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Mesh Analysis

A mesh is a loop which does not contain any other loops within it.

Mesh analysis provides another general procedure for analyzing circuits.

Mesh currents is used as the circuit variables.

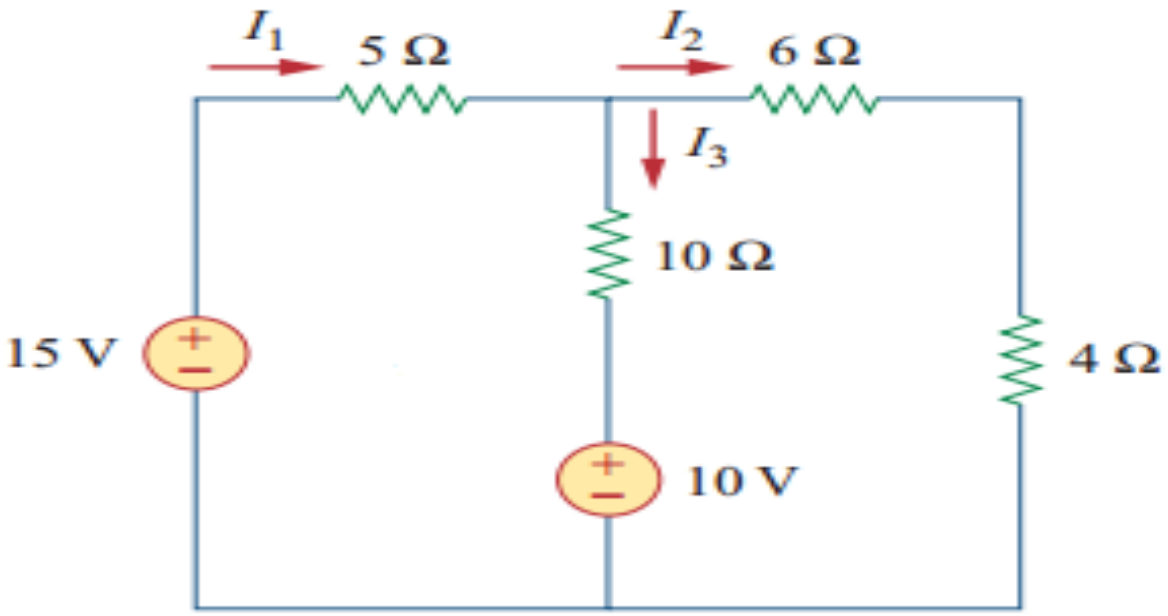
Element current

Steps to Determine Mesh Currents:

1. Assign mesh currents $i_1, i_2, \ldots, i_n$ 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

Problem: Find the branch currents I_1, I_2 and I_3 using mesh analysis.



