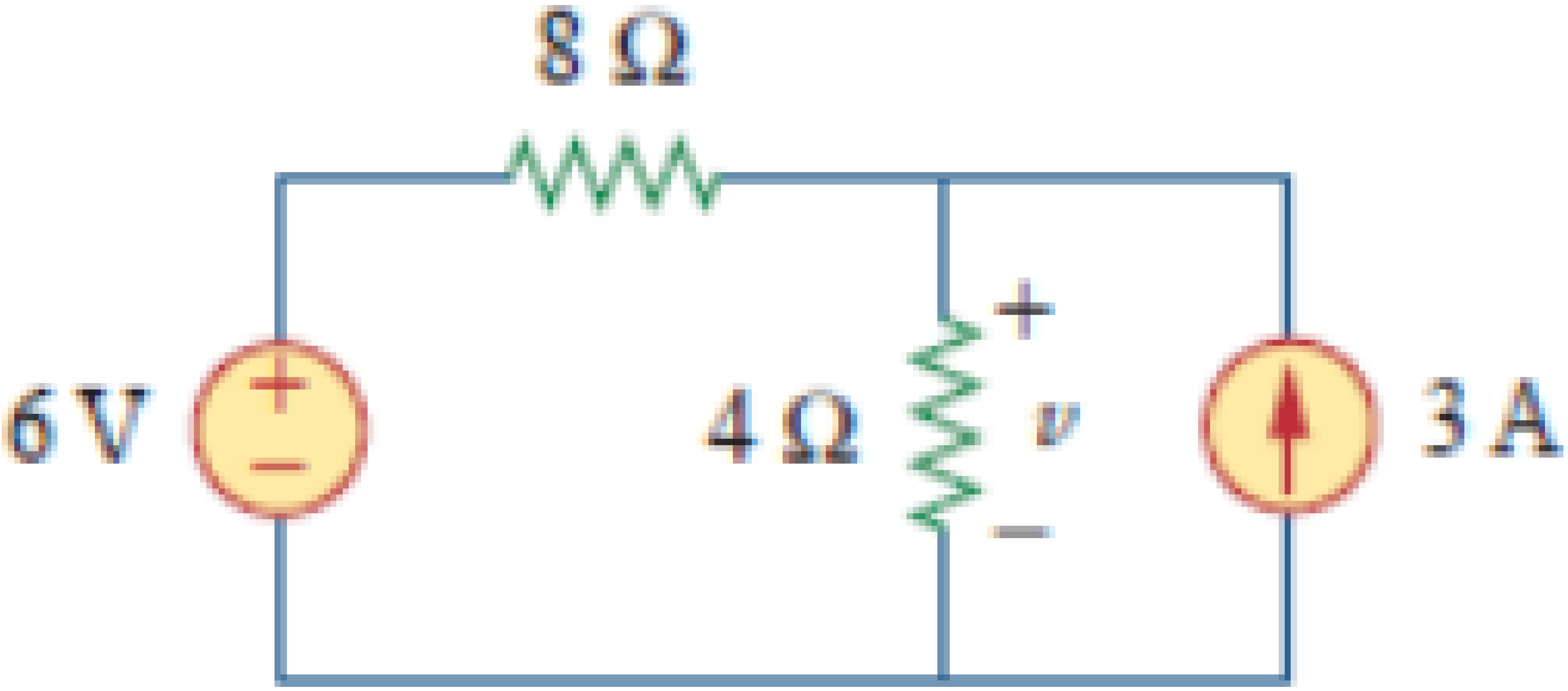
❑ Superposition

- The superposition principle states that the voltage across (or current through) an element in a linear circuit is the algebraic sum of the voltages across (or currents through) that element due to each independent source acting alone. With these in mind, we apply the superposition principle in three steps:

