Basic Electrical Engineering (TEE 101)

Lecture 1: Introduction to the circuit elements

Introduction

Electric energy is convenient and efficient for production of light, mechanical energy and in information processing.

Electric energy also can transport information over tremendous distances.

Electric energy does not occur naturally in usable form and must therefore be centrally generated and instantly transported to myriad points.

BASIC MANIFESTATIONS OF ELECTRICITY

Fundamental electric charge carrying particles are electrons (negative charge) and protons (positive charge).

The unit of electric charge is a coulomb, C.

In terms of this unit, the electronic charge is 1.602×10^{-19} C (–ve for electron and + ve for proton).

Since coulomb is a large unit, it is more practical to use micro-coulomb, µC.

An electric field is established in the space surrounding an electric charge and is manifested in the form of force exerted on another charge brought into the field.

This force is given by Coulomb's law as

$$F = \frac{Q_1 Q_2}{4\pi\varepsilon d^2} \text{ N}$$

where Q_1, Q_2 are charges in coulomb, d the distance between them in metres and f is the permittivity of the medium

Potential Difference

It is the work (J) done when a unit positive charge is moved from a point b in the field to another point a.

The unit of potential difference is volts (V), 1V = 1 J/unit positive charge.

The symbol of potential difference (or voltage) is as v or V.

If work must be done on the charge (energy input to the charge) as it moves from b to a, the voltage of a is higher than that of b (voltage rises from b to a) and is indicated as v_{ab} (a above b) (Fig. 1.1).

In this case, if the charge moves from a to b, energy is output. Obviously

$$v_{ba} = -v_{ab}$$

i.e. the voltage drops in going from a to b.

There are two ways of indicating the voltage difference on a diagram, as shown in Fig. 1.1.

It can be indicated by a line with an pointing towards the point whose voltage is higher than that of the other point (no arrow) by the symbol indicated on the arrow as in Fig. 1.1(a),

or

by arrows at both ends with + and – sign placed at the ends (points) as in Fig. 1.1(b).

Fig. 1.1 Potential difference (voltage difference)

Electric Current

Electric current is the rate of flow of charge through a conducting path as shown in Fig. 1.2.

The positive direction of current is the direction in which positive charge flows; this direction is opposite to that in which electrons flow.

Unit of current is ampere, A.

One ampere is the charge flow rate of 1 C / sec.

The symbol used for current is i or I.

The symbol for charge is q.

Average current over a period of time is $i\,(avg) = \dfrac{\Delta q}{\Delta t}$

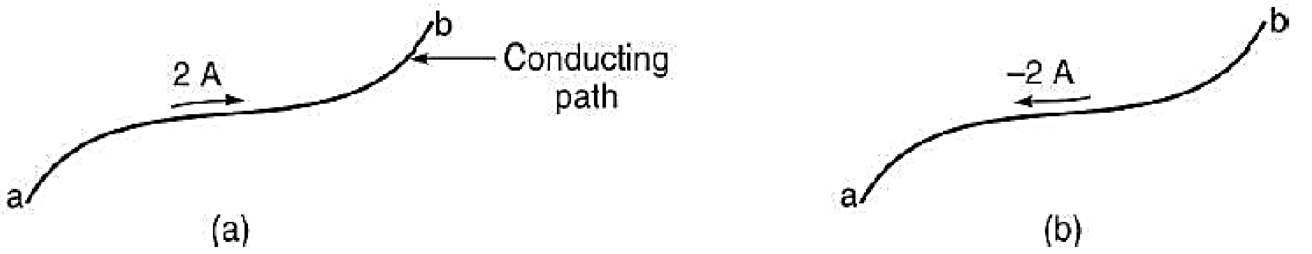


Fig. 1.2 Current

The instantaneous current is defined as $i = \frac{dq}{dt}$

As in Fig (1.2)(a), a reference positive direction is chosen for the current.

