Nodal Analysis for Circuits with No Voltage Sources

Given a circuit with n nodes and no voltage sources, proceed as follows:

1. Select any node as the reference node.
2. Label the remaining $n - 1$ nodes (e.g., v_1, v_2 . . . , v_{n-1}).
3. Arbitrarily assign currents to the elements in which no current is designated.
4. Apply KCL at each nonreference node.
5. Use Ohm's law to express the currents through resistors in terms of the node voltages, and substitute these expressions into the current equations obtained in Step 4.
6. Solve the resulting set of $n - 1$ simultaneous equations for the node voltages.

Having seen an example of nodal analysis for a circuit without a voltage source, let us now consider a circuit in which a voltage source is present.

Example 2.1

Figure 2.7 shows a circuit that contains a 3-V independent voltage source, as well as a dependent current source whose value depends on the voltage across the 6-Ω resistor which is drawn vertically. This circuit has four nodes—one is the reference node and the other three are labeled v_1, v_2, and v_3. The directions of the currents i_1, i_2, i_3, and i_4 through the resistors were chosen arbitrarily.

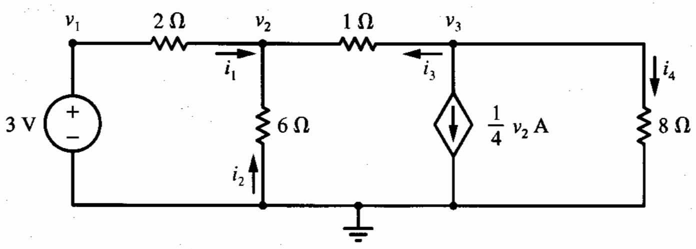

Fig. 2.7 Nodal analysis of a circuit with an independent voltage source.

Problems

2.1 For the circuit shown in Fig. P2.1, select node d as the reference node. (a) Use nodal analysis to find the node voltages. (b) Use the node voltages to determine i_1, i_2, i_3, and i_4.

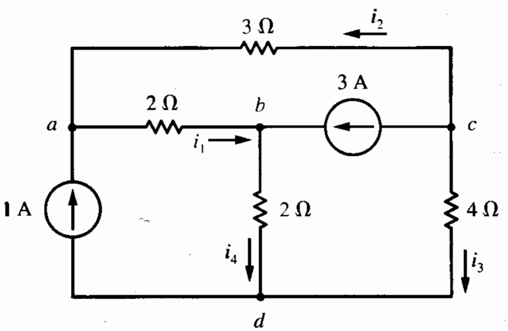

Fig. P2.1

2.2 For the circuit shown in Fig. P2.1, select node c as the reference node. (a) Use nodal analysis to find the node voltages. (b) Use the node voltages to determine i_1, i_2, i_3, and i_4.

2.3 For the circuit shown in Fig. P2.1, select node b as the reference node. (a) Use nodal analysis to find the node voltages. (b) Use the node voltages to determine i_1, i_2, i_3, and i_4.

2.4 For the circuit shown in Fig. P2.1, select node a as the reference node. (a) Use nodal analysis to find the node voltages. (b) Use the node voltages to determine i_1, i_2, i_3, and i_4.