Mesh Analysis

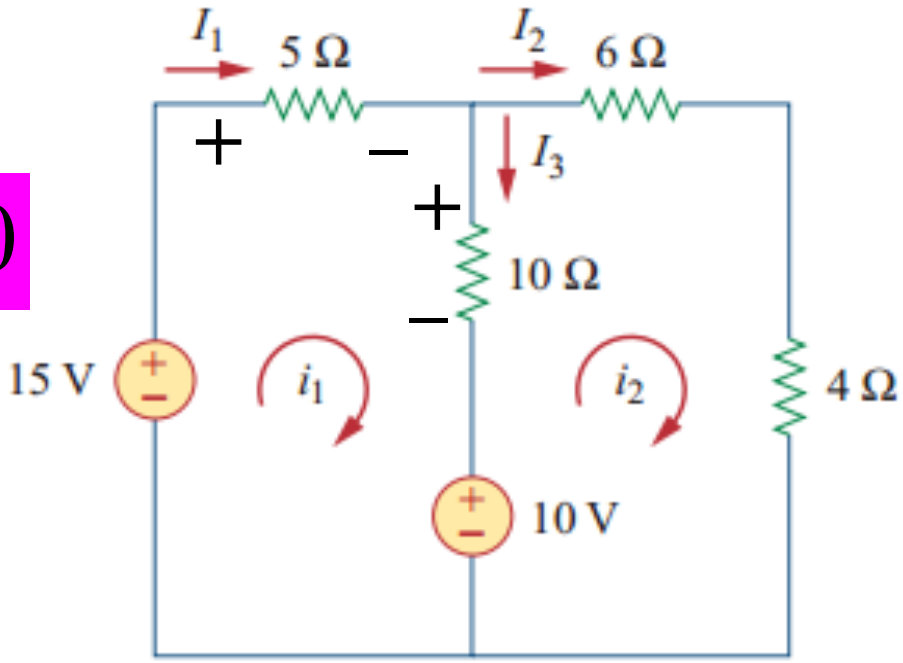
Solution: Assign the mesh current

Apply KVL for mesh 1

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

$$15i_1-10i_2-5=0$$

$$3i_1-2i_2=1.....(i)$$



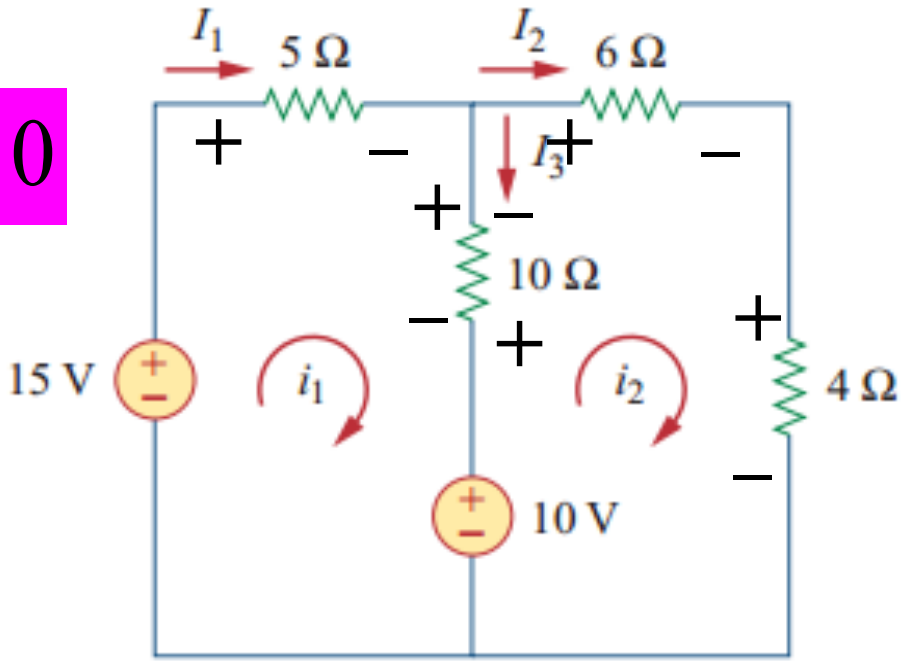
Mesh Analysis

Apply KVL for mesh 2

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

$$-10i_1+20i_2=10$$

$$-i_1+2i_2=1.....(ii)$$



After solving equation (i) and (ii), we get,

$$i_1=1\,A \qquad i_2=1\,A$$

Mesh Analysis

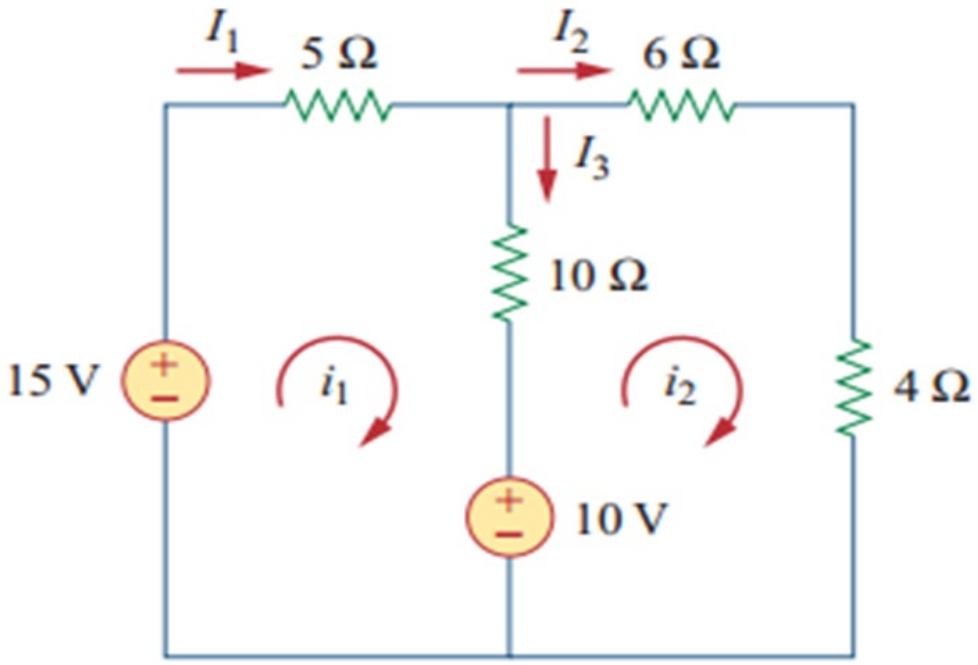
