Electrical Network: Any possible combination of various electric elements (Resistor, Inductor, Capacitor, Voltage source, Current source) connected in any manner what so ever is called an electrical network. We may classify circuit elements in two categories, passive and active elements.

Concept of active and passive elements:

Active Element: The elements that supply energy to the circuit is called active element and the network containing these sources together with other circuitelements are known as active network. Examples of active elements includevoltage and current sources, generators, and electronic devices that requirepower supplies. A transistor is an active circuit element, meaning that it canamplify power of a signal.

Passive Element: The element which receives energy (or absorbs energy) and then either converts it into heat (R) or stored it in an electric (C) or magnetic (L) field is called passive element, and the network containing these elementswithout energy sources are known as passive network. Examples are resistor, inductor, capacitor, transformer etc.

Resistor: Resistor is a dissipative element, which converts electrical energy into heat when the current flows through it in any direction. The law governing the current into and voltage across a resistor is:

$$\boldsymbol{v} = \boldsymbol{R}.\,\boldsymbol{i}$$

Capacitor (C): It is a two terminal element that has the capability of energy storage in electric field. The law governing the v - i relationship of capacitor is:

$$\mathbf{i=c\ dv/dt}$$

$$v = \frac{1}{C}\int_0^t i.\,dt + v_c(0)$$

$v_c(0)$ = Capacitor voltage at t = 0
for initially uncharged capacitor $v_c(0)=0$

Inductor (L): It is a two-terminal storage element in which energy is stored in the magnetic field. The v - i relation of an inductance is:

$$\boldsymbol{v} = \boldsymbol{L}\frac{\boldsymbol{di}}{\boldsymbol{dt}}$$

$$i = \frac{1}{L}\int_0^t v.\,dt + i_L(0)$$

Where $i_L(0)$ = Inductor current at $t = 0$, for initially if current through inductor $i_L(0) = 0$
then

$$i = \frac{1}{L}\int_0^t v.\,dt$$

Linear and Non-Linear Elements

Linear Elements:
Linear elements show the linear characteristics of voltage & current. That is its voltage-current characteristics are at all-times a straight-line through the origin. For example, the current passing through a resistor is proportional to the voltage applied through its and the relation is expressed as V = IR.
A linear element or network is one which satisfies the principle of superposition, i.e., the principle of homogeneity and additivity.
Resistors, inductors and capacitors are the examples of the linear elements and their properties do not change with a change in the applied voltage and the circuit current.

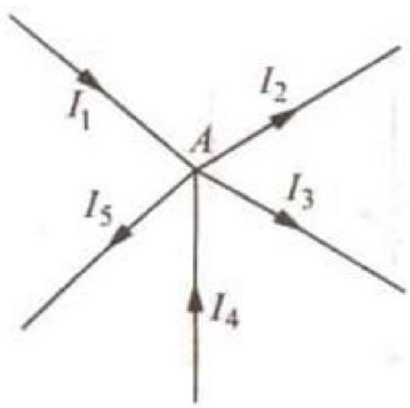
Non-Linear Elements
Non linear element's V-I characteristics do not follow the linear pattern i.e. the current passing through it does not change linearly with the linear change in the voltage across it. Examples are the semiconductor devices such as diode, transistor.

Kirchhoff"s laws: There are two types of Kirchhoff's Law.

1) Kirchhoff's First Law or Kirchhoff's Current Law (KCL)
2) Kirchhoff's Second Law or Kirchhoff's Voltage Law (KVL)