2.5 Find the node voltages for the circuit shown in Fig. P2.5.

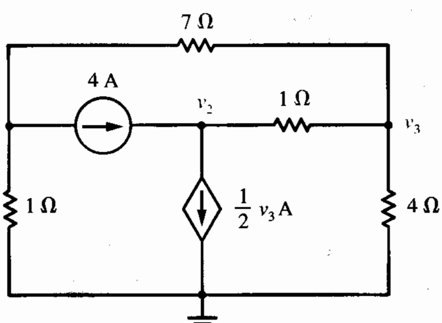

Fig. P2.5

2.6 Find the node voltages for the circuit shown in Fig. P2.6.

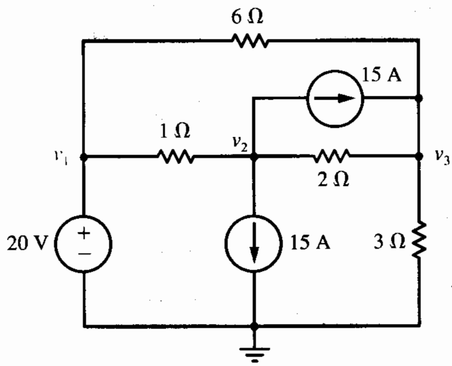

Fig. P2.6

2.7 Find the node voltages for the circuit shown in Fig. P2.7. (See p. 100.)

2.8 Find the node voltages for the circuit shown in Fig. P2.8.

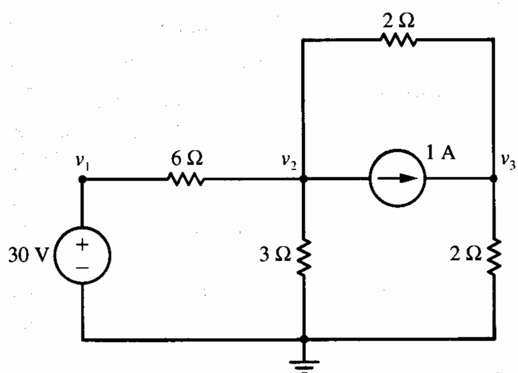

Fig. P2.8

2.9 Find the node voltages for the circuit shown in Fig. P2.9.

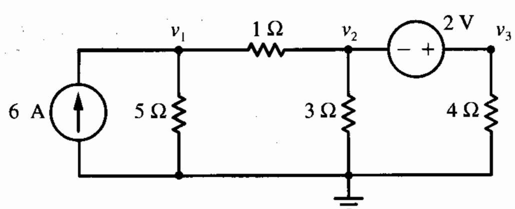

Fig. P2.9

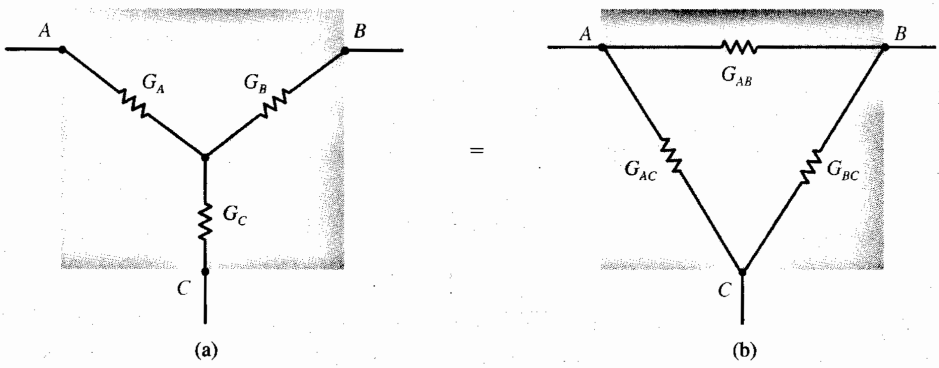

Fig. P2.17 *a,b*

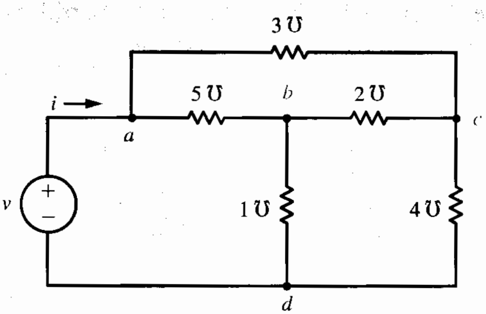

Fig. P2.17 *c*

$$R_A = \frac{R_{AB}R_{AC}}{R_{AB} + R_{AC} + R_{BC}} \quad R_B = \frac{R_{AB}R_{BC}}{R_{AB} + R_{AC} + R_{BC}}$$

$$R_C = \frac{R_{AC}R_{BC}}{R_{AB} + R_{AC} + R_{BC}}$$

where $R = 1/G$. Such a process is called a **Δ-Y (delta-wye) transformation.**

The circuit shown in Fig. P2.18 is identical to the circuit given in Fig. P2.16. Use a Δ-Y transformation on the 2-℧, 3-℧, and 5-℧ conductances, and then combine elements in series and parallel to determine $G = i/v$.

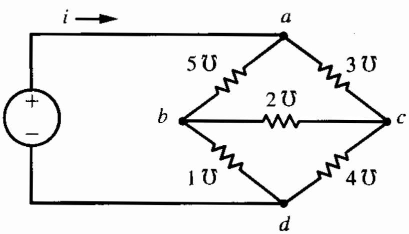

Fig. P2.18

2.19 Find the mesh currents for the circuit shown in Fig. P2.19.

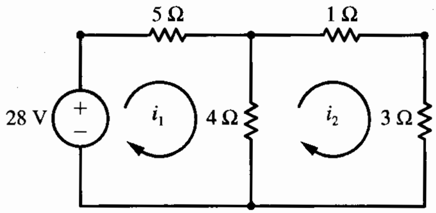

Fig. P2.19

2.20 Assume clockwise mesh currents for the circuit shown in Fig. 2.9 on p. 64. Use mesh analysis to find these mesh currents.

2.21 Assume clockwise mesh currents for the circuit shown in Fig. P2.7. Use mesh analysis to find these mesh currents.

2.22 Assume clockwise mesh currents for the circuit shown in Fig. P2.9. Use mesh analysis to find these mesh currents.

2.23 Assume clockwise mesh currents for the circuit shown in Fig. P2.10. Use mesh analysis to find these mesh currents.

2.24 Use mesh analysis to find the conductance $G = i/v$ for the circuit given in Fig. P2.18.

2.25 Assume clockwise mesh currents for the circuit shown in Fig. P2.8. Use mesh analysis to find these mesh currents.