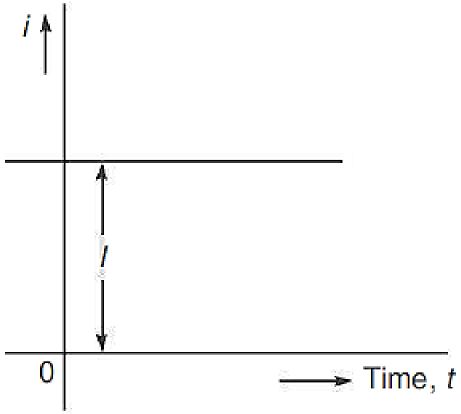
The current in the opposite direction would then be negative as in Fig. 1.2(b).

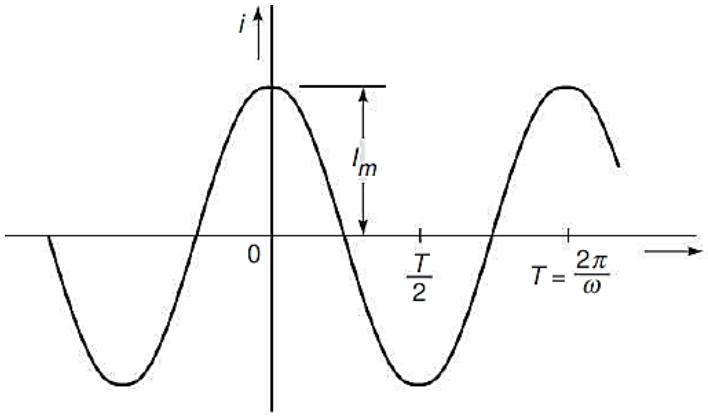
If a current is flowing from a point a to b, it may be indicated by the symbol i_{ab} (a to b). Obviously

$$i_{ba} = -\, i_{ab}$$

The nature of Electric Current is categorized as:

- Unidirectional current
- Alternating current or ac





CIRCUIT ELEMENTS

The general representation of a circuit element is as shown in figure 1.3

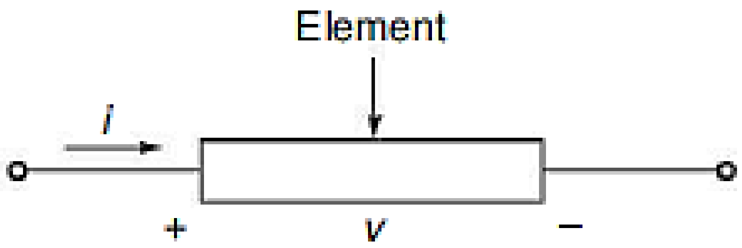


Fig. 1.3 Circuit element

It has voltage and current associated with it.

The voltage is an across variable (AV) and the current is a through variable (TV).

Voltage is cause and current is its effect

Types of Circuit Elements

- Active Circuit Elements
- Passive Circuit Elements

Active Elements are those which can generate energy. Examples include batteries, generators, operational amplifiers and diodes. Note that in an electrical circuit, the source elements are the most significant active elements.

Passive Elements can be defined as elements which can control the flow of electrons through them.

They either increase or decrease the voltage. Here are some examples of passive elements.

Resistance

Capacitance

Inductance

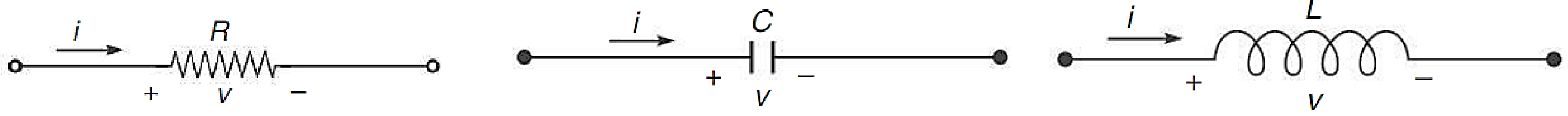


Fig. 1.4 Schematic representation of Circuit Elements

Resistor: A resistor opposes the flow of current through it. For a linear circuit, Ohm's law is applicable, which states that voltage across the resistor is directly proportional to the current flowing through it, the proportional constant being the resistance.

Inductor: An inductor stores energy in form of the electromagnetic field. The voltage across an inductor is proportional to the rate of change of current flowing through it.

Capacitor: A capacitor stores energy in form of the electrostatic field. The voltage across a capacitor is proportional to the charge.