BEEE101L – Basic Electrical Engineering

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Module I: DC Circuits 6 Hrs

Basic circuit elements and sources; Ohms law, Kirchhoff's laws; Series and parallel connection of circuit elements; Source transformation; Node voltage analysis; Mesh current analysis; Maximum power transfer theorem

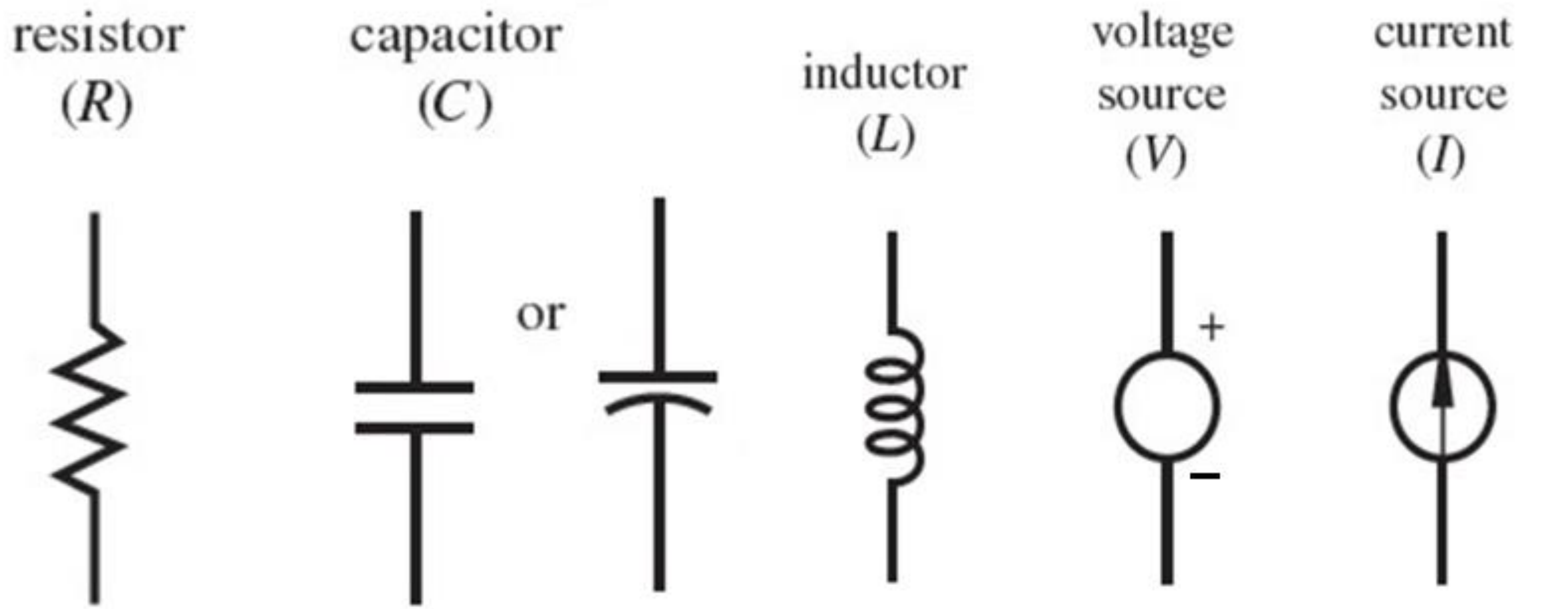
CO1:

Evaluate DC and AC circuit parameters using various laws and theorems

Module 1

Evaluate DC circuit parameters using various laws and theorems

Basic circuit elements and sources



RESISTOR

- Resistor is an electrical component that opposes the flow of electric current.
- It is measured in units of ohms (symbol: Ω).
- **$R=\rho l/A$**

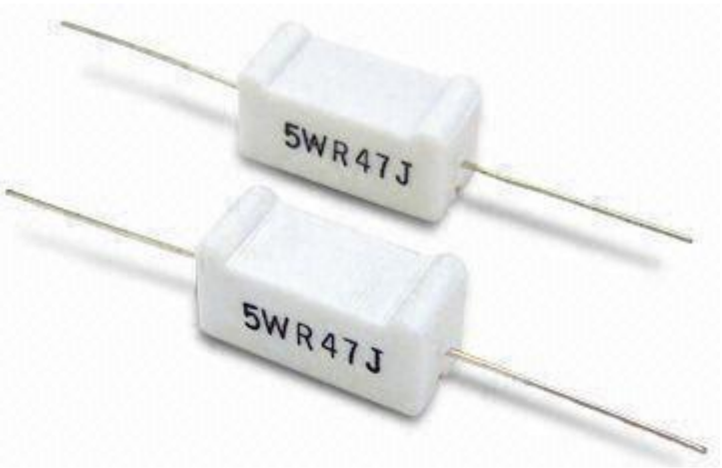
ρ is the resistivity in ohms-meter (Ω-m)

l is the length of the conductor (m)

A is the cross sectional area of the conductor (m^2)