Branch current is

$$I_1 = i_1 = 1\,A$$

$$I_2 = i_2 = 1\,A$$

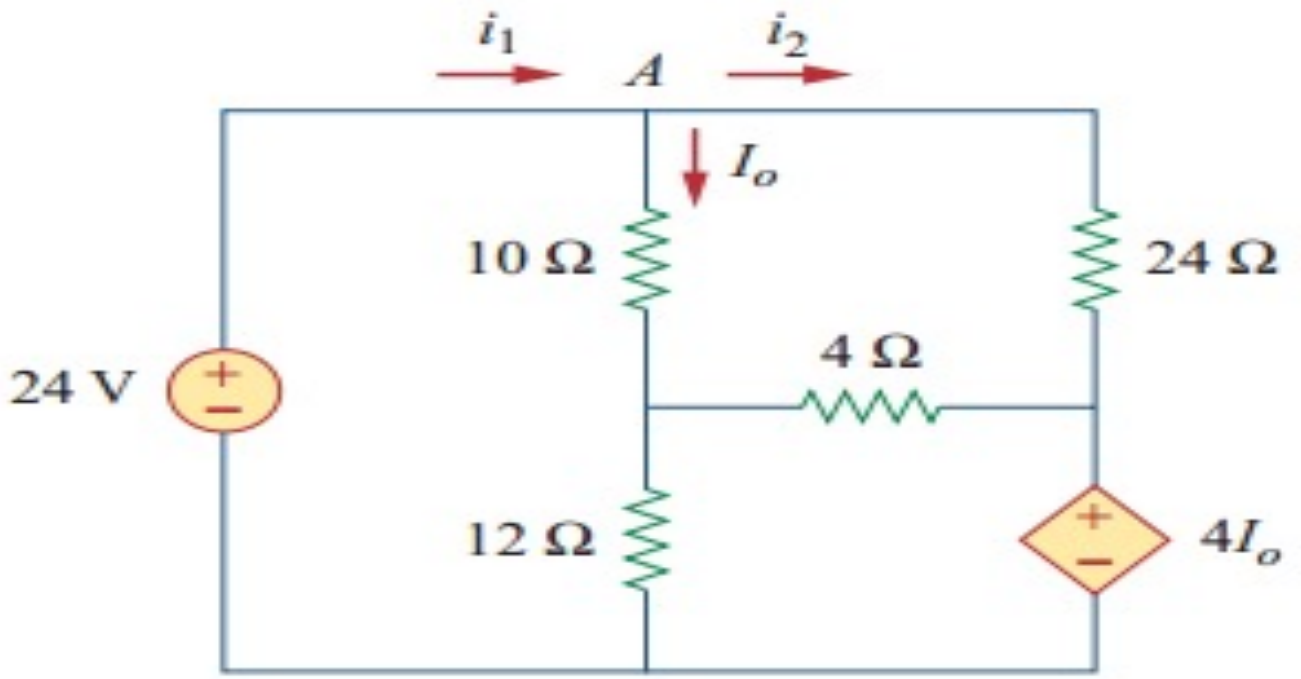
$$I_3 = i_1 - i_2$$

$$I_3 = 0\,A$$



Mesh Analysis

Problem: Use mesh analysis to find the current I_o



Mesh Analysis

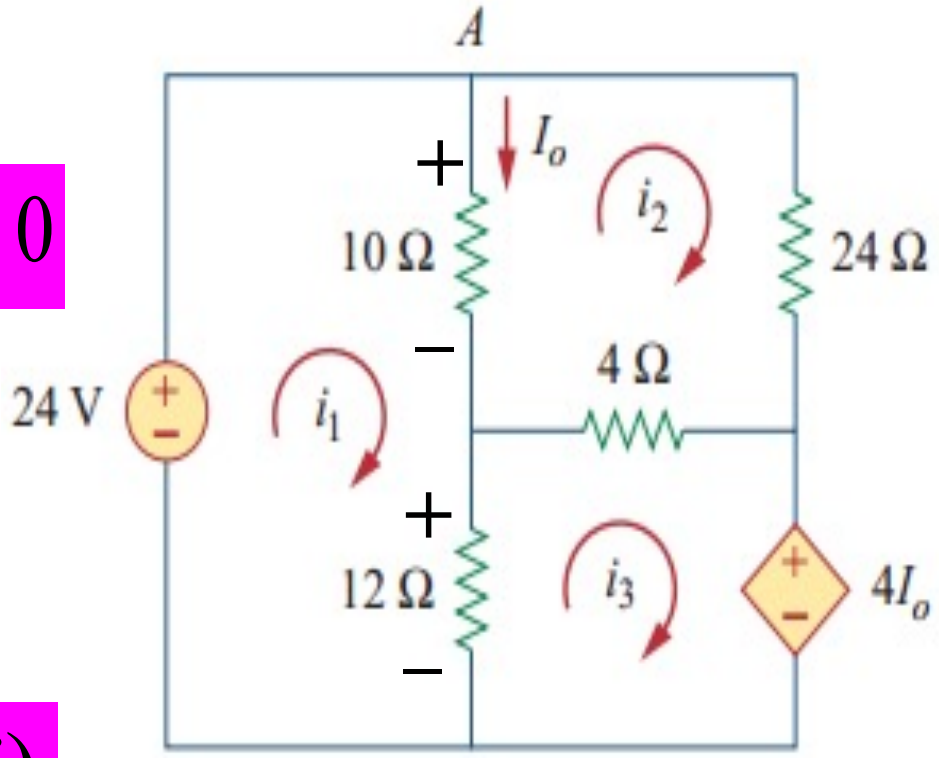
Solution: Assign the mesh current

Apply KVL for mesh 1

$$-24+10(i_1-i_2)+12(i_1-i_3)=0$$

$$22i_1-10i_2-12i_3=24$$

$$11i_1-5i_2-6i_3=12.....(i)$$



Mesh Analysis

Apply KVL for mesh 2

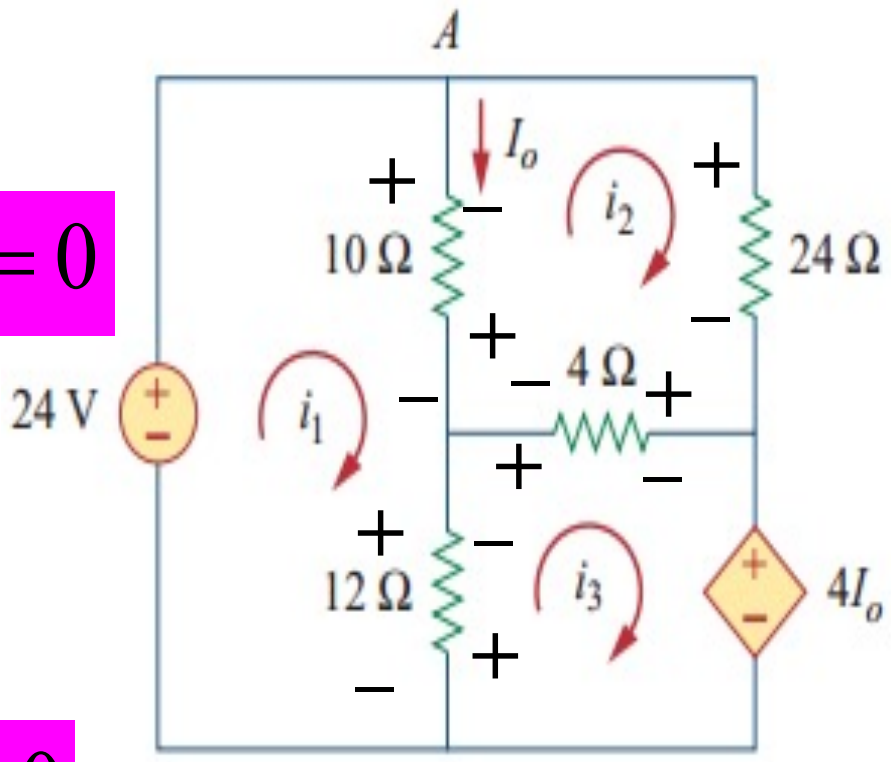
$$10(i_2 - i_1) + 24i_2 + 4(i_2 - i_3) = 0$$