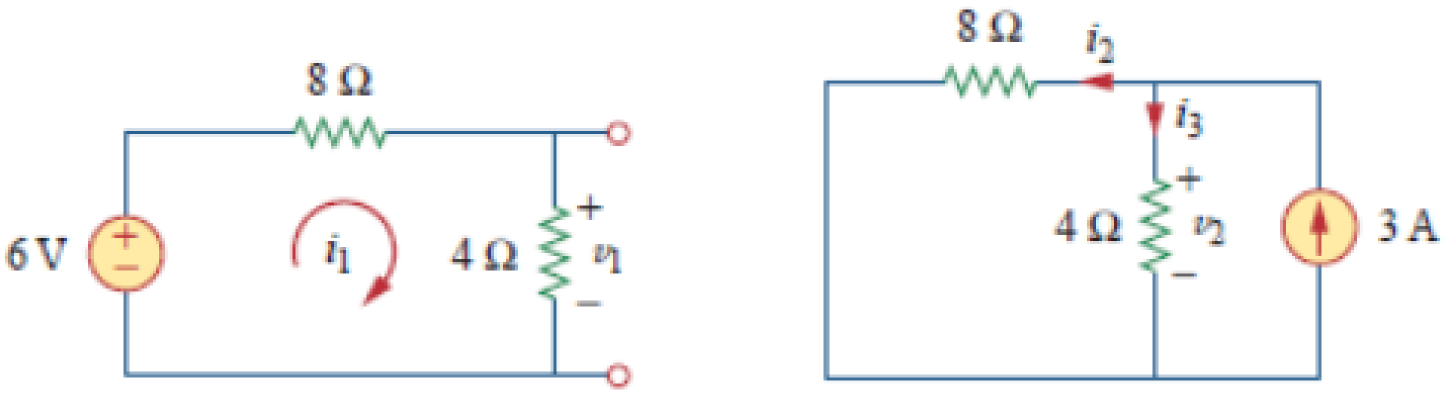
1. Turn off all independent sources except one source. Find the output (voltage or current) due to that active source.
2. Repeat step 1 for each of the other independent sources.
3. Find the total contribution by adding algebraically all the contributions due to the independent sources.

❑ Example5:

- Use the superposition theorem to find v in the circuit



❑ Example5:



(a) (b)

