D.C. Circuit

D.C. Circuits

Electricity: Electricity plays an important role in our day to day life.

Electricity is used for

1. Lighting (lamps)
2. Heating(heaters)
3. Cooling
4. Entertainment (T.V. and radio)
5. Transportation
6. Calculations(Calculators)

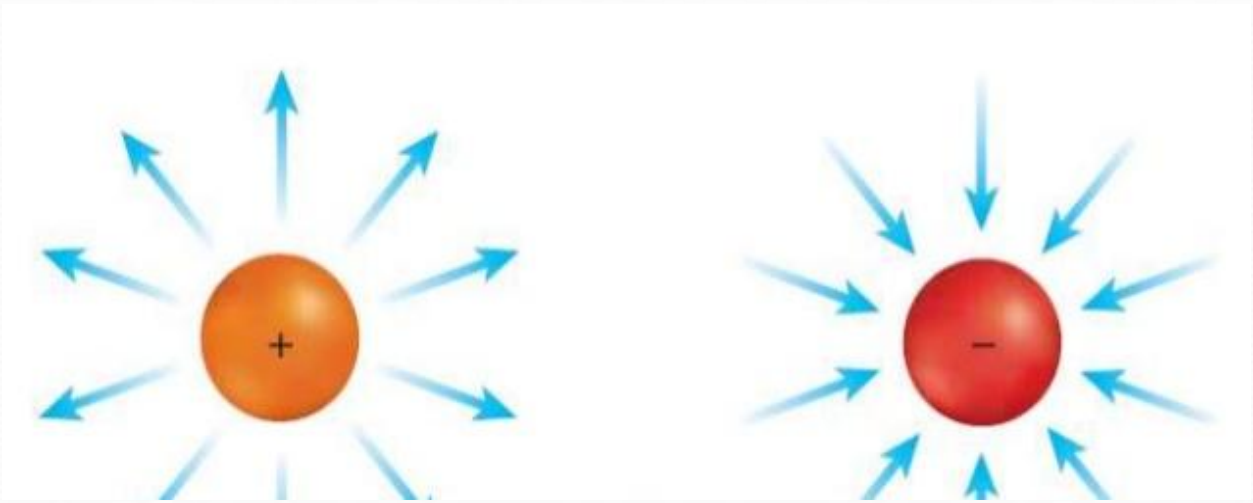
Now- a- days all the activities are dependent upon electricity.

Electricity: The invisible energy which constitutes flow of electrons in a closed circuit to do work is called electricity.

Nature of Electricity: Every matter is electrical in nature since it contains charged particles like electrons and protons. Therefore

1. Ordinarily, a body is neutral as it contains same number of protons and neutrons.
2. If some of electrons are removed from the body, there is a deficit of electrons and the body attains a positive charge.
3. If some of electrons are supplied to the body, there occurs excess of electrons and the body attains a negative charge.

A body is said to be charged +vely or –vely if it has deficit or excess of electrons from its normal due share respectively.



Unit of Charge:

The practical unit of charge is coulomb.

One Coulomb= charge on 6.28×10^{18} electrons.

Free Electrons: The valence electrons which are loosely attached to the nucleus of an atom and free to move when external energy is applied are called free electrons.

Electrical Potential: The capacity of charged body to do work is called electrical potential.

$$\textbf{Electrical Potential} = \frac{\textbf{Workdone}}{\textit{Charge}} = \frac{\textbf{W}}{\textit{Q}}$$

$$V = \frac{\textbf{W}}{\textit{Q}}$$

- Unit of electrical potential is **Volts or Joules/Coulomb.**
- Def: A body is said to have an electric potential of 1 Volt if 1 Joule of work is done to charge the body to 1 coulomb.

Potential Difference:

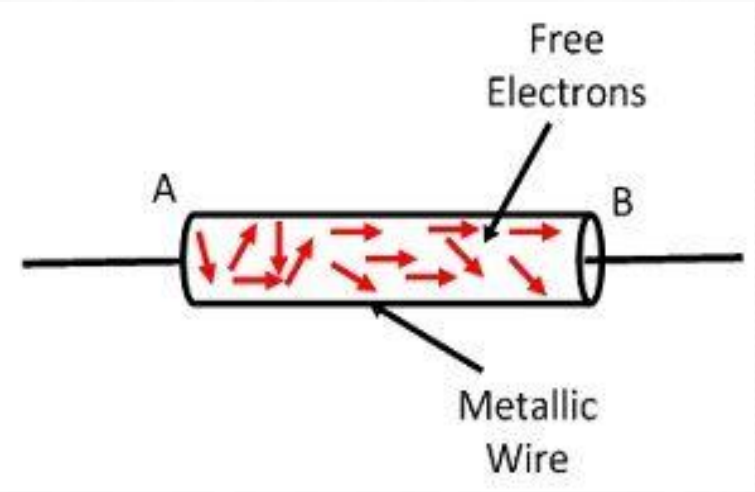
The difference in electrical potential of the two charged bodies is called potential difference.

