Nodes, Branches, and Loops

Introduction:

Since the elements of an electric circuit can be interconnected in several ways, we need to understand some basic concepts of network topology. To differentiate between a circuit and a network, we may regard a network as an interconnection of elements or devices, whereas a circuit is a network providing one or more closed paths. The convention, when addressing network topology, is to use the word network rather than circuit. We do this even though the words network and circuit mean the same thing when used in this context. In network topology, we study the properties relating to the placement of elements in the network and the geometric configuration of the network. Such elements include branches, nodes, and loops

A branch represents a single element such as a voltage source or a resistor.

In other words, a branch represents any two-terminal element. The circuit in Fig. 2.10 has five branches, namely, the 10-V voltage source, the 2-A current source, and the three resistors.

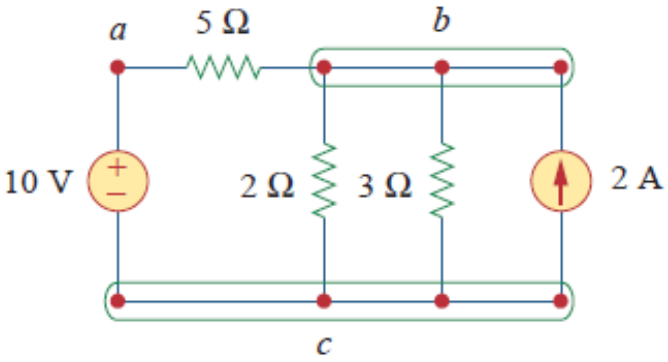

Figure 2.10 Nodes, branches, and loops.

A node is the point of connection between two or more branches.

A node is usually indicated by a dot in a circuit. If a short circuit (connecting wire) connects two nodes, the two nodes constitute a single node. The circuit in Fig. 2.10 has three nodes a, b and c. Notice that the three points that form node b are connected by perfectly conducting wires and therefore constitute a single point. The same is true of the four points forming node c.

We demonstrate that the circuit in Fig. 2.10 has only three nodes by redrawing the circuit in Fig. 2.11. The two circuits in Figs. 2.10 and 2.11 are identical. However, for the sake of clarity, nodes b and c are spread out with perfect conductors as in Fig. 2.10.

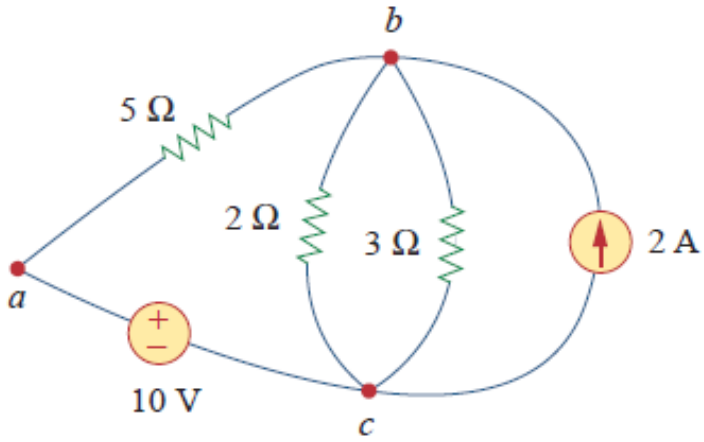

Figure 2.11 The three-node circuit of Fig. 2.10 is redrawn.

A loop is any closed path in a circuit.

A loop is a closed path formed by starting at a node, passing through a set of nodes, and returning to the starting node without passing through any node more than once. A loop is said to be independent if it contains at least one branch which is not a part of any other independent loop. Independent loops or paths result in independent sets of equations.

It is possible to form an independent set of loops where one of the loops does not contain such a branch. In Fig. 2.11, abca with the 2Ω resistor is independent. A second loop with the 3Ωresistor and the current source is independent. The third loop

could be the one with the3Ω resistor in parallel with the 3Ωresistor. This does form an independent set of loops.

A network with b branches, n nodes, and l independent loops will satisfy the fundamental theorem of network topology:

$$b = l + n - 1$$

As the next two definitions show, circuit topology is of great value to the study of voltages and currents in an electric circuit.

Two or more elements are in series if they exclusively share a single node and consequently carry the same current.
Two or more elements are in parallel if they are connected to the same two nodes and consequently have the same voltage across them.

Elements are in **series** when connected end to end, sharing a single common node with no other connections. They are in **parallel** if they share the same pair of terminals

Example (1): Determine the number of **branches** and **nodes** in the circuit shown in Fig. 2. Identify which elements are in series and which are in parallel.

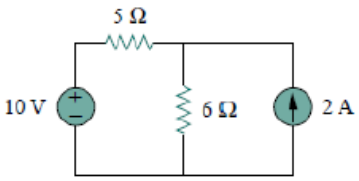

Figure 2

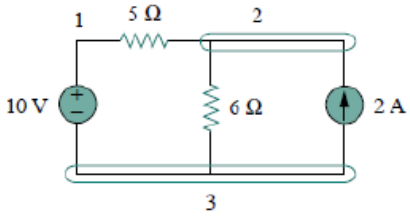

Figure 3

Solution

- Since there are four elements in the circuit, the circuit has four branches:

  10 V, 5 Ω, 6 Ω, and 2 A.

- The circuit has three nodes as shown in Fig. 3
- The 5Ω resistor is in series with the 10-V voltage source. The 6 Ω resistor is in parallel with the 2-A current source

resistor is in parallel with the 2-A current source because both are connected to the same nodes 2 and 3.

Practical Problem

How many branches and nodes does the circuit in Fig. 4 have? Identify the elements that are in series and parallel.

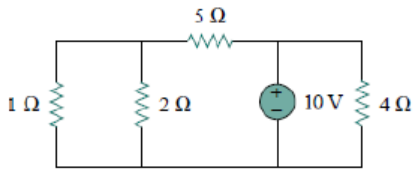

Figure 4

Email (ayat.ayad.hussein@uomus.edu.iq)