COM234 ELECTRONICS

The Mesh Current Method

Mesh Currents

The mesh method uses the **mesh currents** as the circuit variables. The procedure for obtaining the solution is similar to that followed in the Node method and the various steps are given below.

1.Clearly label all circuit parameters and distinguish the unknown parameters from the known.

2. Identify all meshes of the circuit.

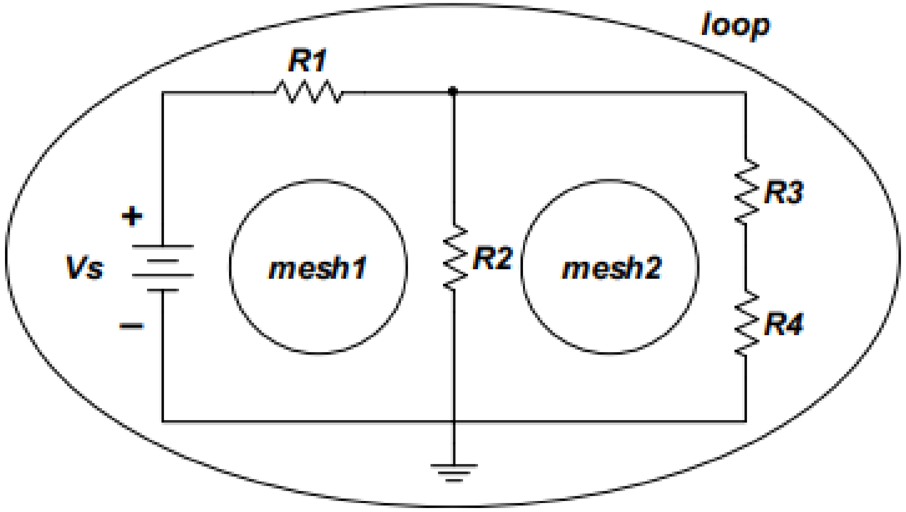
3. Assign mesh currents and label polarities.

4. Apply KVL at each mesh and express the voltages in terms of the mesh currents.

5. Solve the resulting simultaneous equations for the mesh currents.

The Mesh Method 1. Step

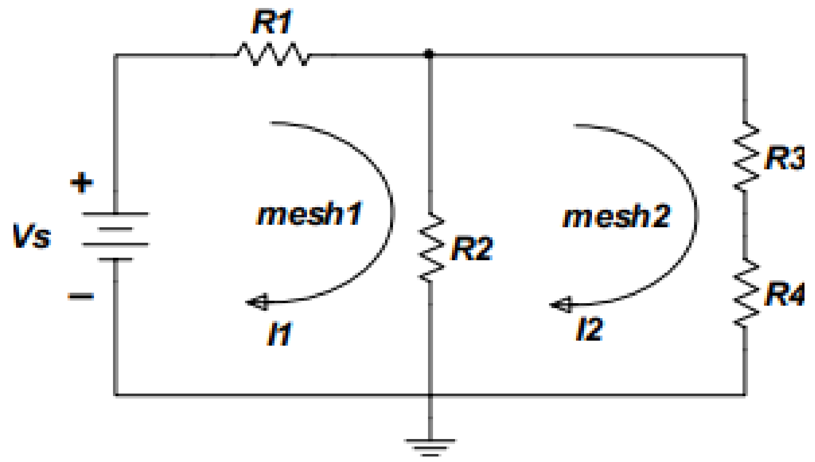
A mesh is defined as a loop which does not contain any other loops. Our circuit example has three loops but only two meshes as shown on Figure. Note that we have assigned a ground potential to a certain part of the circuit. Since the definition of ground potential is fundamental in understanding circuits this is a good practice and thus will continue to designate a reference (ground) potential as we continue to design and analyze circuits regardless of the method used in the analysis.



The Mesh Method 2. Step

For the next step we will assign mesh currents, define current direction and voltage polarities.