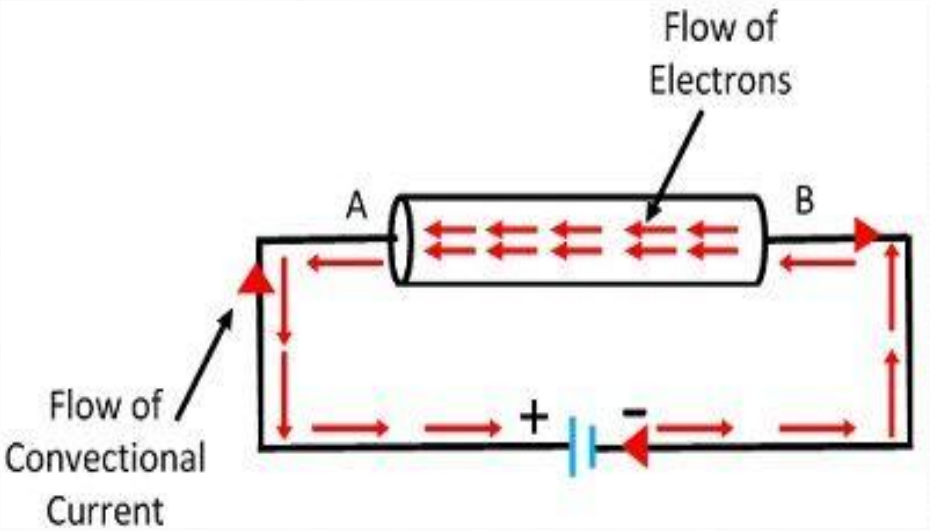
Unit of potential difference is **Volts.**

Electric Current

In metallic wire, a large number of electrons are available which move from one atom to other at random.

When an electrical potential is applied across a metallic wire, the loosely attached free electron start moving towards positive terminal of the cell.





- **Thus, continuous flow of electrons in an electric circuit is called electric current**

Definition-

Current is rate of flow of electrons i.e. charge flowing per second.

$$\mathbf{I} = \frac{Q}{t}$$

The unit of current is Ampere (A)

E.M.F. (Electromotive force) and potential difference:

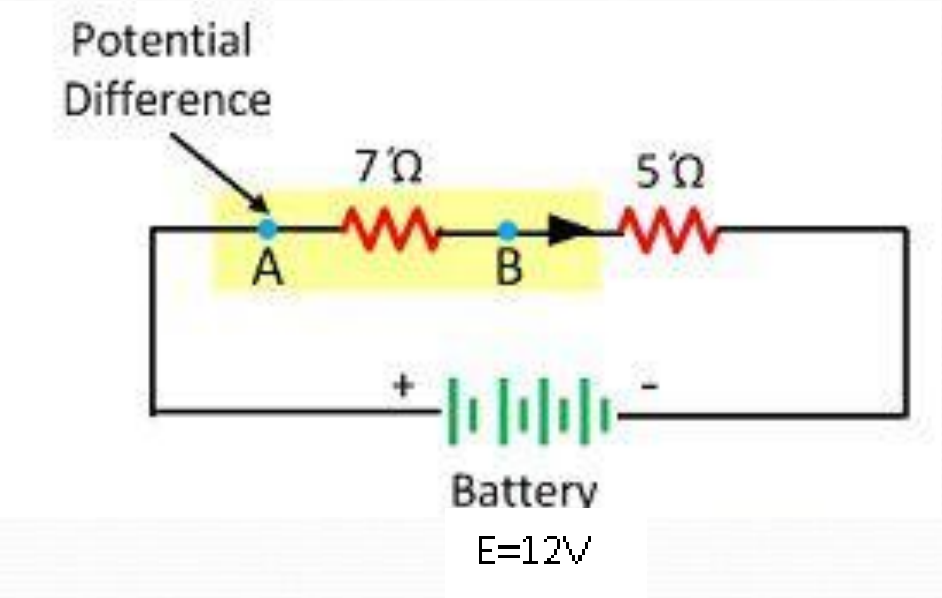
E.m.f is the force that causes an electric current to flow in an electric circuit. Infact it is not a force but it is an energy.

E.m.f: The electromotive force is the amount of energy supplied by the source to each coulomb of charge.

Potential Difference: The potential difference is the amount of energy used by the one coulomb of charge in moving from one point to the other.

The electromotive force transfers the energy in the whole of the circuit. The potential difference is the measure of energy between any two points on the circuit.

In the following figure battery has emf of 12V and the potential difference between A and B is 7V.



Ohms Law

Ohm's laws state that the current through any two points of the conductor is directly proportional to the potential difference applied across the conductor, provided physical conditions i.e. temperature, etc. do not change. It is measured in (Ω) ohm.