Carbon resistor

Wire-wound resistor

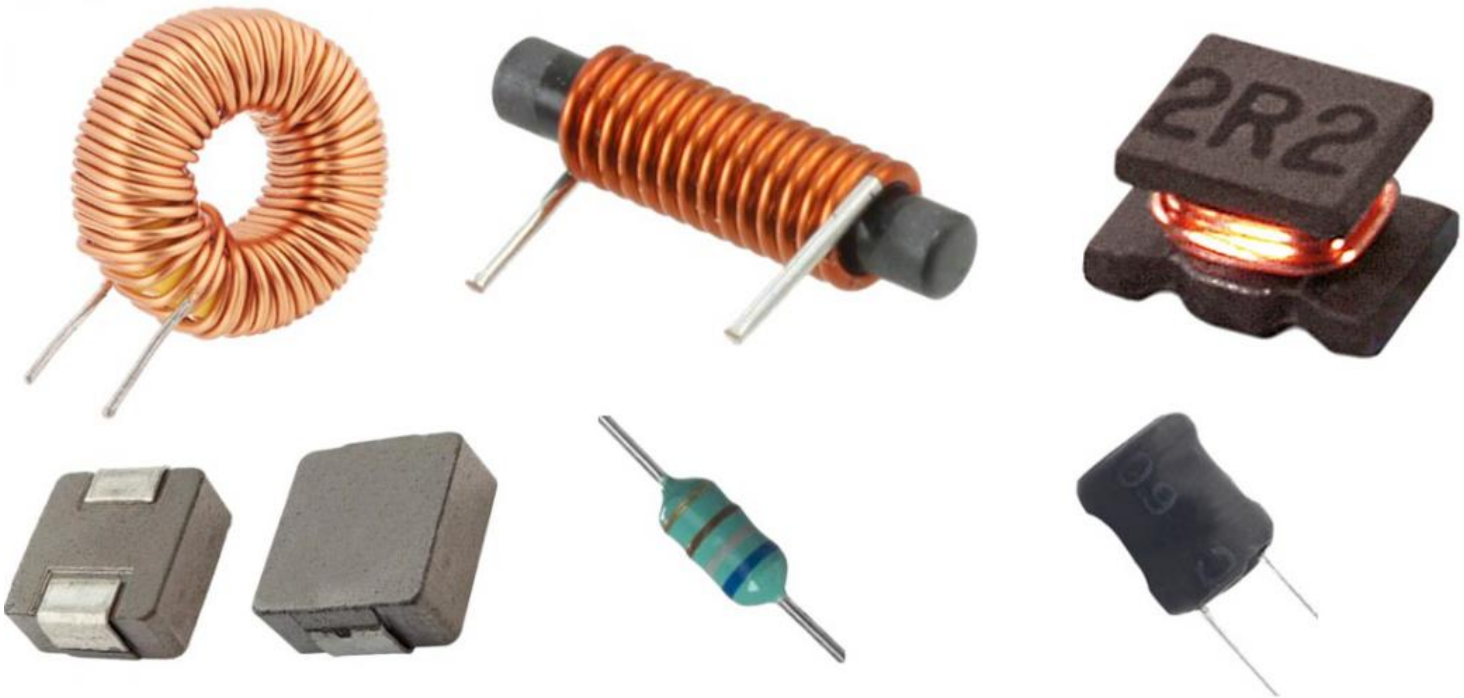


INDUCTOR

- An **inductor** is a passive two-terminal electrical component which resists changes in electric current passing through it.
- It stores energy in magnetic field
- It consists of a conductor such as a wire, usually wound into a coil.
- It is measured in units of Henry (symbol: H).
- **$L=\mu N^2 A/l$**

μ is the permeability (H/m)