$$-5i_1 + 19i_2 - 2i_3 = 0 \ldots (ii)$$

Apply KVL for mesh 3

$$12(i_3 - i_1) + 4(i_3 - i_2) + 4I_o = 0$$

$$-i_1 - i_2 + 2i_3 = 0 \ldots\ldots (iii)$$



But,

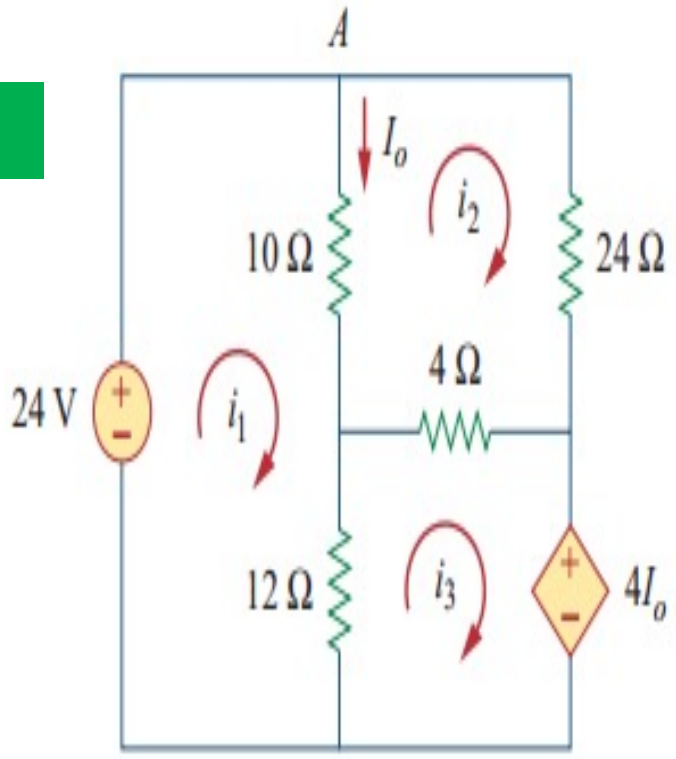
$$I_o = i_1 - i_2$$

Mesh Analysis

After solving equation (i), (ii) and (iii), we get,

$$i_1 = 2.25\,A \qquad i_2 = 0.75\,A$$

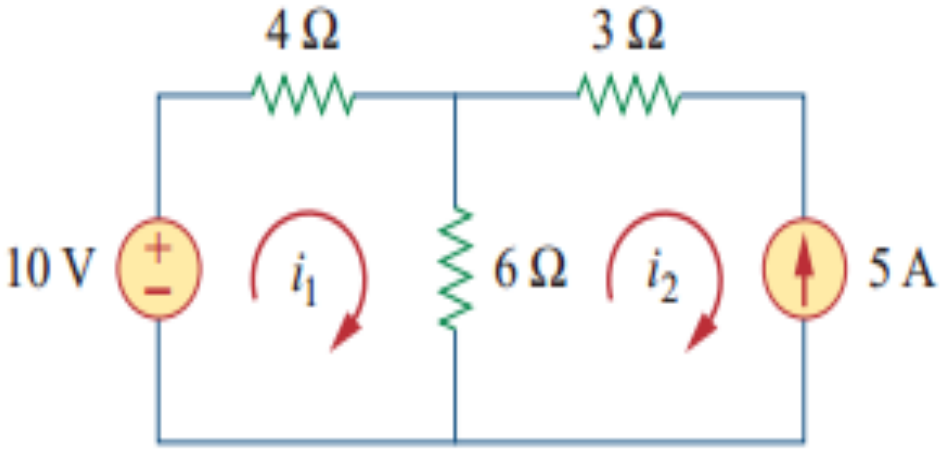
$$i_3 = 1.5\,A$$



Thus,

$$I_o = i_1 - i_2 = 2.25 - 0.75 = 1.5\,A$$

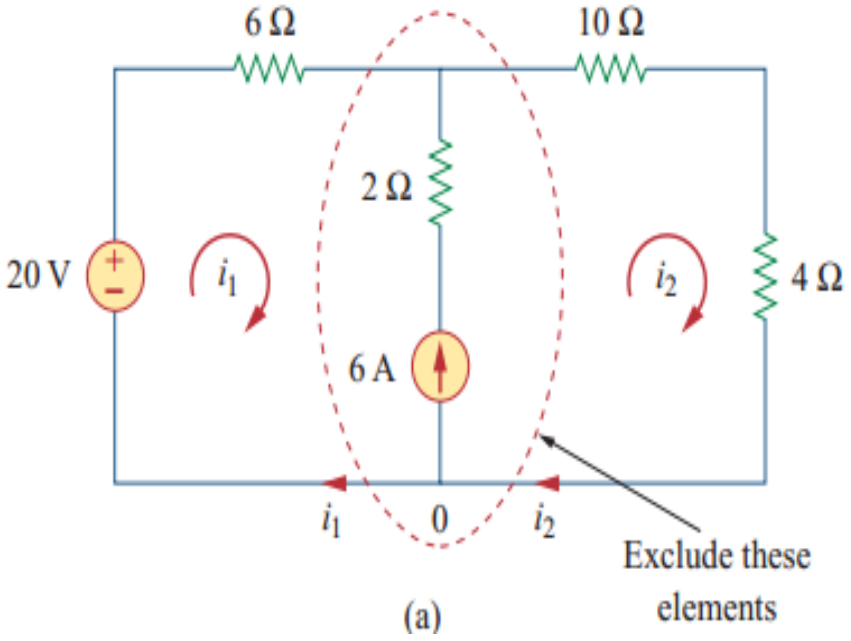
Mesh Analysis with Current Sources

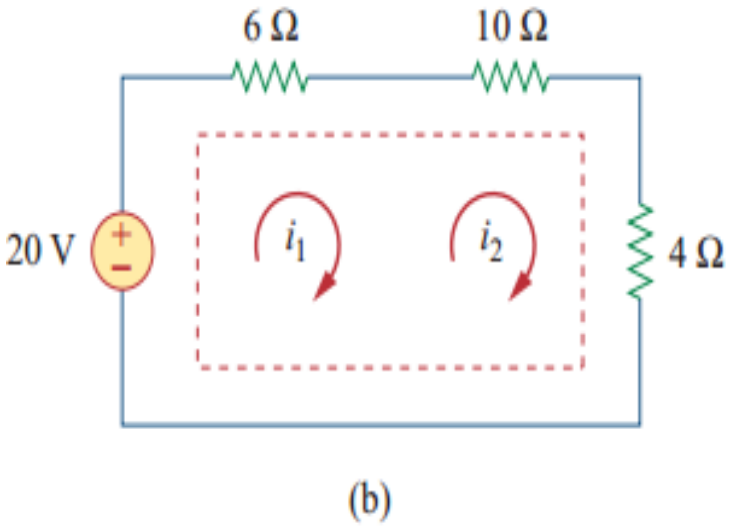


When a current source exists only in one mesh, mesh current can be determined directly. Consider the above circuit, we can set i_2= -5 A and write a mesh equation for the other mesh in the usual way.

Mesh Analysis with Current Sources

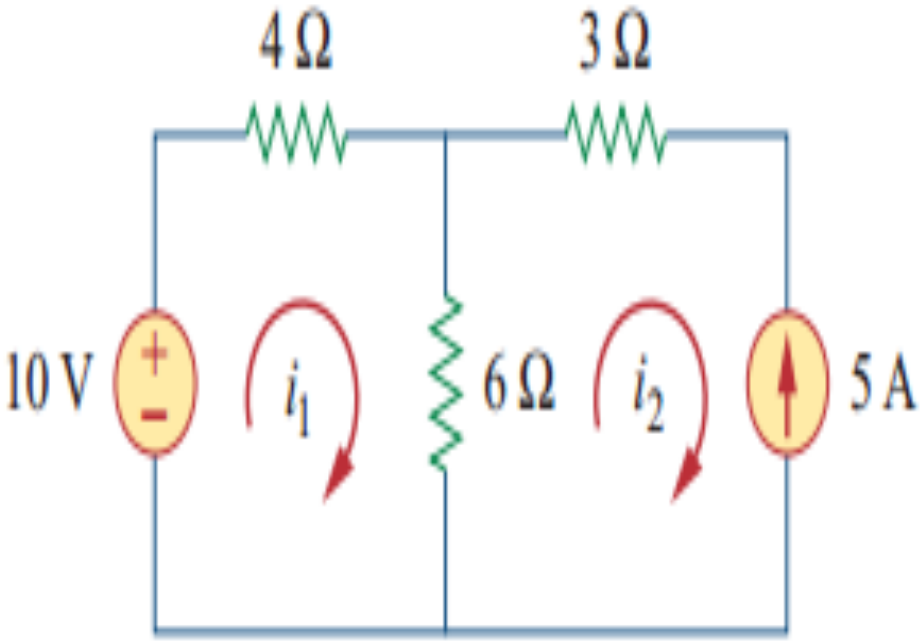
When a current source exists between two meshes, we create a supermesh by excluding the current source and any elements connected in series with it.