Answer: $v = v_1 + v_2$

from figure a by voltage divider

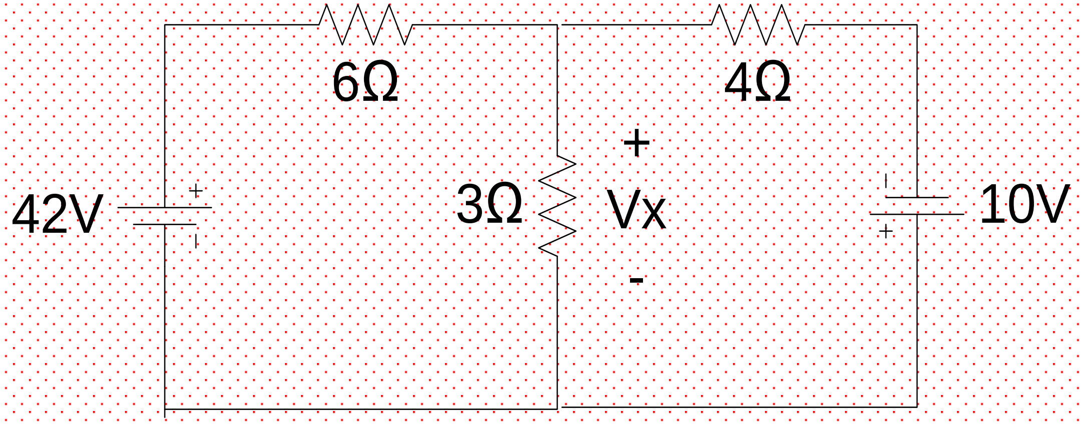
$$v_1 = 4i_1 = \frac{4}{4+8} * 6 = 2V$$

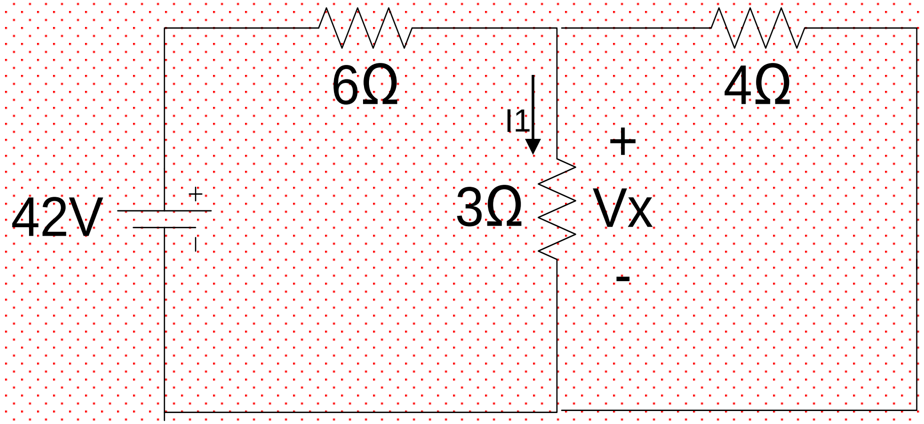
from figure b by current divider

$$v_2 = 4i_3 = 4 * \frac{8}{4+8} * 3 = 8V$$

$$v = v_1 + v_2 = 2 + 8 = 10V$$

Example 6: Find voltage Vx using superposition theorem

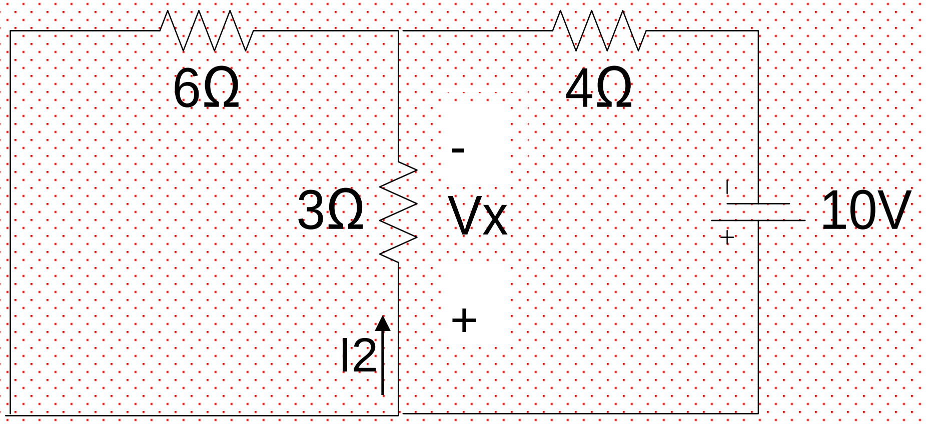




$$Considering\,42V source only (10V source SC)$$

$$Vx_{(42V)} = \frac{(3 \| 4)}{6 + (3 \| 4)} \times 42 = \frac{(12/7)}{6 + (12/7)} \times 42$$

