

or

$$6i_1 + 14i_2 = 20 \quad (3.18)$$

We apply KCL to a node in the branch where the two meshes intersect. Applying KCL to node 0 in Fig. 3.23(a) gives

$$i_2 = i_1 + 6 \quad (3.19)$$

Solving Eqs. (3.18) and (3.19), we get

$$i_1 = -3.2 \text{ A}, \quad i_2 = 2.8 \text{ A} \quad (3.20)$$

Note the following properties of a supermesh:

1. The current source in the supermesh provides the constraint equation necessary to solve for the mesh currents.
2. A supermesh has no current of its own.
3. A supermesh requires the application of both KVL and KCL.

For the circuit in Fig. 3.24, find i_1 to i_4 using mesh analysis.

Example 3.7

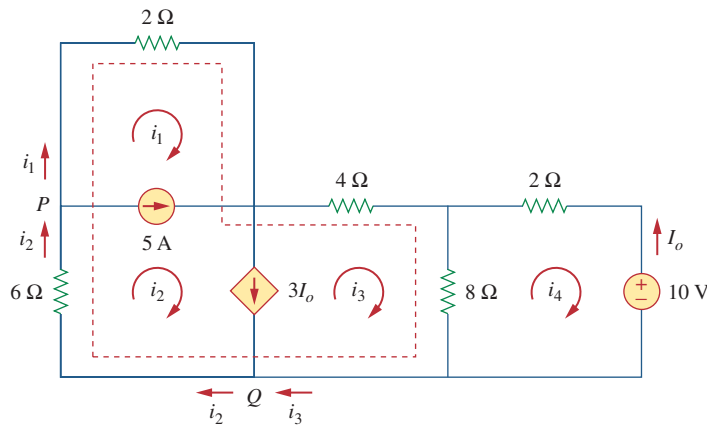


Figure 3.24
For Example 3.7.

Solution:

Note that 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. Applying KVL to the larger supermesh,

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

or

$$i_1 + 3i_2 + 6i_3 - 4i_4 = 0 \quad (3.7.1)$$

For the independent current source, we apply KCL to node P :

$$i_2 = i_1 + 5 \quad (3.7.2)$$

For the dependent current source, we apply KCL to node Q :

$$i_2 = i_3 + 3I_o$$

But $I_o = -i_4$, hence,

$$i_2 = i_3 - 3i_4 \quad (3.7.3)$$

Applying KVL in mesh 4,

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

or

$$5i_4 - 4i_3 = -5 \quad (3.7.4)$$

From Eqs. (3.7.1) to (3.7.4),

$$i_1 = -7.5 \text{ A}, \quad i_2 = -2.5 \text{ A}, \quad i_3 = 3.93 \text{ A}, \quad i_4 = 2.143 \text{ A}$$

Practice Problem 3.7

Use mesh analysis to determine i_1 , i_2 , and i_3 in Fig. 3.25.

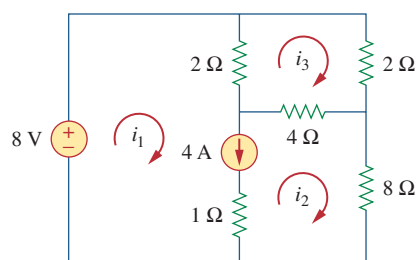


Figure 3.25

For Practice Prob. 3.7.

Answer: $i_1 = 4.632 \text{ A}$, $i_2 = 631.6 \text{ mA}$, $i_3 = 1.4736 \text{ A}$.

3.6 Nodal and Mesh Analyses by Inspection

This section presents a generalized procedure for nodal or mesh analysis. It is a shortcut approach based on mere inspection of a circuit.

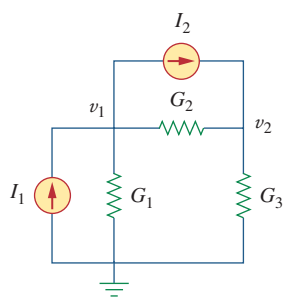
When all sources in a circuit are independent current sources, we do not need to apply KCL to each node to obtain the node-voltage equations as we did in Section 3.2. We can obtain the equations by mere inspection of the circuit. As an example, let us reexamine the circuit in Fig. 3.2, shown again in Fig. 3.26(a) for convenience. The circuit has two nonreference nodes and the node equations were derived in Section 3.2 as

$$\begin{bmatrix} G_1 + G_2 & -G_2 \\ -G_2 & G_2 + G_3 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = \begin{bmatrix} I_1 - I_2 \\ I_2 \end{bmatrix} \quad (3.21)$$

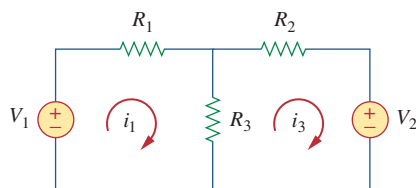
Observe that each of the diagonal terms is the sum of the conductances connected directly to node 1 or 2, while the off-diagonal terms are the negatives of the conductances connected between the nodes. Also, each term on the right-hand side of Eq. (3.21) is the algebraic sum of the currents entering the node.