Mesh Analysis with Current Sources

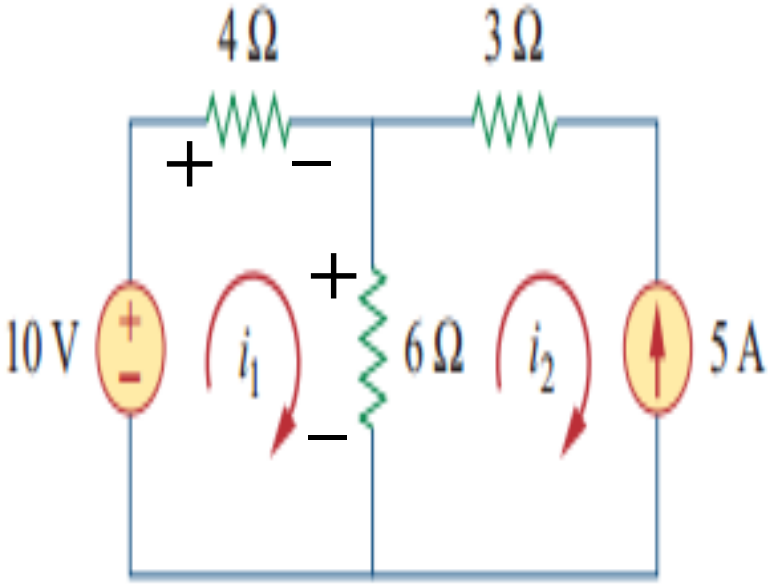
Problem: Use mesh analysis to find the current i_1 and i_2