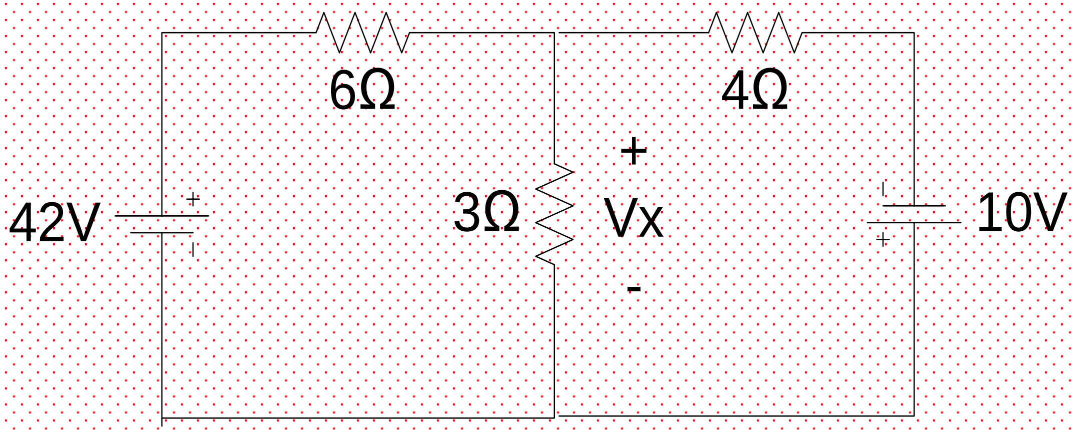
$$= 9.333V$$



$$Only 10V source connected \, (42V source replaced by SC)$$

$$Vx_{(10V)} = -\frac{(6 \| 3)}{(6 \| 3) + 4} \times 10 = -\frac{2}{2+4} \times 10$$

$$= -3.333V$$

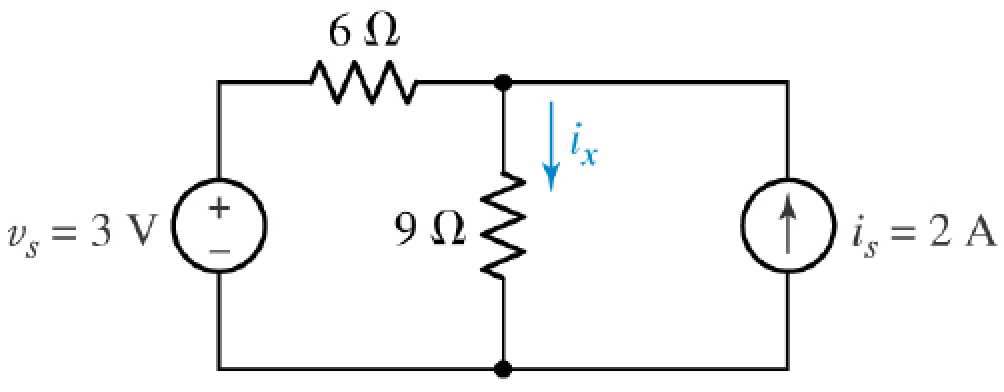


$$TotalVoltage =$$

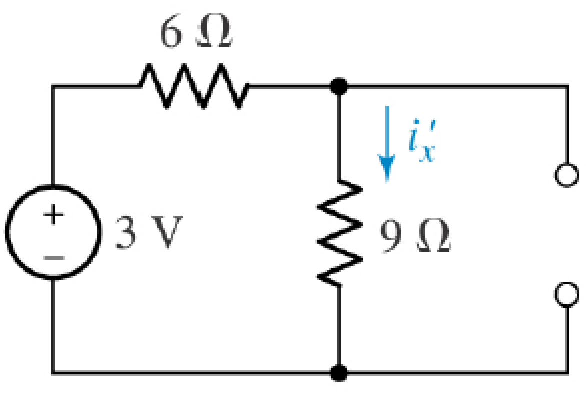
$$Vx = Vx_{(42V)} + Vx_{(10V)}$$

$$= 9.333 - 3.333 = 6V$$

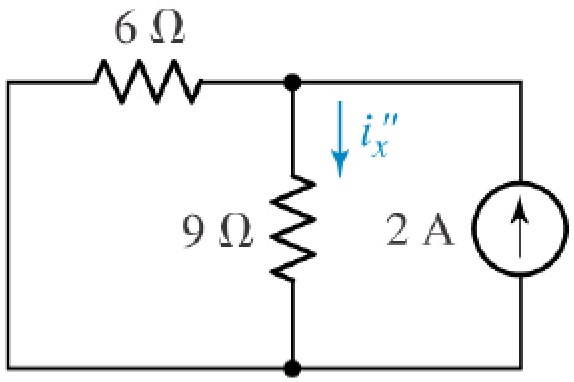
Example 7: Use superposition to find i_x