In general, if a circuit with independent current sources has N non-reference nodes, the node-voltage equations can be written in terms of the conductances as

$$\begin{bmatrix} G_{11} & G_{12} & \cdots & G_{1N} \\ G_{21} & G_{22} & \cdots & G_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ G_{N1} & G_{N2} & \cdots & G_{NN} \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ \vdots \\ v_N \end{bmatrix} = \begin{bmatrix} i_1 \\ i_2 \\ \vdots \\ i_N \end{bmatrix} \quad (3.22)$$



(a)



(b)

Figure 3.26

(a) The circuit in Fig. 3.2, (b) the circuit in Fig. 3.17.

- 3.40** For the bridge network in Fig. 3.86, find i_o using mesh analysis.

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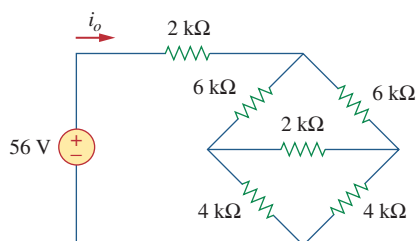


Figure 3.86

For Prob. 3.40.

- 3.41** Apply mesh analysis to find i in Fig. 3.87.

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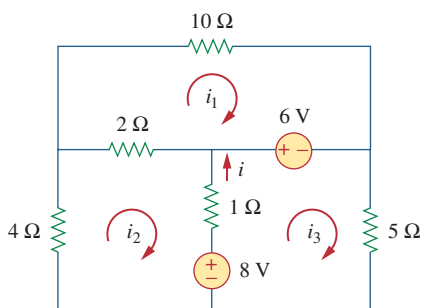


Figure 3.87

For Prob. 3.41.

- 3.42** Using Fig. 3.88, design a problem to help students better understand mesh analysis using matrices.

e2d

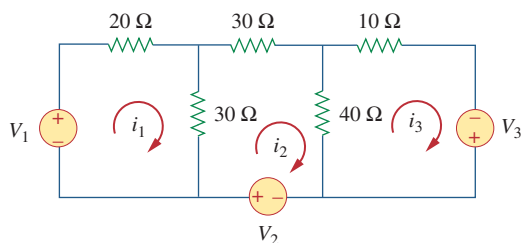


Figure 3.88

For Prob. 3.42.

- 3.43** Use mesh analysis to find v_{ab} and i_o in the circuit of Fig. 3.89.

ML

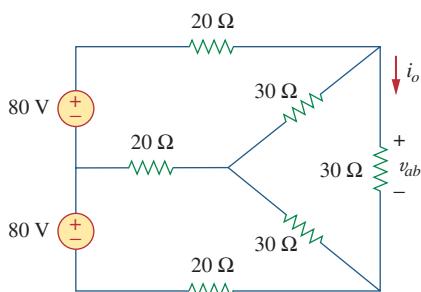


Figure 3.89

For Prob. 3.43.

- 3.44** Use mesh analysis to obtain i_o in the circuit of Fig. 3.90.

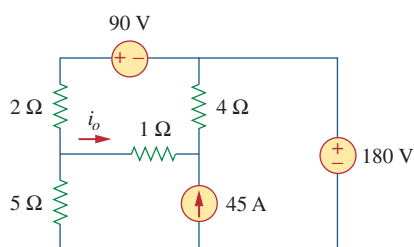


Figure 3.90

For Prob. 3.44.

- 3.45** Find current i in the circuit of Fig. 3.91.

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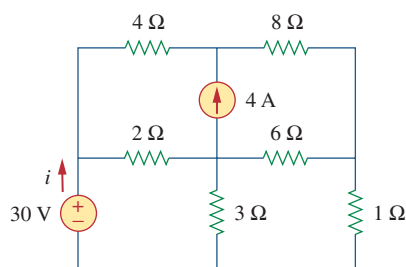


Figure 3.91

For Prob. 3.45.

- 3.46** Calculate the mesh currents i_1 and i_2 in Fig. 3.92.

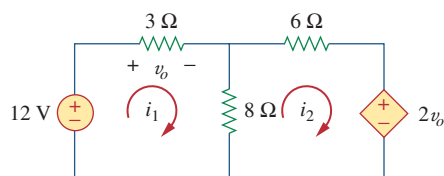


Figure 3.92

For Prob. 3.46.

- 3.47** Rework Prob. 3.19 using mesh analysis.

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