N – no. of turns in the coil


2R2

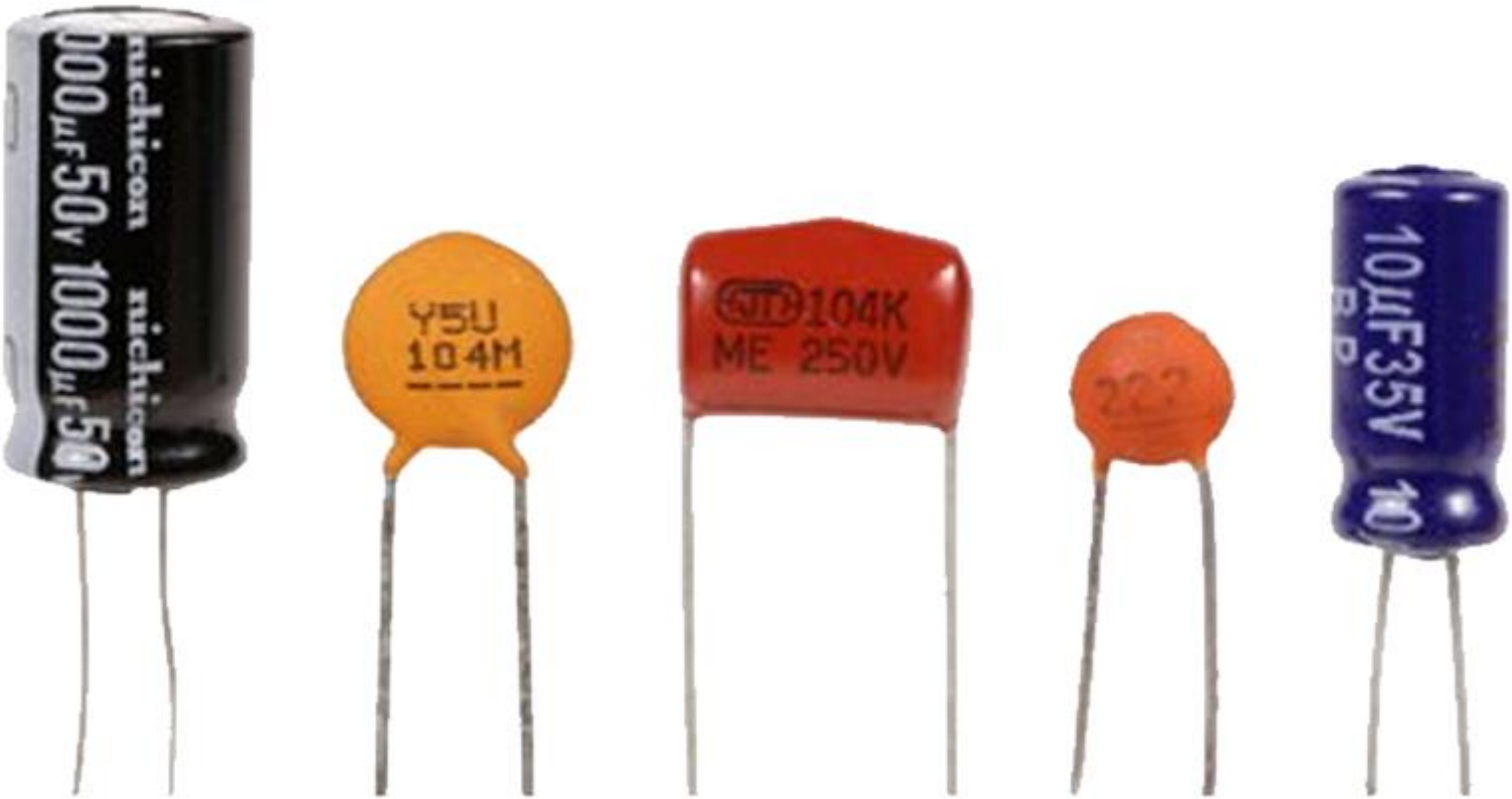
CAPACITOR

- A capacitor is a passive two-terminal electrical component used to store energy electro-statically in an electric field.
- The simplest capacitor consists of two parallel conductive plates separated by a dielectric
- It is measured in units of Farad (symbol: F).
- **$C = \varepsilon A/d$**

ε is the permittivity (F/m)

d is the distance between the plates (m)

A is the cross sectional area of the plates (m^2)


nichicon
Y5U
104M
104K
ME 250V
10µF35V

Sources

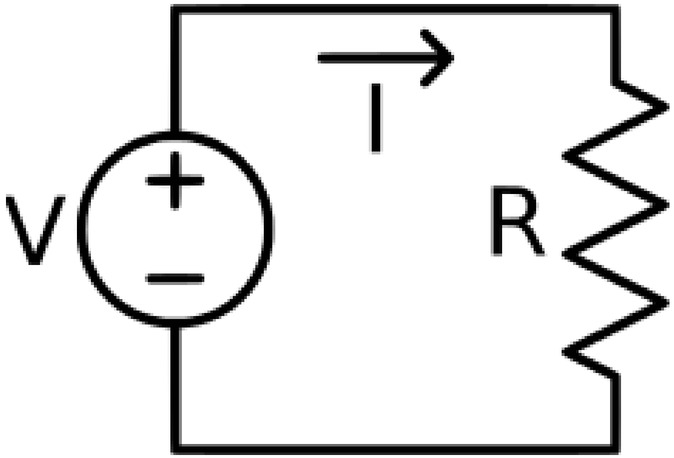
1. Voltage source 2. Current source

AC source & DC source

Ideal source & Practical source

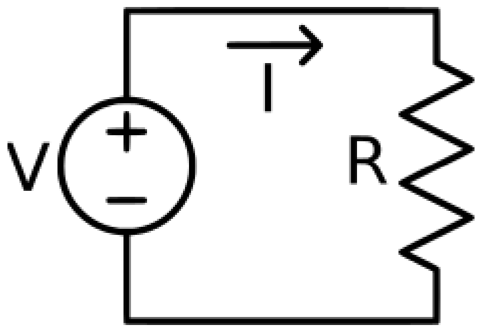
Independent source & Dependent source

Ideal voltage source



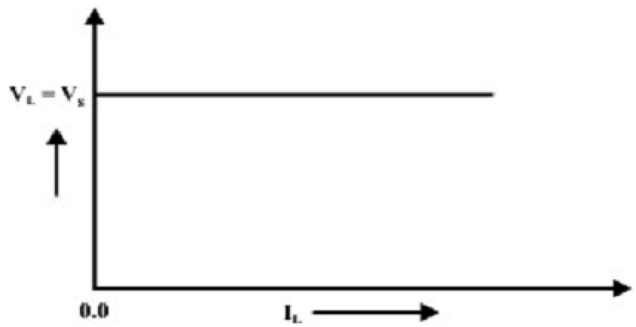
- Produces constant voltage
- Terminal voltage is independent of load.
- $V_{in}=V_{out}$
- Ideal Internal Resistance

  is zero.