Mesh Analysis with Current Sources

Solution: i_2 current can be directly found from mesh 2 that is

$$i_2 = -5\,A$$



Apply KVL for mesh 1

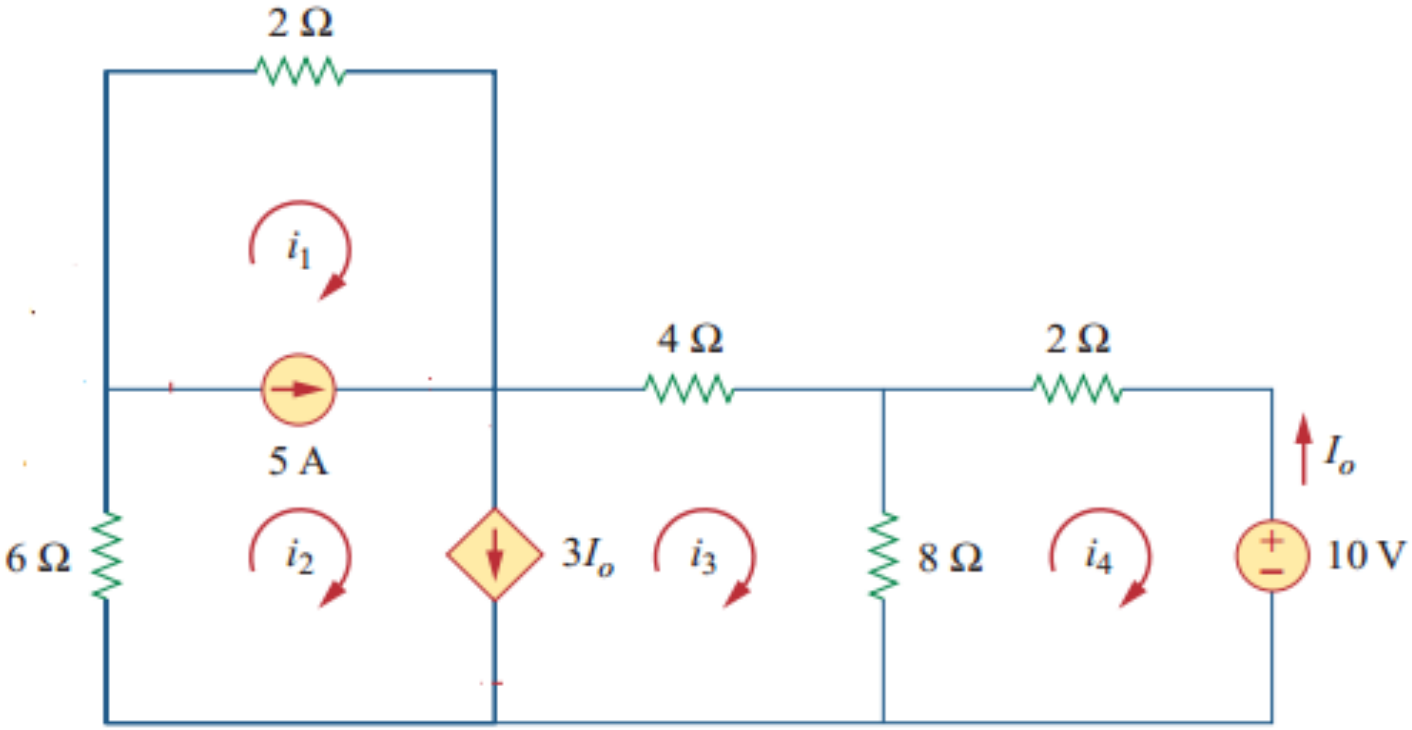
$$-10 + 4i_1 + 6(i_1 - i_2) = 0$$

$$10i_1 - 6i_2 = 10$$

$$i_1 = -2\,A$$

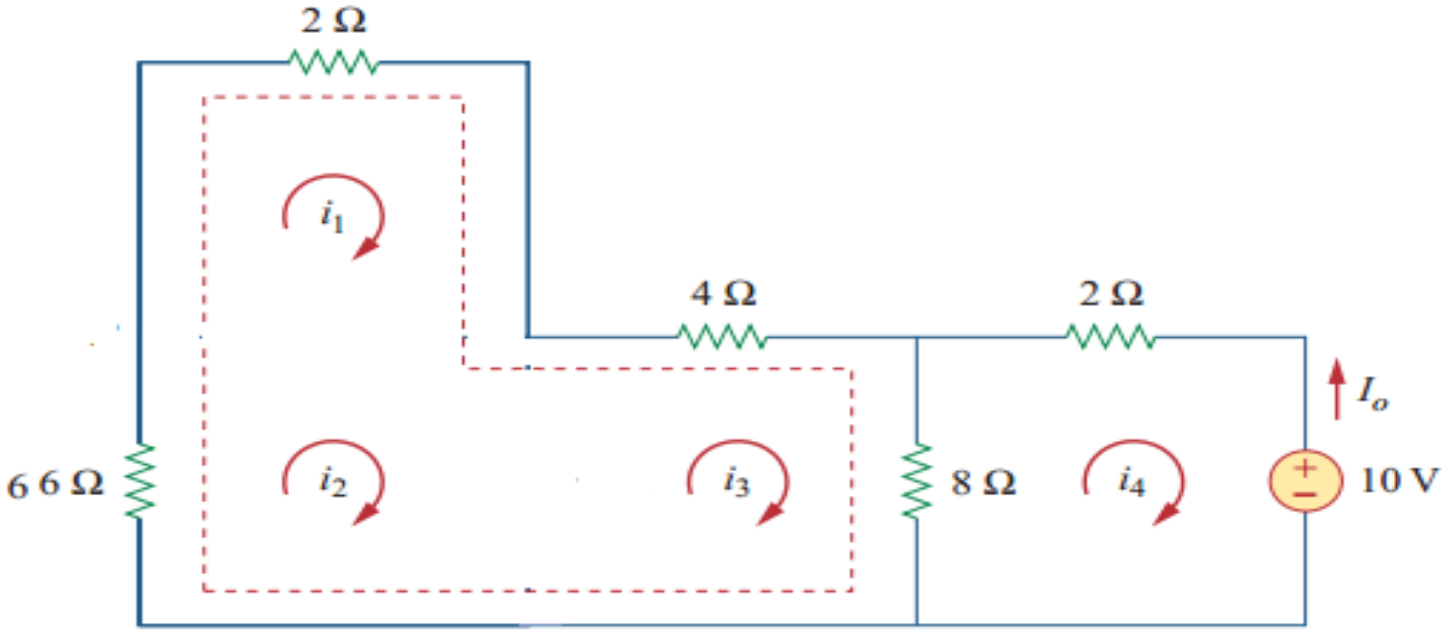
Mesh Analysis with Current Sources

Problem: Find i_1 to i_4 using mesh analysis.