Mathematically it is expressed as

$$I \propto V$$

$$\frac{V}{I} = constant$$

$$\frac{V_1}{I_1} = \frac{V_2}{I_2} = \cdots = \frac{V_n}{I_n} = constant$$

This constant is also called the resistance (R) of the conductor (or circuit)

$$R = \frac{V}{I}$$

In a circuit, when current flows through a resistor, the potential difference across the resistor is known as voltage drops across it, i.e., V = IR.

Limitations of Ohm's Law

- Ohm's law is not applicable in unilateral networks. Unilateral networks allow the current to flow in one direction. Such types of network consist of elements like a diode, transistor, etc.
- It is not applicable for the non-linear network. In the nonlinear network, the parameter of the network is varied with the voltage and current. Their parameter likes resistance, inductance, capacitance and frequency, etc., not remain constant with the times. So ohms law is not applicable to the nonlinear network. Ohm's law is used for finding the resistance of the circuit and also for knowing the voltage and current of the circuit.

Resistor

Materials in general have a characteristic behavior of resisting the flow of electric charge. This physical property, or ability to resist the flow of current, is known as resistance and is represented by the symbol R.The Resistance is measured in ohms (Ω). The circuit element used to model the current-resisting behavior of a material is called the resistor.

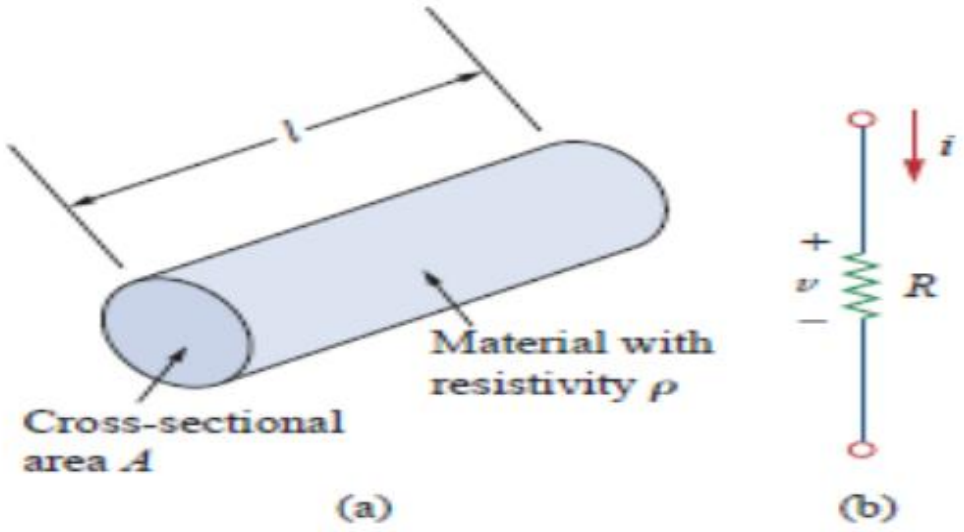


Fig. 1.13 (a) Typical Resistor, (b) Circuit Symbol for Resistor

Law of resistance

The resistance of a resistor depends on the material of which the conductor is made and geometrical shape of the conductor. The resistance of a conductor is proportional to the its length (l) and inversely proportional to its cross sectional area (A). Therefore the resistance of a conductor can be written as,

$$R = \frac{\rho l}{A}$$

The proportionality constant ρ is called the specific resistance o resistivity of the conductor and its value depends on the material of which the conductor is made.

The inverse of the resistance is called the conductance and inverse of resistivity is called specific conductance or conductivity. The symbol used to represent the conductance is G and conductivity isσ. Thus conductivity $\sigma = 1/\rho$ and its units are Siemens per meter

$$G = \frac{1}{R} = \frac{A}{\rho l} = \frac{1}{\rho}.\frac{A}{l} = \sigma.\frac{A}{l}$$

Electric Circuit:

The path for flow of electric current is called electric circuit. The electric circuit is an arrangement of electrical energy sources and various circuit elements such as R, L and C are connected in series, parallel or series parallel combinations.

Circuit Elements:

The circuit elements can be categorized as:

1. Active and passive elements
2. Unilateral and bilateral elements
3. Linear and non-linear elements
4. Lumped and distributed elements

1. Active and passive elements:

Active elements are those who supply energy or power in the form of a voltage or current to the circuit or network.

Examples of the active components are batteries or generators etc.

Passive elements are those who receive energy in the form of voltage or current.

Examples of the passive components are resistor, capacitor and inductor.

2. Unilateral and bilateral elements:

- **Unilateral elements:** The elements which conduct the current in one direction only are called unilateral elements such as diodes, transistors, rectifiers etc
- **Bilateral elements:** The elements which conduct the current in both the directions are called bilateral elements such as resistors.