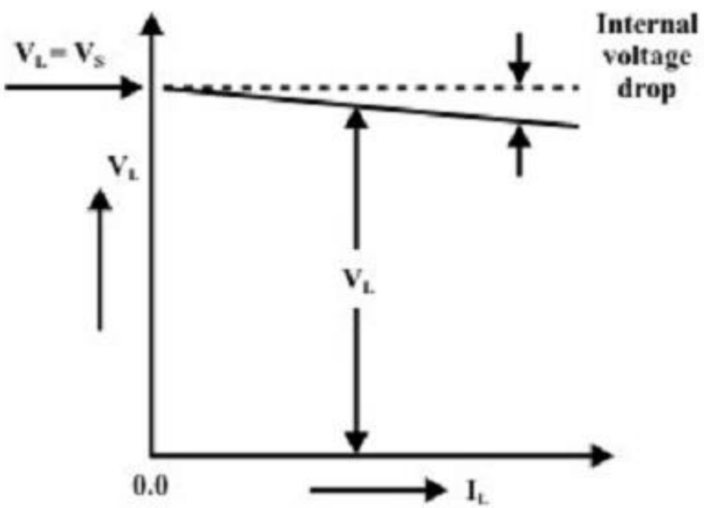


V-I characteristics

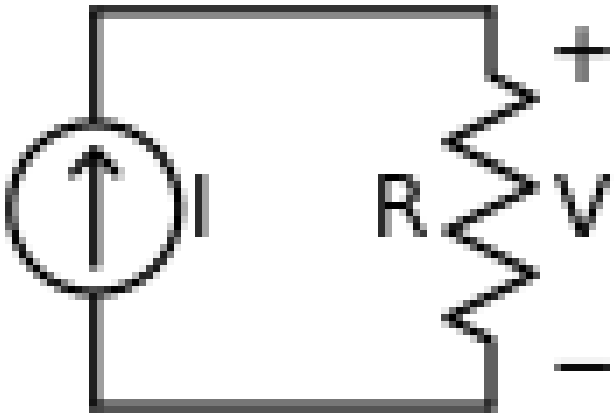
Ideal V source



Practical V source

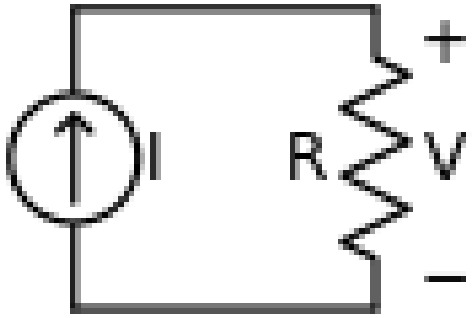


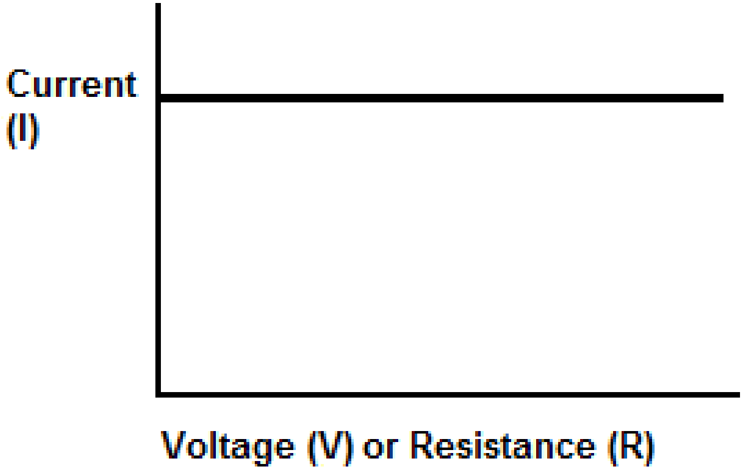
Ideal current source

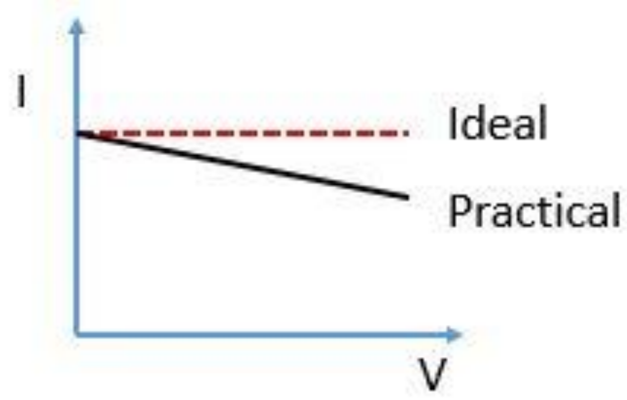


- Delivers constant current to any load resistance
- Independent of the voltage
- Ideal Internal resistance is infinity