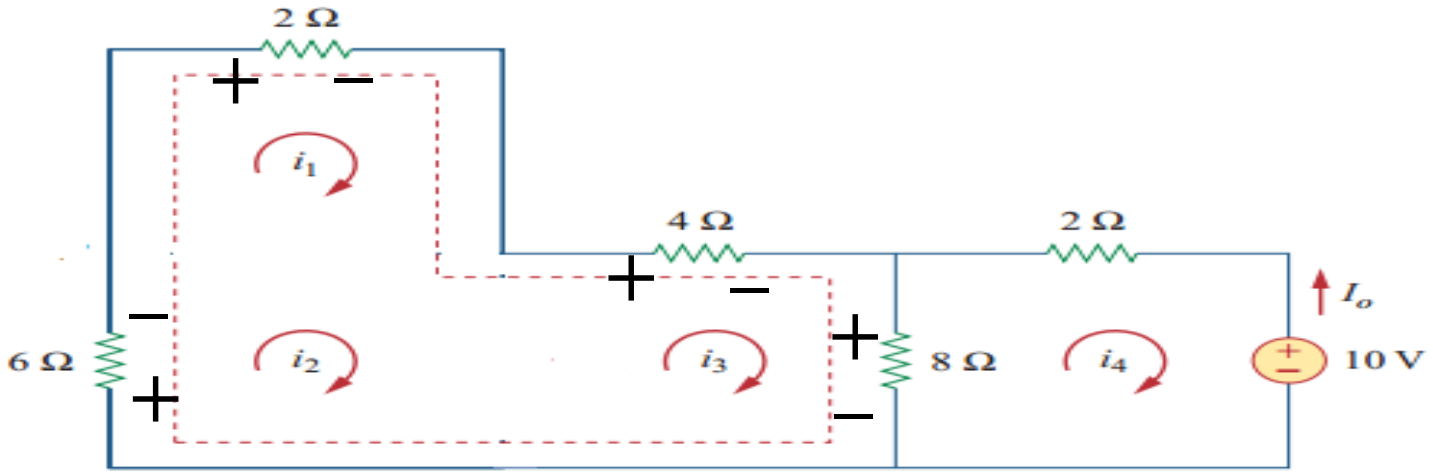


Mesh Analysis with Current Sources

Solution: Meshes 1 and 2 form a supermesh since they have an independent current source in common. Also, meshes 2 and 3 form another supermesh because they have a dependent current source in common. The two supermeshes intersect and form a larger supermesh as shown.