3. Linear and non-linear elements

- **Linear Elements:** The elements which follow the linear relation between current and voltage.

e.g. resistors

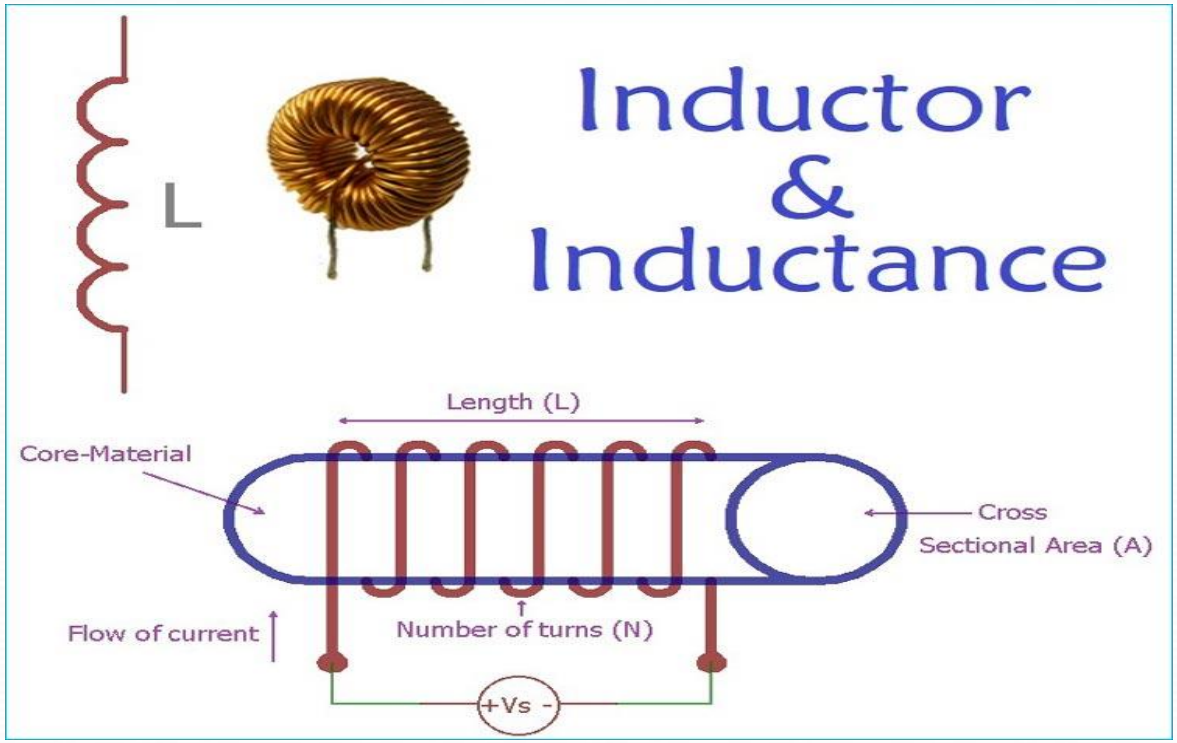
- **Non Linear Elements:** The elements which don’t follow the linear relation between current and voltage.

e.g. Diode and transistors

4. Lumped and distributed elements:

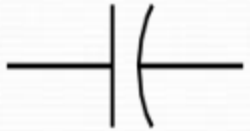
- **Lumped elements:** The elements in which action takes place simultaneously are lumped elements such as resistor, capacitor and inductor. These elements are smaller in size.
- **Distributed elements:** The elements in which for a given cause is not occurring simultaneously at the same instant but it is distributed are called distributed elements such as transmission lines.

- **Inductor -**
  - Coil of wire.
  - Opposes change in current.
  - Used to create magnetic field for rotation.
- - Unit is henry(H).
- Inductor in series L= L1+L2 & in parallel 1/L=1/L1+1/L2



- **Capacitor -**

- Two metal plates separated by a DI-electric material (Max volts/mm which a medium can withstand without breakdown).
- Gets charged when voltage is applied.
- Unit of capacitance is farad.
- Capacitor in series 1/C=1/C1+1/C2 & in parallel C= C1+C2.
- C = Q / V
- Practical units Micro and Pico farad.



- **Insulators and Conductors -**
  - **Conductors -**
    - **-** Materials that have a low resistance to current flow are classified as conductors.
    - Copper and aluminium wires are conductors.
    - Conductors are used in electrical circuits to connect components to one another.
    - Conductors are wrapped in insulators to isolate from one another.
  - **Insulators -**
    - **-** Materials that have a high resistance to current flow are classified as Insulators.
  - - Glass, rubber & dry air are insulators

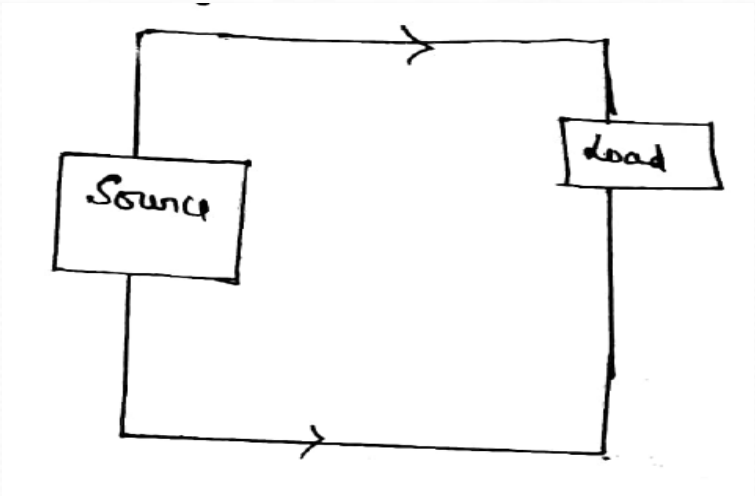
ELECTRICAL TERM

the following table show some common electrical terms, their abbreviation, units of measure, symbol and measuring instruments.