V-I Characteristics







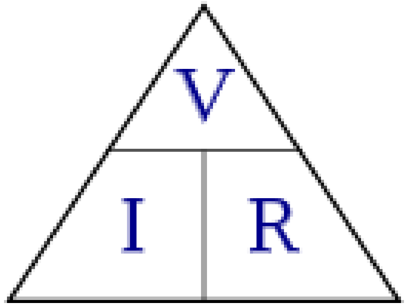
Ohm's Law

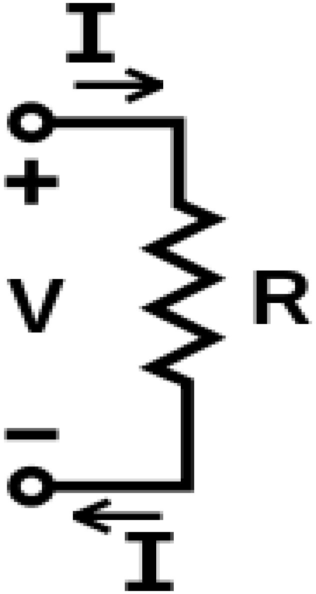
The current through a conductor is directly proportional to the potential difference across the two points.

$I \propto V$

$I = V/R$

$V = IR$



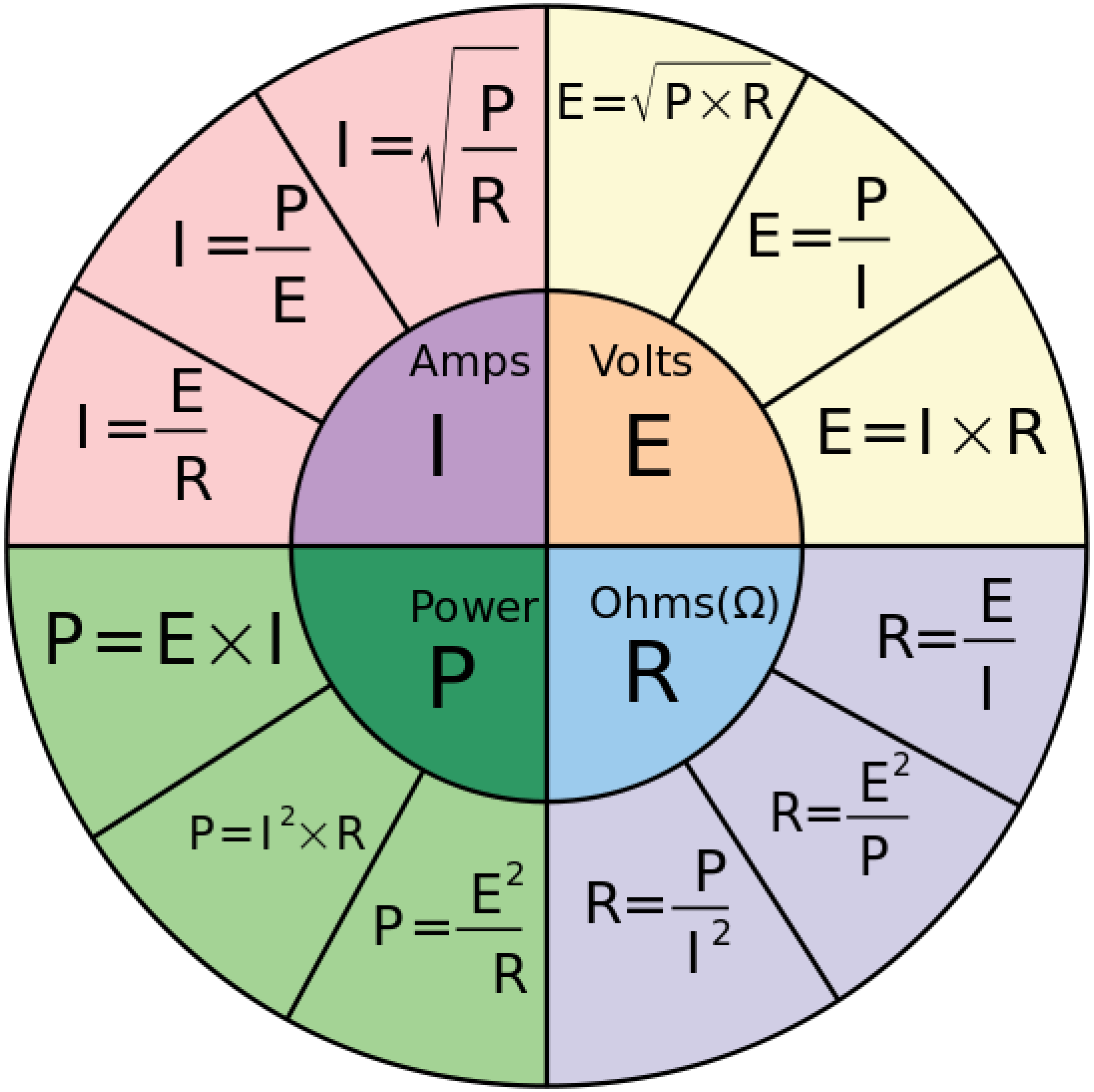


Voltage $E=IR$

Power $P=EI$

$P=I^2R$

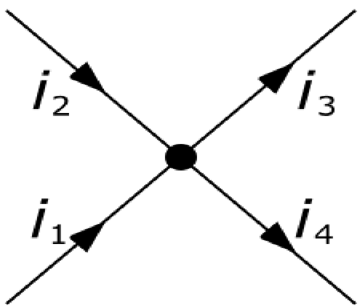
$P=E^2/R$



Kirchhoff's Current Law

The algebraic sum of currents in a node is zero. (OR)

At any node (junction) in an electrical circuit, the sum of the currents entering the node is equal to the sum of the currents leaving the node.