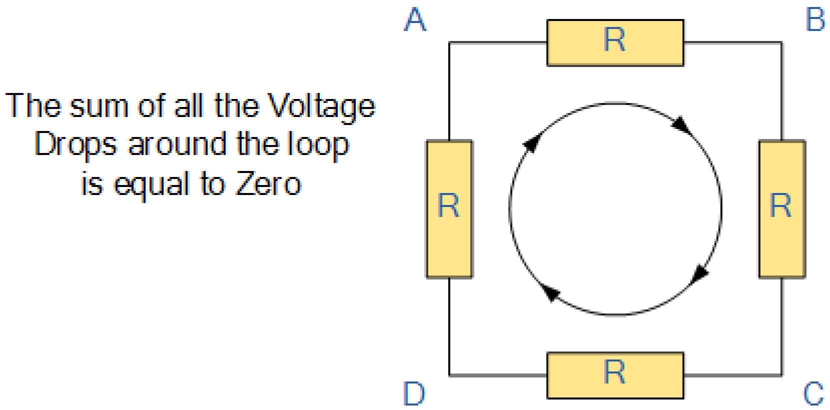
1) Kirchhoff's First Law or Kirchhoff's Current Law (KCL): Kirchhoff's current law states that, in a given electric circuit, algebraic sum of all the currents meeting at a junction is always zero. In another way we can say that, the total current flowing towards a junction is equal to the total current flowing away from that junction.

Consider the case of a network shown in Fig (a*)*.



I1+(-I2)+(-I3)+(+I4)+(-I5) = 0
I1+I4-I2-I3-I5 = 0

2) **Kirchhoff's Second Law or Kirchhoff's Voltage Law (KVL)**:
Kirchhoff's Voltage Law or KVL, states that "in any closed loop network, the total voltage around the loop is equal to the sum of all the voltage drops within the same loop" which is also equal to zero. In other words the algebraic sum of all voltages within the loop must be equal to zero.



$$V_{AB} + V_{BC} + V_{CD} + V_{DA} = 0$$

Nodes, Branches and Loops of a Circuit:

<u>Branches</u>

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 Figure 1 has five branches, namely, the 10V voltage source, the 2A current source, and the three resistors.

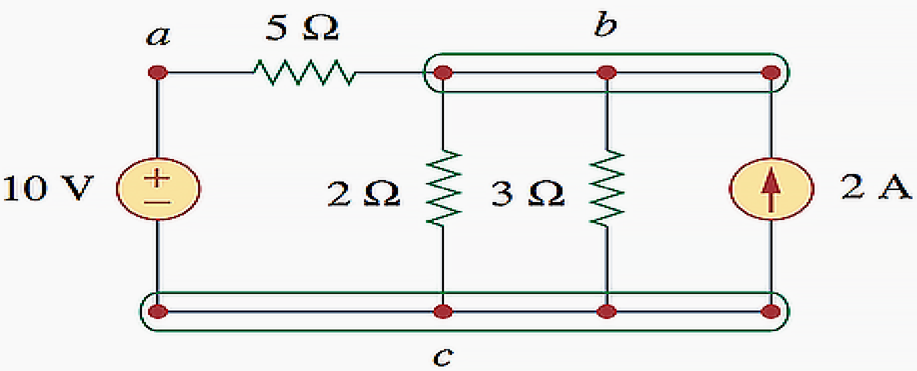


Figure 1

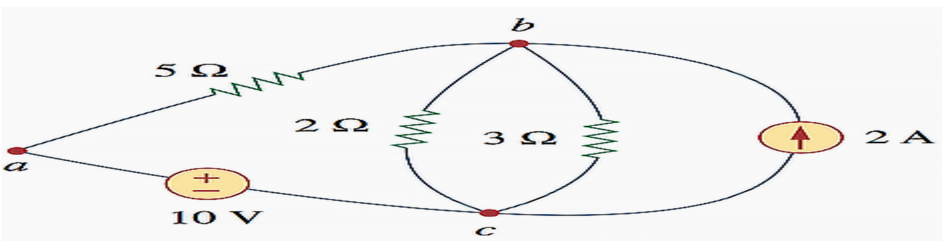


Figure 2

Nodes

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 (a connecting wire) connects two nodes, the two nodes constitute a single node. The circuit in Figure 1 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. 1 has only three nodes by redrawing the circuit in Fig. 2. The two circuits in Figs. 1 and 2 are identical.

However, for the sake of clarity, **nodes b** and **c** are spread out with perfect conductors as in Fig. 1.

Loops:

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

$b = l + n - 1$