Term	Abbreviation	Unit	Symbol	Measuring Tool
Current	I	Ampere	A	Ammeter
Voltage	E	Volt	V	Voltmeter
Resistance	R	Ohm	Ω	Ohmmeter
Power	P	Watt	W	Wattmeter

Voltage and Current Source:

- To deliver electrical energy to the electrical circuits, a source is required and a load is connected to source as shown in fig.



- The source may be d.c. source or a.c source.

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- **D.C. source:**

Any source that produces direct voltage continuously and has ability to deliver direct current is called d.c. source such as batteries and generators etc.

- **A.C. source:**

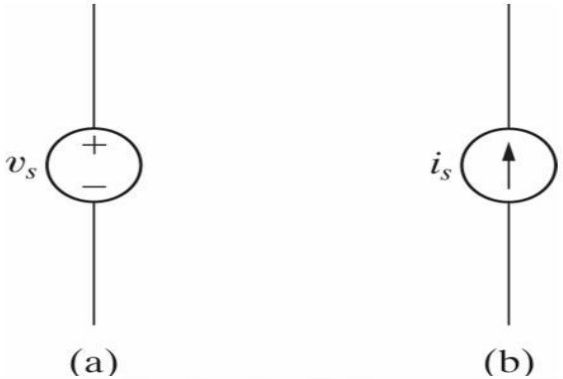
Any source that produces alternating voltage continuously and has ability to deliver the alternating current is called a.c. source such as alternators, oscillators or signal generators.

Independent and dependent sources:

- There are two types of sources- Voltage source and current source. Sources can be either independent or dependent upon some other quantities.

Independent voltage/ current source:

- The voltage (a.c or d.c.) does not dependent on other voltages or current in the circuit.
- Symbol for independent voltage and current source

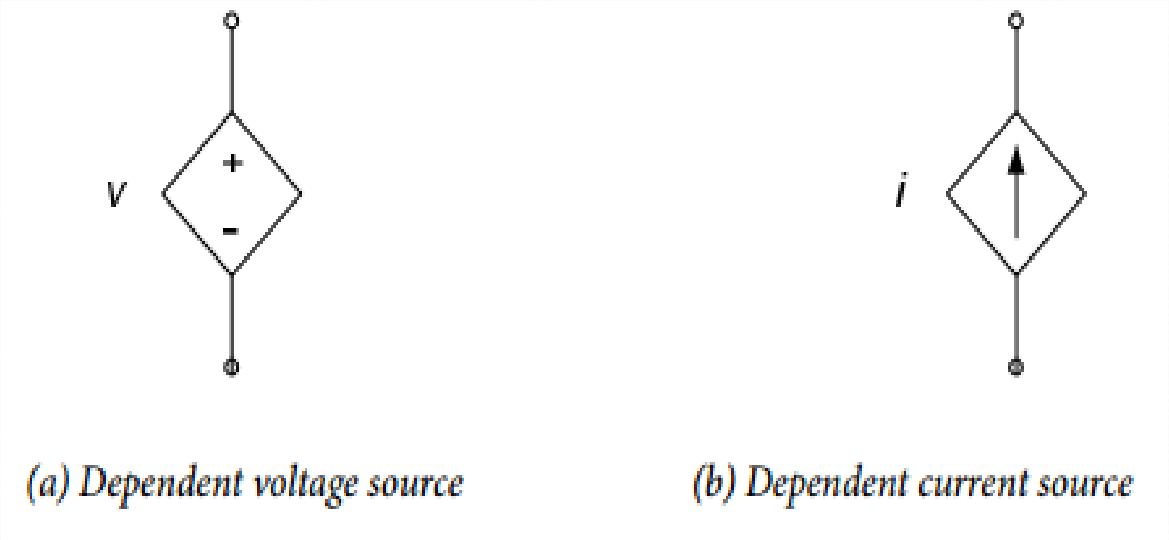


- Examples of independent voltage source batteries and generators.
- Examples of independent current source semiconductor devices such as Diode and transistors

Dependent voltage/ current source:

- The voltage does dependent on another voltage or current in the circuit.