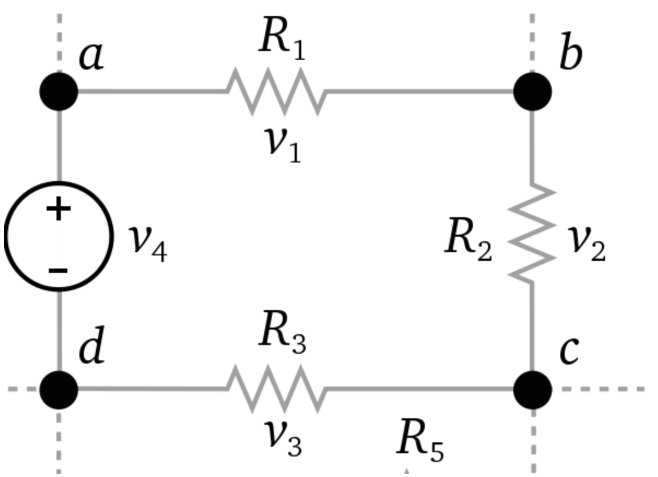


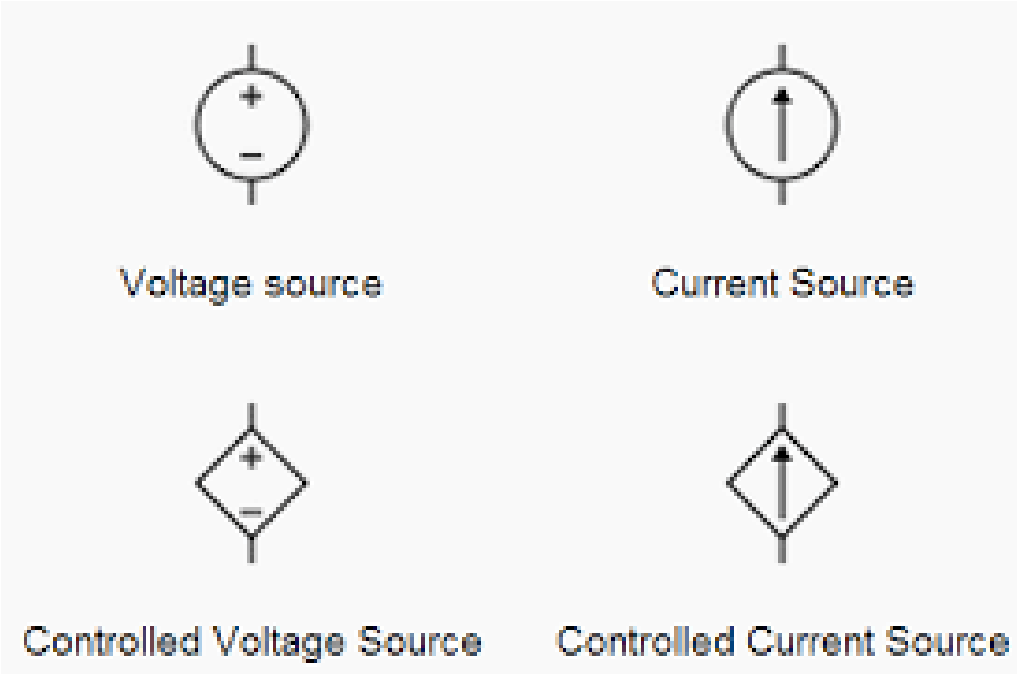
$$i_1 + i_2 = i_3 + i_4$$

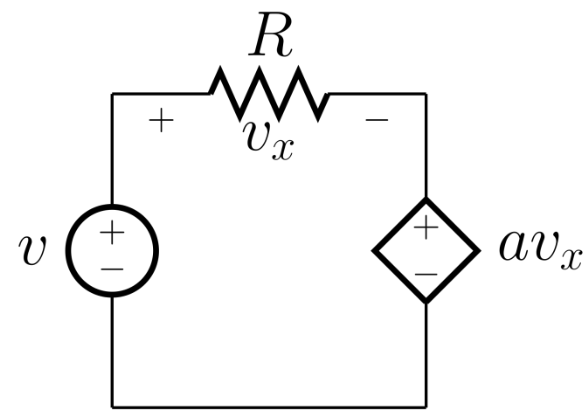
Kirchhoff’s Voltage Law

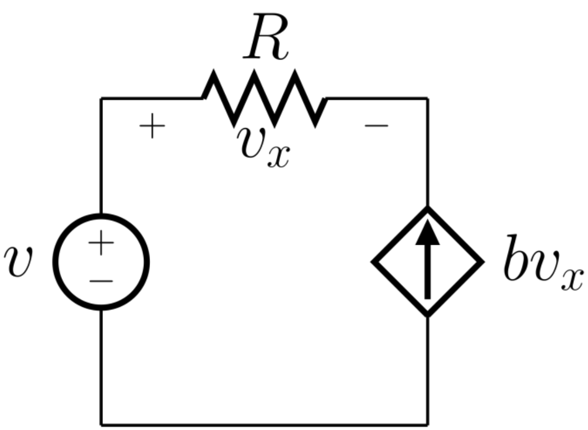
The sum of the electrical potential differences (voltage) around any closed path is zero. (OR)

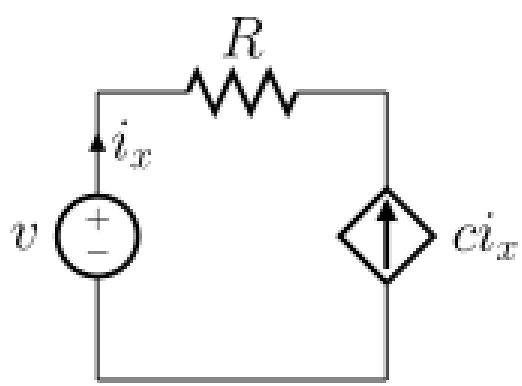
The sum of the potential rises in any closed loop equal to the sum of the potential drops in that loop.

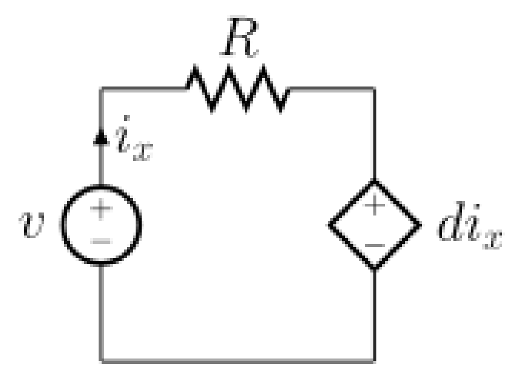



Voltage source
Current Source
Controlled Voltage Source
Controlled Current Source


R
v_x
v
av_x


R
v_x
v
bv_x


R
i_x
v
ci_x