The direction of the mesh currents I1 and I2 is defined in the clockwise direction as shown on Figure. This definition for the current direction is arbitrary but it helps if we maintain consistence in the way we define these current directions. Note that in certain parts of the mesh the branch current may be the same as the current in the mesh. The branch of the circuit containing resistor R2 is shared by the two meshes and thus the branch current (the current flowing through R2) is the difference of the two mesh currents. (Note that in order to distinguish between the mesh currents and the branch currents by using the symbol **I** for the mesh currents and the symbol **i** for the branch currents.)



The Mesh Method 3. Step

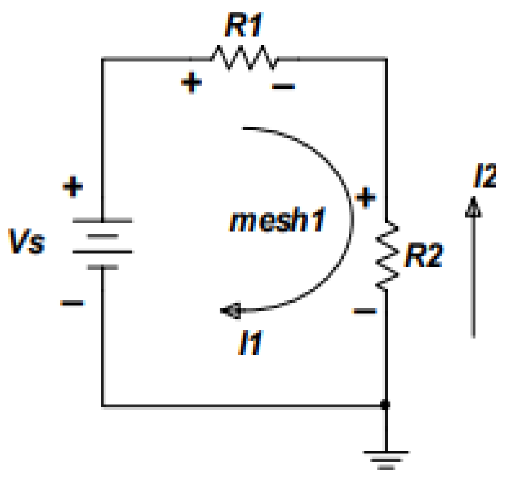
Now let's turn our attention in labeling the voltages across the various branch elements.

We choose to assign the voltage labels to be consistent with the direction of the indicated mesh currents. In the case where a certain branch is shared by two meshes as is the case in our example with the branch that contains resistor R2 the labeling of the voltage is done for each mesh consistent with the assigned direction of the mesh current.

In this, our first encounter with mesh analysis let's consider the each mesh separately and apply KVL around the loop following the defined direction of the mesh current. Considering mesh1. For clarity we have separated mesh1 from the circuit on Figure 11. In doing this, care must be taken to carry all the information of the shared branches. Here we indicate the direction of mesh current I2 on the shared branch.

Considering mesh1.

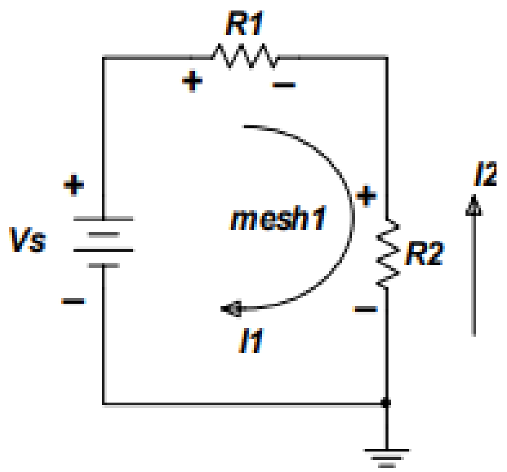
For clarity we have separated mesh1 from the circuit on Figure. In doing this, care must be taken to carry all the information of the shared branches. Here we indicate the direction of mesh current I2 on the shared branch.



The Mesh Method 4. Step

Apply KVL to mesh1.

Starting at the upper left corner and proceeding in a clock-wise direction the sum of voltages across all elements encountered is:



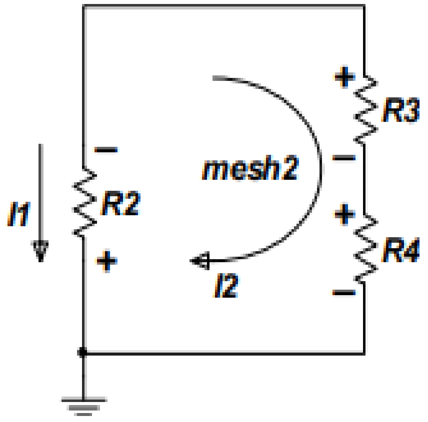
$$I1R1 + (I1 - I2)R2 - Vs = 0$$

The Mesh Method 4. Step

Apply KVL to mesh2.

Similarly, consideration of mesh2 is shown on Figure. Note again that we have indicated the direction of the mesh current I1 on the shared circuit branch.