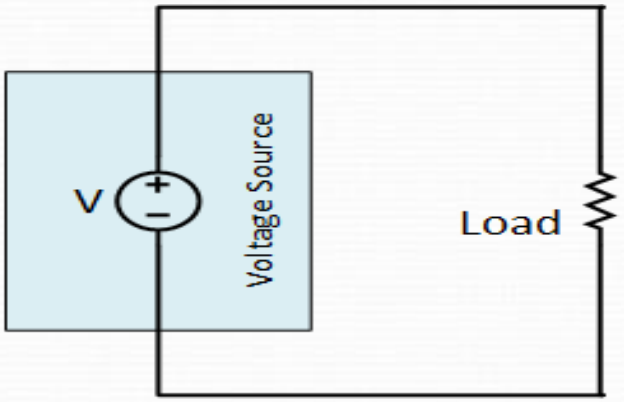
- Symbol for dependent voltage and current source



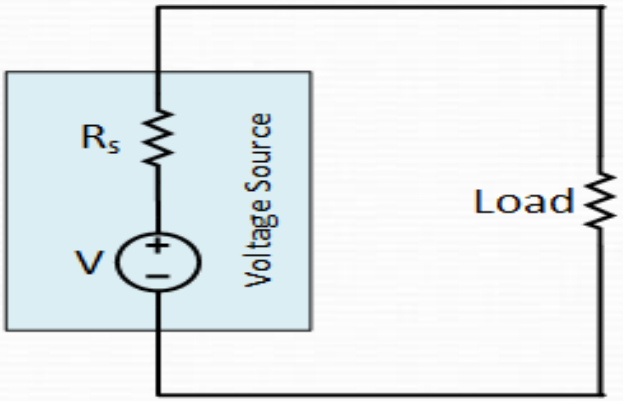
(a) Dependent voltage source (b) Dependent current source

Ideal and practical voltage sources:

- Ideal voltage sources: An imaginary voltage source, which can provide a constant voltage to load ranging from zero to infinity. Such voltage source is having zero internal resistance, Rs and is called Ideal Voltage Source. Practically it is not possible to build a voltage source with no internal resistance and constant voltage for that long range of the load.



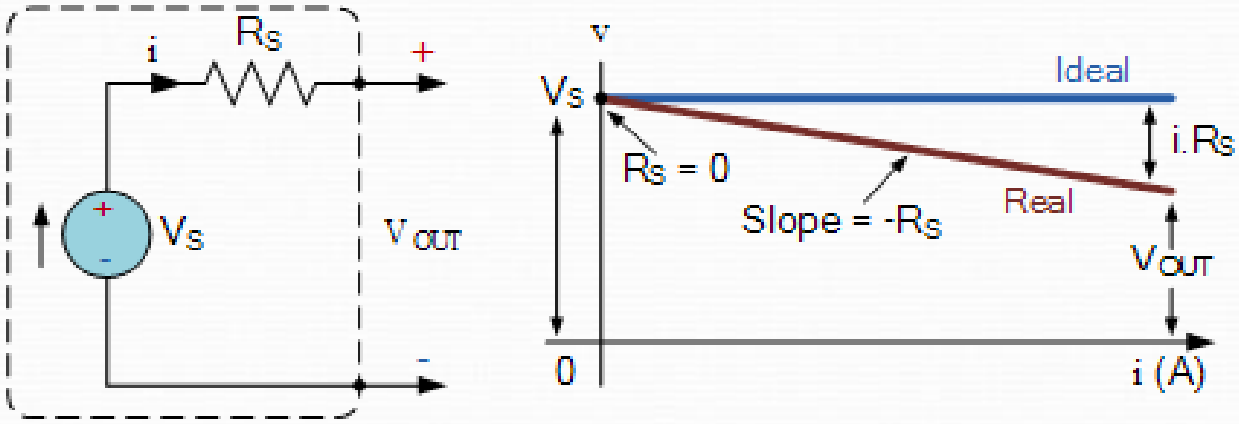
Ideal Voltage Source



Practical Voltage Source

Practical voltage sources:

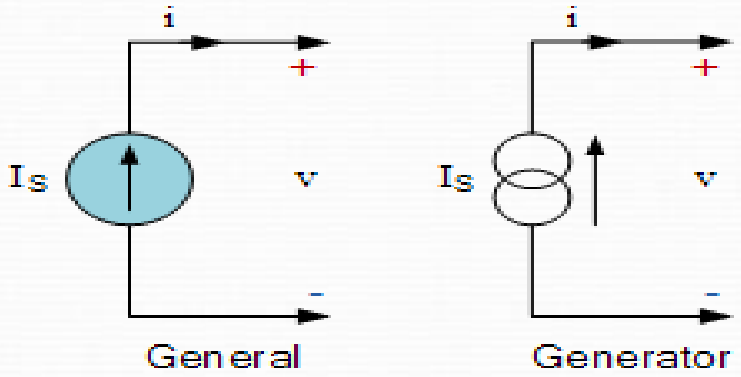
- Practical voltage sources always have some resistance value in series with an ideal voltage source and because of that series resistance, voltage drops when current passes through it. So, Practical Voltage Source has internal resistance and slightly variable voltage.