R
i_x
v
di_x

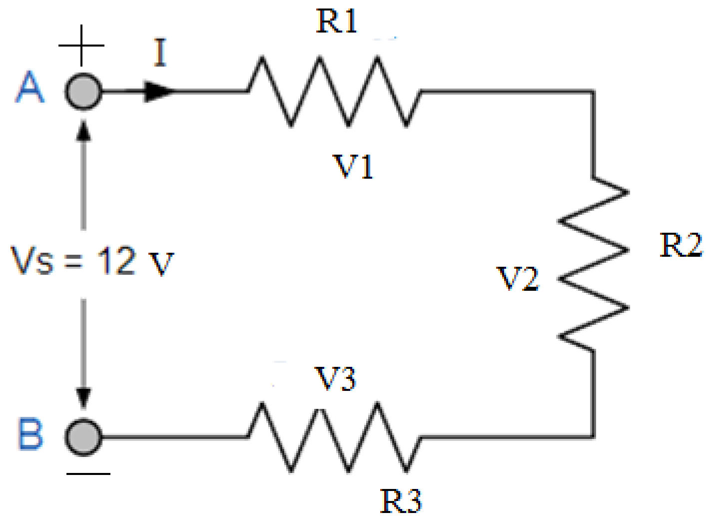
Resistances in series

Resistances are connected end to end so that there is one path for the current flow

$$V1=IR1$$
$$V2=IR2$$
$$V3=IR3$$

$$V=V1+V2+V3$$
$$V=IR1+IR2+IR3$$
$$V=I(R1+R2+R3)$$
$$V=I\ Req$$

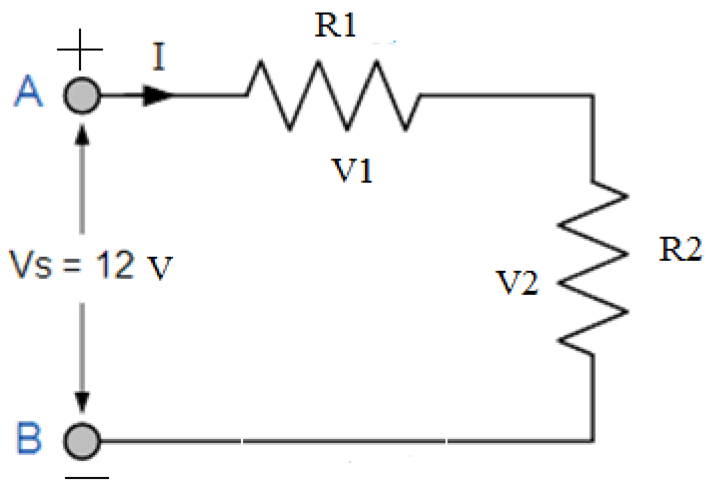
$$Req=R1+R2+R3$$



Concepts of series circuit

- Resistances are connected end to end
- Current remains same
- Voltage drops are additive
- Resistances are additive
- Powers are additive
- The applied voltage equals the sum of voltage drops across resistors
- Voltage across different resistors depends upon the resistance value