(a)



(b)



(c)

Step 1:

Only 3V source connected(2A source is OC)

$i_x' = 3/15 = 0.2\text{ A}$

Step2:

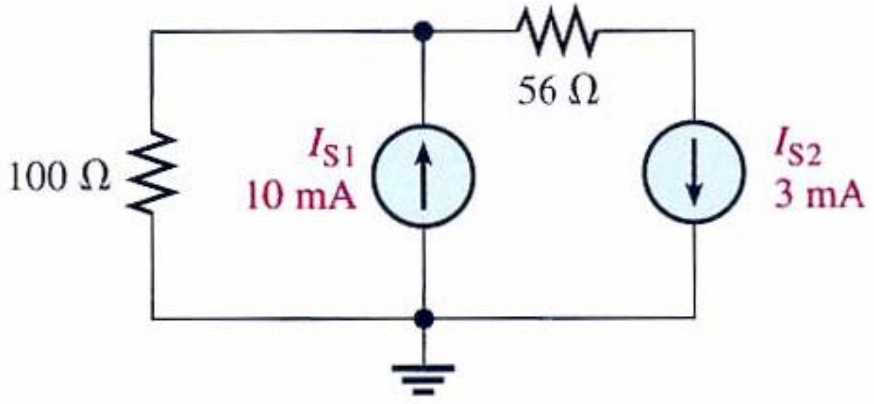
Only 2A source connected(3V source is SC)

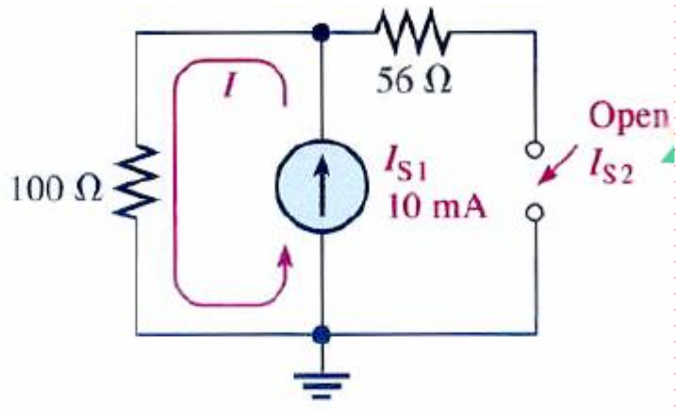
$i_x'' = 2x6/(6+9) = 0.8\text{ A}$

Step 3:Totalcurrent=0.2+0.8=1A

$i_x = 1.0\text{ A}$

EXAMPLE Find the current through the 100 Ω resistor.

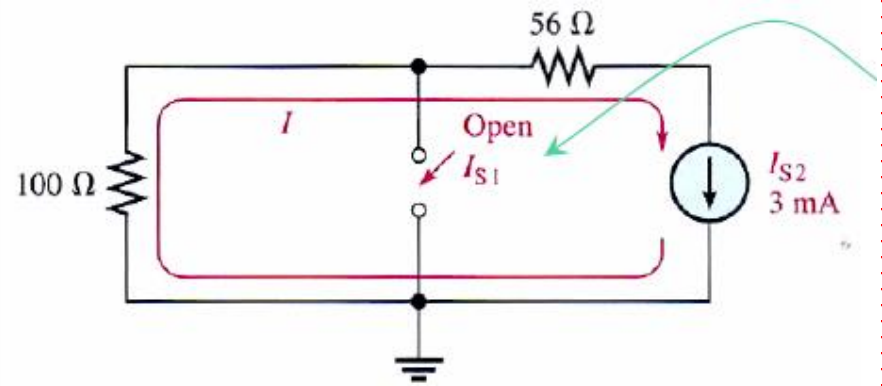




Step 1:

Only 10ma source connected in circuit(3mA source OC)

I=10mA



Step2: Only 3mA source connected(10mA source OC)

I'=3mA

Total Current:10mA-3mA=7mA


Thank you