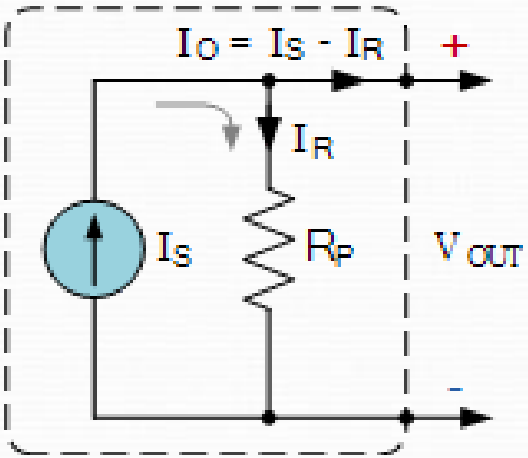


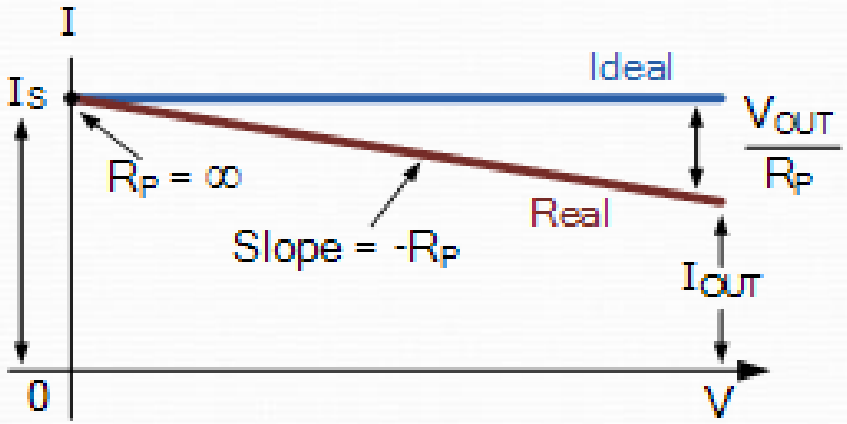
Ideal and Practical current sources:

- Ideal constant current sources are represented in a similar manner to voltage sources, but this time the current source symbol is that of a circle with an arrow inside to indicates the direction of the flow of the current.