Voltage division rule



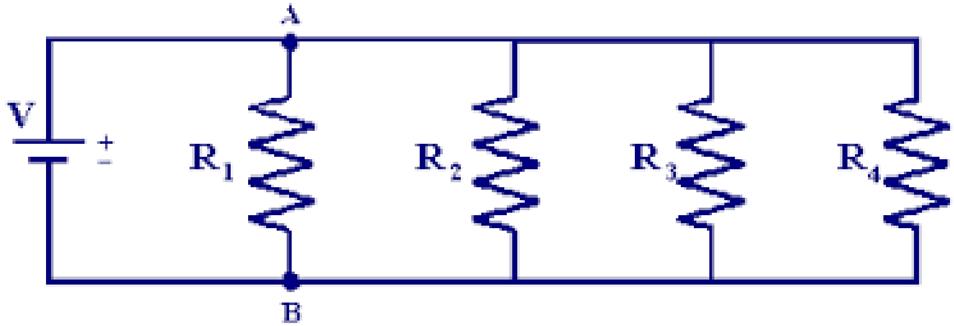
V1=IR1
V2=IR2

V=V1+V2
V=IR1+IR2
V=I(R1+R2)
V=I Req
V/(R1+R2)=I
Req=R1+R2

$$V_1 = V\frac{R_1}{R_1 + R_2} \qquad V_2 = V\frac{R_2}{R_1 + R_2}$$

Resistances in parallel

One end of each resistance is connected to one common point and the other end of each resistance is connected to another common point.



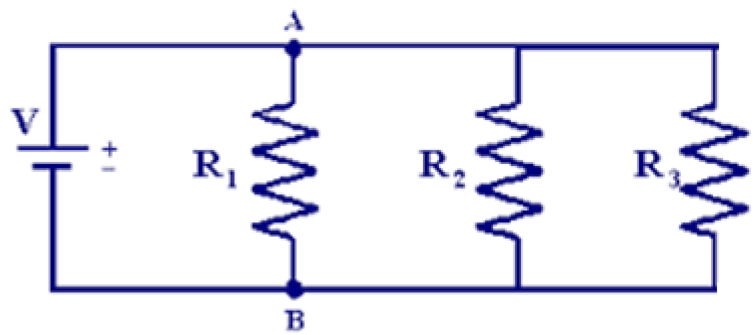
Concepts of parallel circuit

- Voltage remains same
- Branch currents are additive
- Conductance are additive
- Powers are additive
- The total resistance is always less than the smallest of the resistances
- Current through different resistors depends upon the resistance value

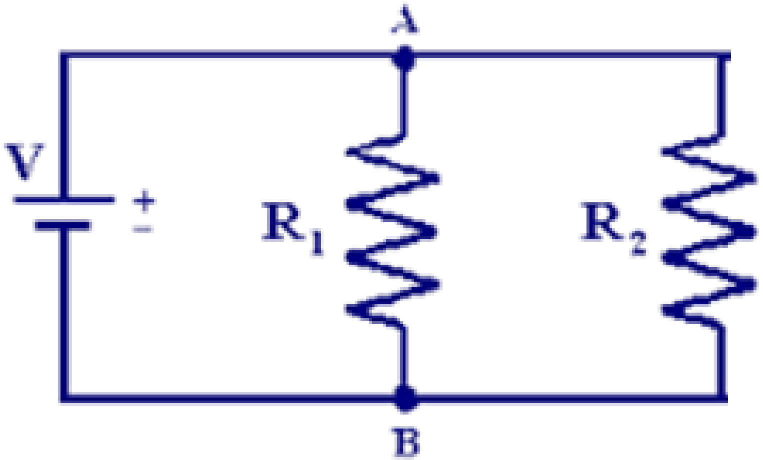
3 resistors:

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$R_{eq} = \frac{R_1 R_2 R_3}{R_1 R_2 + R_1 R_3 + R_2 R_3}$$



Current division rule



2 resistors:

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$$

$$I_1 = I \frac{R_2}{R_1 + R_2} \qquad I_2 = I \frac{R_1}{R_1 + R_2}$$

Simple problems

1. Two resistors of 4 Ω and 6 Ω are connected in parallel. If the total current is 30A, find the current through each resistor.
2. Four resistors of 2 Ω, 3 Ω, 4 Ω and 5 Ω respectively are connected in parallel. What voltage must be applied to the group in order that total power of 100 W may be absorbed?

Simple problems

3. The current flowing through a resistor is 0.8 A when a p.d. of 20 V is applied. Determine the value of the resistance.

4. Determine the p.d. which must be applied to a 2 kΩ resistor in order that a current of 10 mA may flow.

5. A 60 W electric light bulb is connected to a 240 V supply. Determine (a) the current flowing in the bulb and (b) the resistance of the bulb.