Starting at the upper right corner and proceeding in a clock-wise direction the sum of voltages across all elements encountered is:



$$I2(R3+R4)+(I2-I1)R2=0$$

The Mesh Method 5. Step

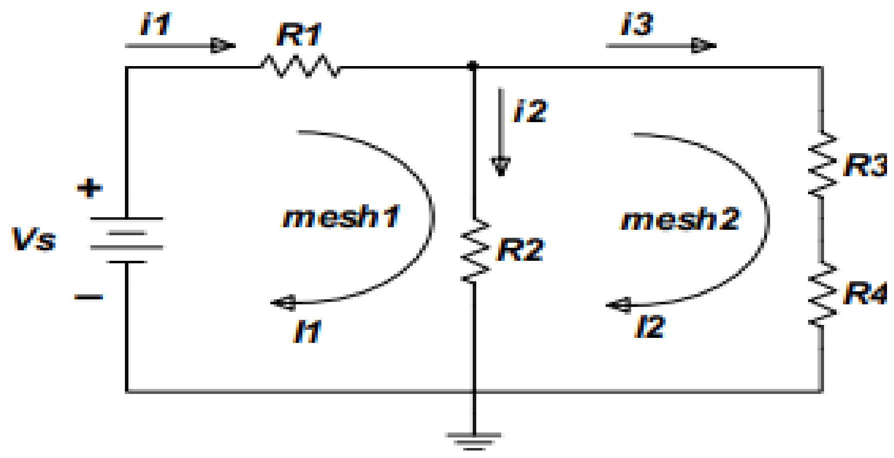
Solve equations

Keeping in mind that the unknowns of the problem are the mesh currents I1 and I2 we rewrite the mesh equations as:

$$I1(R1+R2)-I2R2=Vs$$

$$-I1R2+I2(R2+R3+R4)=0$$

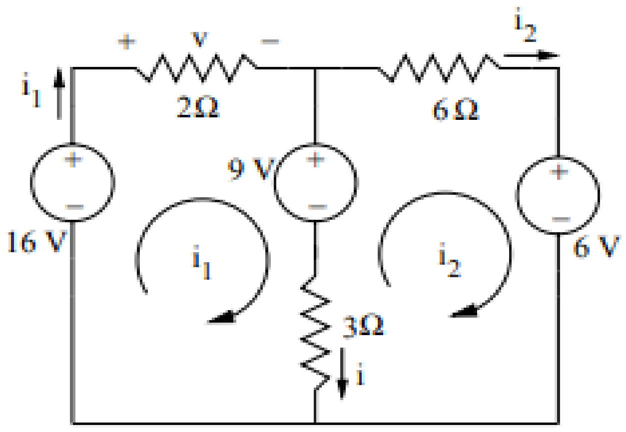
$$\begin{bmatrix} R1+R2 & -R2 \\ -R2 & R2+R3+R4 \end{bmatrix}\begin{bmatrix} I1 \\ I2 \end{bmatrix}=\begin{bmatrix} Vs \\ 0 \end{bmatrix}$$



$$i1 = I1$$
$$i2 = I1 - I2$$
$$i3 = I2$$

Example 1.

Example Find i and v.
Using mesh-current method:



Mesh 1: $\quad 2i_1 + 9 + 3(i_1 - i_2) - 16 = 0$

Mesh 2: $\quad 6i_2 + 6 + 3(i_2 - i_1) - 9 = 0$

$$\begin{cases} 5i_1 - 3i_2 = 7 \\ -3i_1 + 9i_2 = 3 \end{cases} \rightarrow \begin{cases} i_1 = 2 \text{ A} \\ i_2 = 1 \text{ A} \end{cases}$$

The problem unknowns, i and v can now be found from the mesh currents:

$$i = i_1 - i_2 = 1 \text{ A}$$

$$v = 2i_1 = 4 \text{ V}$$

Node-voltage or mesh-current?