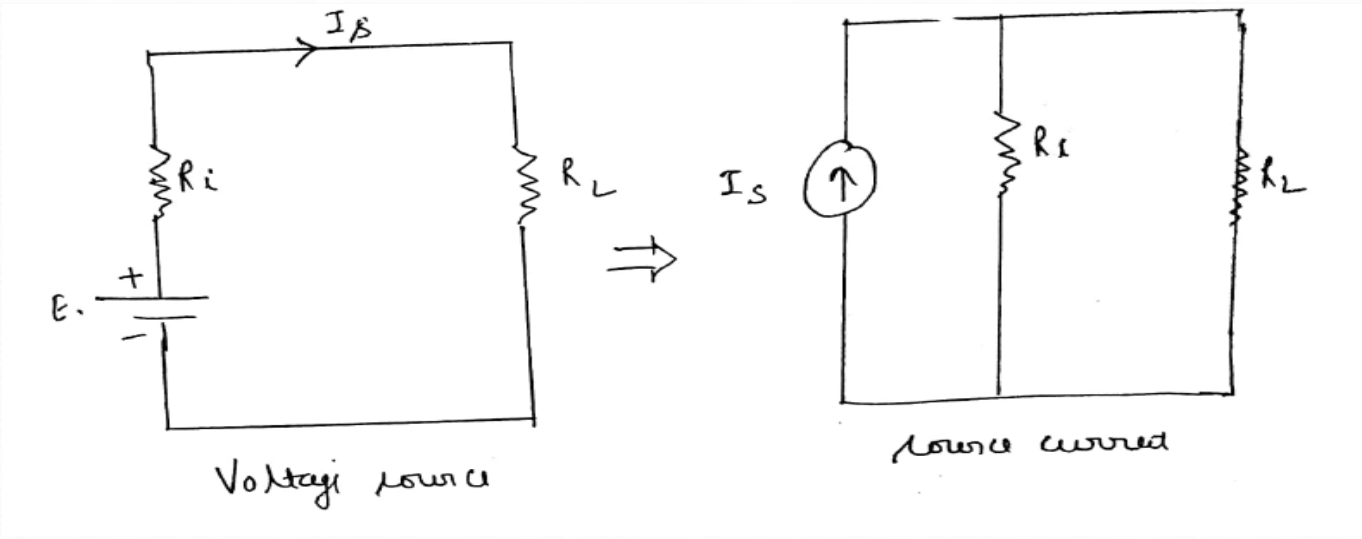
- Ideal current source

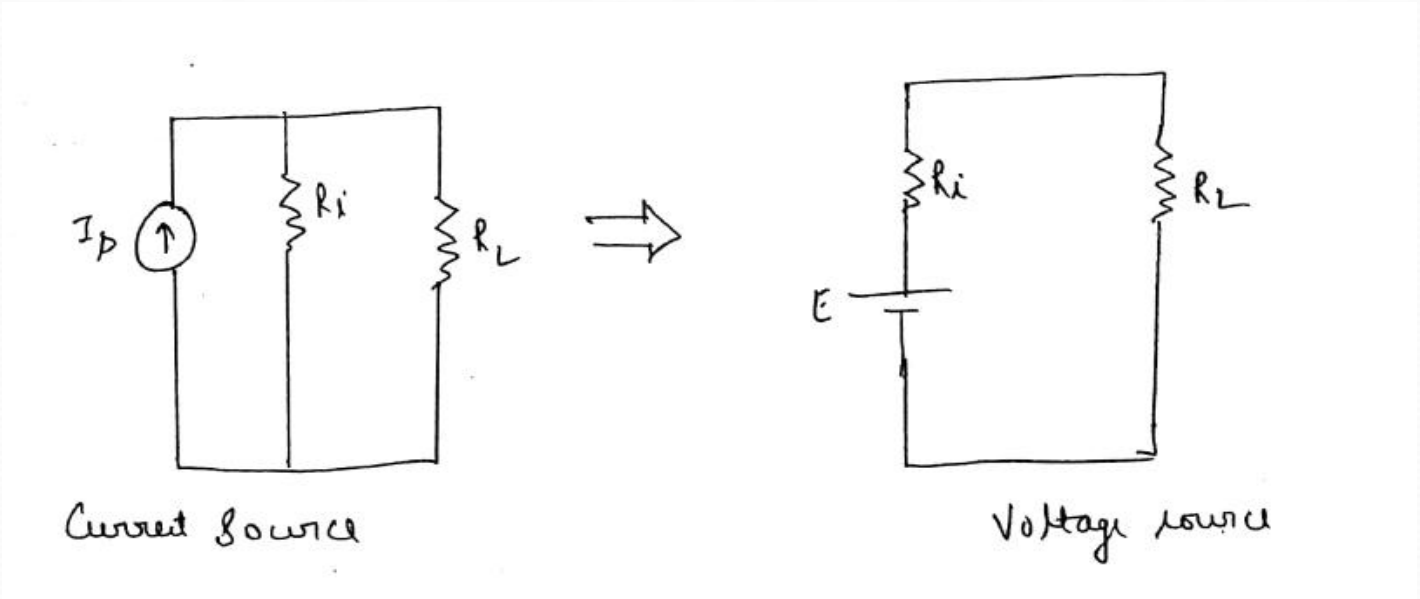






Source Transformation:

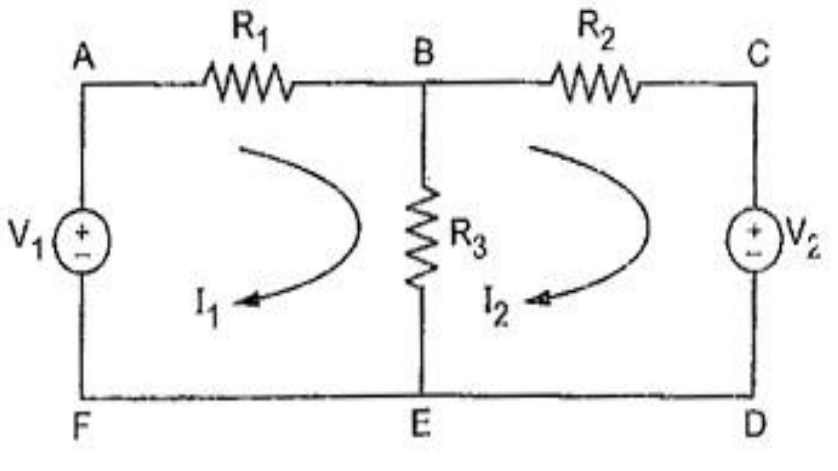




Network Terminology:

1. Electric Network:

Electric network is interconnection of electric components. E.g. Batteries, resistors, inductors and capacitors.



2. Electric Circuit:

The path for flow of electric current is called electric circuit.

3. Active Elements:

The elements which supplies energy to the circuit. In fig V_1 and V_2 are active elements.

4. Passive Elements:

The elements which receives energy. In fig R_1, R_2 and R_3 are passive elements.

Cont…

5. Node: Node is a point where two or more circuit elements are connected together. In Fig. A, B, C and E are nodes.

6. Junction: Junction is a point in the network where three or more circuit elements are connected together. It is a point where current is divided. In Fig. B and E are junctions.

7. Loop: The closed path of a network. E.g. ABEFA, BCDEB and ABCDEFA are loops.

8. Mesh: The elementary form of loop which cannot be further divided is called mesh. E.g. ABEFA, BCDEB are mesh.

9. Branch: Part of a network which lies between two junction points. In fig. ABEFA, BCDEB AND BE are the three branches.