Mesh Analysis with Current Sources

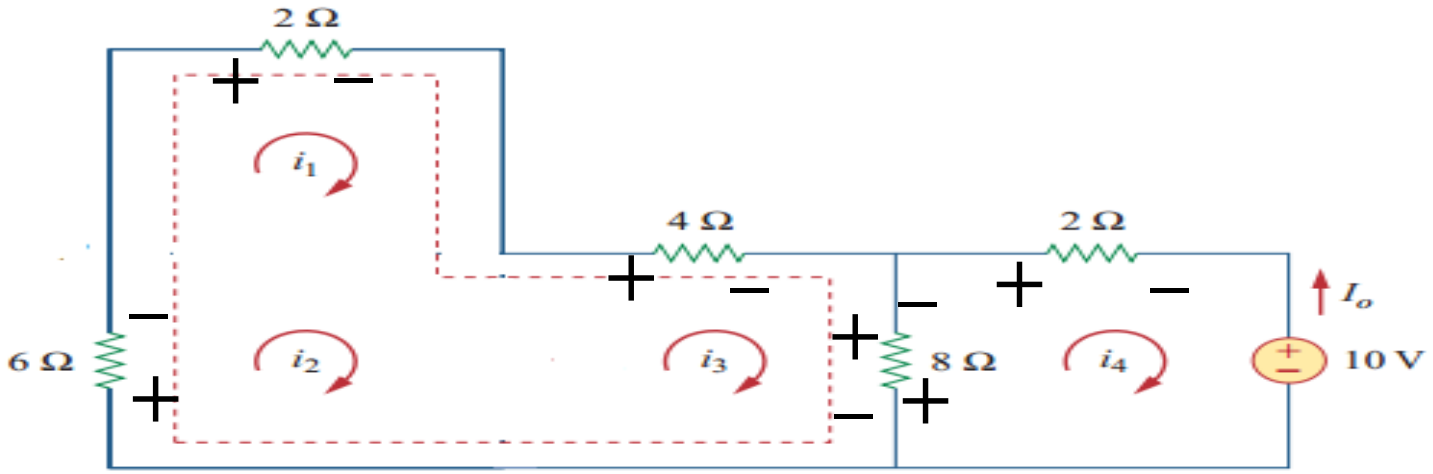


Applying KVL to the larger supermesh

$$6i_2 + 2i_1 + 4i_3 + 8(i_3 - i_4) = 0$$

$$i_1 + 3i_2 + 6i_3 - 4i_4 = 0 \ldots\ldots\ldots (i)$$

Mesh Analysis with Current Sources

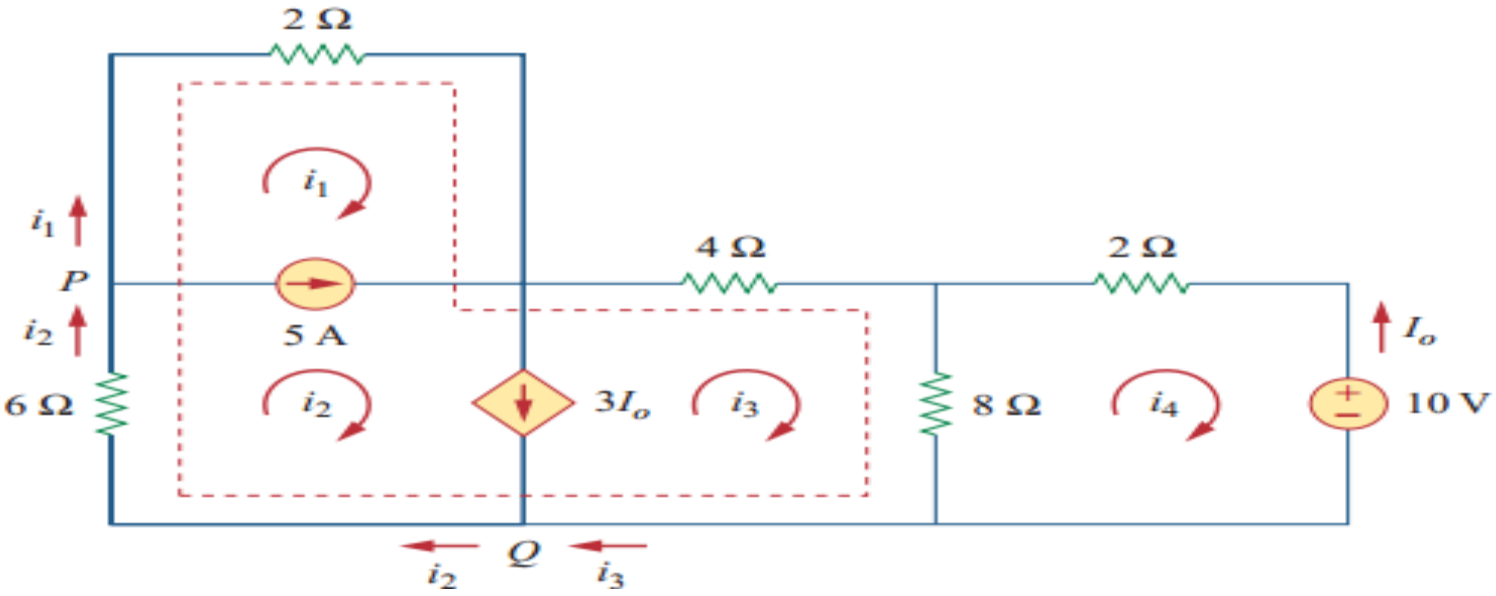


Applying KVL to the mesh 4

$$8(i_4 - i_3) + 2i_4 + 10 = 0$$

$$4i_3 - 5i_4 = -5 \ldots\ldots (ii)$$

Mesh Analysis with Current Sources



But,

$$i_2 - i_1 = 5 \ldots\ldots (iii)$$

$$i_2 - i_3 = 3I_0 \leftarrow I_0 = -i_4$$

$$i_2 - i_3 + 3i_4 = 0 \ldots\ldots\ldots (iv)$$

Mesh Analysis with Current Sources

After solving equation (i), (ii), (iii) and (iv), we get,

$$i_1 = -7.5\,A$$

$$i_3 = 3.93\,A$$

$$i_2 = -2.5\,A$$

$$i_4 = 2.143\,A$$

Home Work

Practice Problem: 2.9, 2.10, 2.14, 2.15, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7

Thank You