Deciding which approach to take in a particular circuit usually boils down to determining which method leads to easier math – fewest number of simultaneous equations.

node number (N)

1. Count number of nodes in the circuit.
2. Subtract 1 for ground.
3. Subtract 1 for each voltage source which has a connection (+ or –) to ground.
4. Add 1 for each voltage source which has no connection to ground.

mesh number (M)

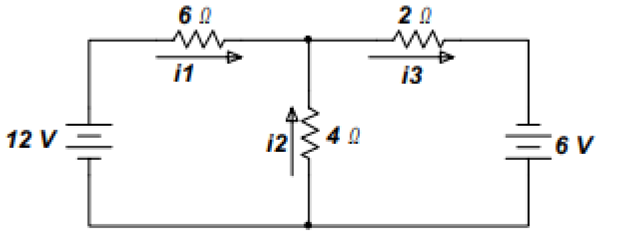
1. Count number of meshes in the circuit.
2. Subtract 1 for each current source which is located in an outside branch of a mesh.
3. Add 1 for each current source which is located in an interior branch (shared between two meshes). (More on this later.)

If $N < M$, the node-voltage method should have less math.

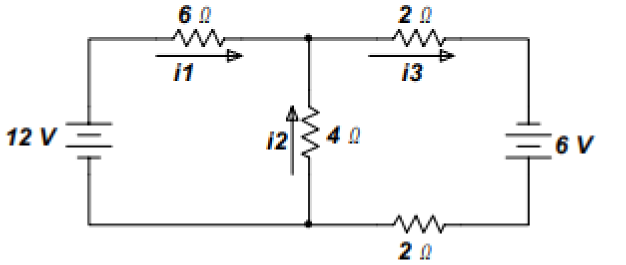
If $M < N$, the mesh-current method should have less math.

Practice problems with answers.

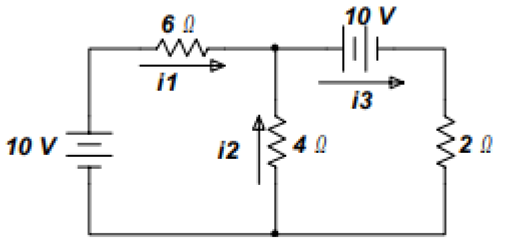
Determine the currents in the following circuits with reference to the indicated direction.



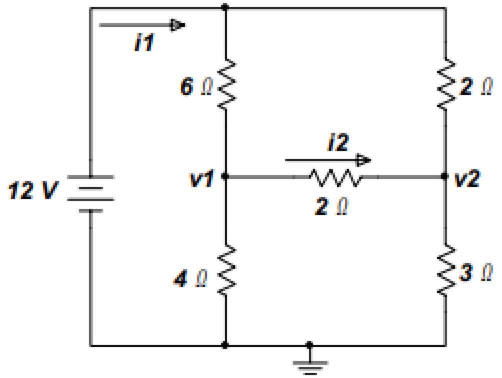
Answer: $i1 = 2.180A$, $i2 = 0.270A$, $i3 = 2.450A$



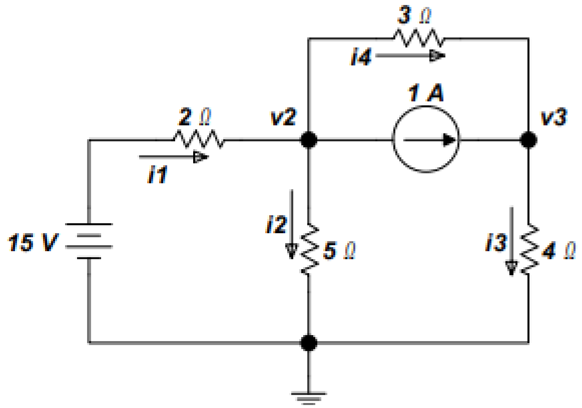
Answer: $i1 = 1.877A$, $i2 = -0.187A$, $i3 = 1.690A$



Answer: $i1 = 0.455A$, $i2 = -1.820A$, $i3 = -1.36A$



Answer: $i1 = 3.690A$, $i2 = -0.429A$, $v1 = 5.83V$, $v2 = 6.69V$



Answer: $i1 = 3.31A, i2 = 1.68A, i3 = 1.63A, i4 = 0.627A, v2 = 8.39V, v3 = 6.51V$