

## Circuit concepts –Resistor(R)-Inductor(L)-Capacitor(C)-Voltage and Current Sources

In electrical and electronics engineering, we frequently come across two terms "**circuit**" and "**circuit element**". Where, an **electric circuit element** is the most elementary building block of an electric circuit, and the electric circuit is an interconnection of different circuit elements connected in a fashion so they form a closed path for current to flow.

Technically, an electric circuit element is the mathematical model of an electrical device and can be completely characterized by its voltage and current relationship. Also, a circuit element being the most basic building block cannot be subdivided into other devices.

There are three most basic circuit elements that we use to form different electrical and electronic circuits are **Resistor**, **Inductor** and **Capacitor**. In this article, we shall learn about these three elements in detail.

### What is a Resistor?

#### Types of Resistors

Resistors can be classified in different types based on different parameters.

Depending on the ohm's law, resistors may be classified into following two types –

- Linear Resistors
- Non-Linear Resistors

A resistor that obeys the Ohm's law is called a **linear resistor** or **ohmic resistor**. On the other hand, if the resistor does not obey the ohm's law, then it is called a **non-linear resistor** or **unohmic resistor**.

Depending on the changing of resistance value, there are two types of resistors –

- Fixed Resistors
- Variable Resistors

Resistors whose resistance value remains constant and can never be changed are known as **fixed resistors**. Where, resistors whose value can be changed are known **variable resistors**.

The resistor always converts the electrical energy into heat energy, and hence dissipated the energy that can never be obtained at a later point of time.

### Important Equations Related to Resistor

The voltage and current relationship of a resistor is given by,

$$V \propto I$$

The power dissipated by resistor is given by,

$$P = I^2 R = \frac{V^2}{R}$$

The amount of electrical energy converted into heat is given by,

$$W = I^2 R t = \frac{V^2 t}{R}$$

The equivalent resistance of resistors connected in series is given by,

$$R_s = R_1 + R_2 + R_3 + \dots + R_n$$

The equivalent resistance of resistors connected in parallel is given by,

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots + \frac{1}{R_n}$$

## What is an Inductor?

**Inductor** is basically a wire of finite length twisted into a coil. An inductor is also a basic circuit element that used to introduce inductance in an electrical or electronic circuit. The inductor has a property, known as **inductance**, which oppose any change in the electric current. The circuit symbol of a typical inductor is shown in the following figure.



In terms of voltage-current relationship, if a two terminal circuit element whose terminal voltage is directly proportional to derivative of current with respect to time, then the element is called an **inductor**. Therefore, the mathematical relation between voltage current of an inductor is given by,

From this expression it is clear that the voltage across the inductor would be zero if the through it remains constant. Hence, an inductor with DC behaves as a short-

circuit coil. Also, if the current through the inductor changes within zero time, then it gives an infinite voltage across the inductor which is practically not possible. Consequently, the current through an inductor cannot change abruptly.

A very important property of an inductor is that it can store finite amount of energy in the form of magnetic field. An ideal inductor does not dissipate energy, but only stores it.

## Important Expressions Related to Inductor

The voltage across an inductor is given by,

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

The energy stored by an inductor in the form of magnetic field is given by,

$$W = \frac{1}{2} Li^2$$

The equivalent inductance of inductors connected in series is given by,

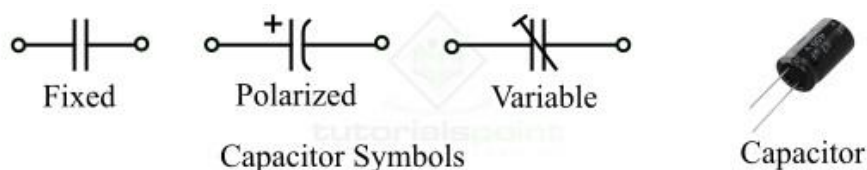
$$L_s = L_1 + L_2 + L_3 + \dots + L_n$$

The equivalent inductance of inductors connected in parallel is given by,

$$\frac{1}{L_p} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \dots + \frac{1}{L_n}$$

## What is a Capacitor?

An electric circuit element that has an ability of storing electrical energy in the form of electric field is called a **capacitor**. The property of the capacitor by virtue of which it store electrical energy is known as **capacitance**.



In other words, a circuit element whose terminal voltage is directly proportional to integral of current with respect to time is called a **capacitor**, i.e.,

$$v = \int i dt \quad v = \int i dt$$

A simple capacitor consists of two metallic plates separated by an insulating material. This insulating material is called dielectric and it stores the electrical energy in the form of electric field. Depending on the type of dielectric material used, there are several types of capacitors like paper capacitor, air capacitor, mica capacitor, ceramic capacitor, electrolytic capacitor, etc.

## Types of Capacitors

May also be classified based on their polarity as –

- Polarized Capacitors
- Non-Polarized Capacitors

A **polarized capacitor** is one which has a fixed terminal polarity and its terminals are marked with fixed positive and negative polarities. Thus, polarized capacitors can be used in DC circuits only. On the other hand, the **non-polarized capacitor** is one whose terminal polarity is not fixed, thus this type of capacitor can be used AC circuits as well.

Depending on the change in capacitance, the capacitors may be of two types namely **fixed capacitors** and **variable capacitors**.

The expression of the current of a capacitor is given by,

$$i = C \frac{dv}{dt} = C \frac{dv}{dt}$$

From this expression it is clear that if the voltage across a capacitor is constant, then current through it is zero. This means that the capacitor on application of DC voltage acts as a short circuit. A capacitor can store finite amount of energy in the form of electric field. Also, an ideal capacitor does not dissipate energy, but only stores it.

## Important Expressions Related to Capacitor

The capacitor current is given by,

$$i = C \frac{dv}{dt}$$

The energy stored in the capacitor is given by,

$$W = \frac{1}{2} C v^2$$

The equivalent capacitance of capacitors connected in series is given by,

$$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \dots + \frac{1}{C_n}$$

The equivalent capacitance of capacitors connected in parallel is given by,

$$C_p = C_1 + C_2 + C_3 + \dots + C_n$$

## Conclusion

In this article, we discussed in detail about the three most basic electric circuit elements namely resistor, inductor and capacitor. From the above discussion, it is clear that a resistor dissipates the electrical energy in the form of heat which cannot be recovered. On the other hand, inductors and capacitors store the electrical energy in the form of magnetic field and electric field respectively. We may retrieve this stored energy later.