22AIE114 : Electrical and Electronic Engineering (2-0-3-3)

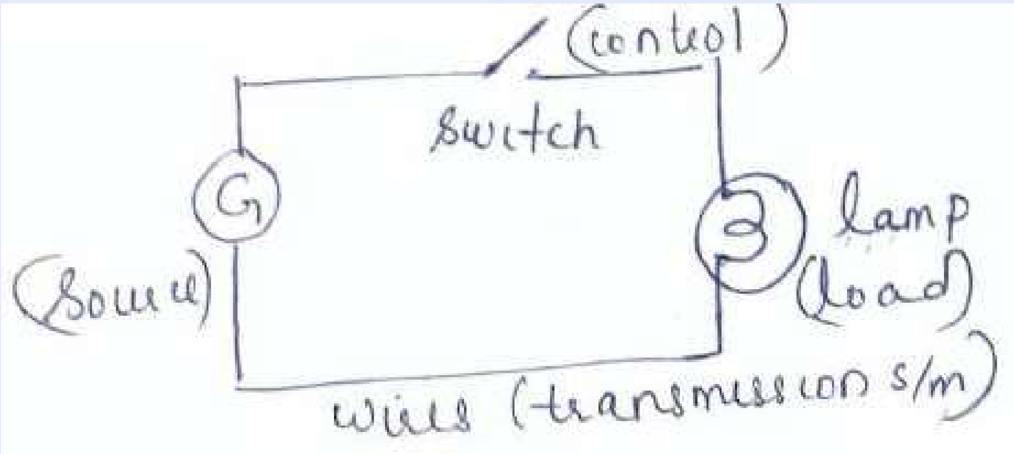
Unit 1, Lecture 2

Topic: Basic Terms and Elements

Outline

- Introduction to basic terms
- Problems
- Active and passive elements
- Ideal and Practical sources
- Resistance, Inductance and Capacitance

1. Introduction to Basic Terms



The Basic electrical system has four parts

1. The source – to provide energy for the electrical system, eg: generators, battery.
2. The load – to absorb the electrical energy, eg: lamp, heater, fan
3. Transmission system – This conducts energy from source to load
4. Control apparatus – to control the energy flow. eg: switches

1. Introduction to Basic Terms

Charge:

- ❖ Fundamental electrical quantity.
- ❖ Movement of electric charge transmits energy.
- ❖ It can be +ve or –ve charge.
- ❖ The unit is **Coulomb (C)**
- ❖ Charge Q = I*t, where I is the current flow and t is the time.
- ❖ The negative charge 1 electron = -1.6×10^{-19} C

1. Introduction to Basic Terms

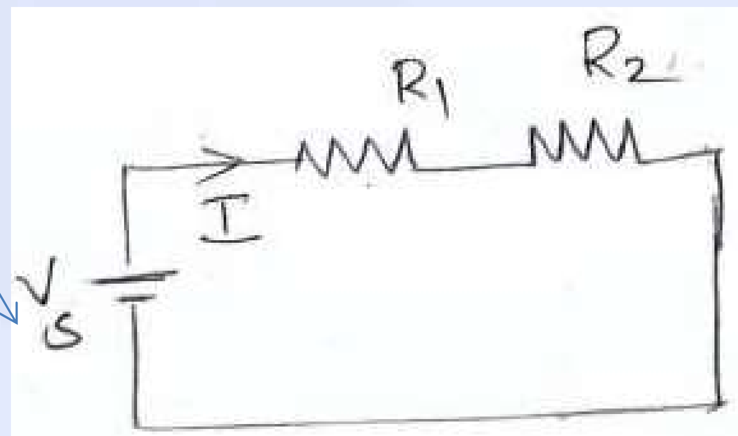
Current:

- **Rate of flow of charge** is called current.
- $I = dq/dt$ or Q/t
- The current flows from higher potential to lower potential.
- By convention +ve terminal to –ve terminal.
- But the **actual flow of electron is from –ve terminal to +ve terminal.**
- The unit of current is **Amperes (A)**

1. Introduction to Basic Terms

Current:

- For the current to flow
  1. There must be a closed path in the circuit.
  2. There must be a driving force to cause continuos flow. It is called electro motive force (EMF).



1. Introduction to Basic Terms

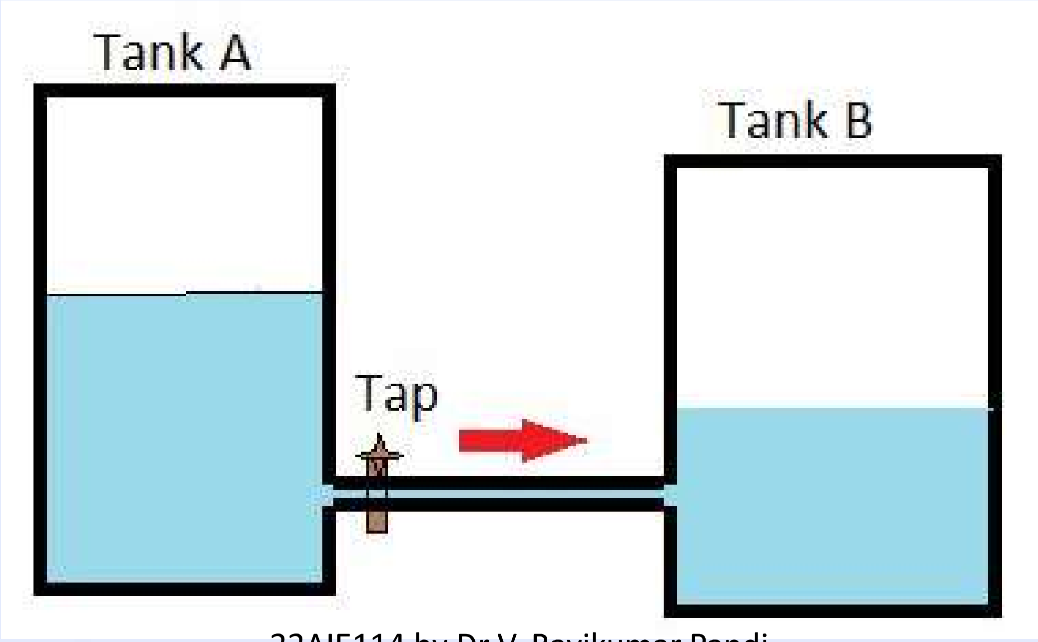
EMF:

- ❖It is the driving force that causes the current to flow.
- ❖It is not a force, but represent the energy expended during the passing of a unit charge through the source.
- ❖ The energy transferred due to the passage of unit charge between two points in a circuit is called as "Potential Difference (pd)".
- ❖ Unit of emf is **Volts (V).**
- ❖ V = W / Q = Energy / charge

1. Introduction to Basic Terms

Analogy in water pipes:

- The flow of current in electrical circuit when there is a potential difference can be analogy to the water flow in pipes when there is a level difference in two storage tanks as shown below.



1. Introduction to Basic Terms

Power:

- It is the time rate of expending or absorbing energy
- Unit – **Watts (W)**
- Power $P = dW/dt$
- Power $P = VxI = I^2 R$
- Law of conservation of energy : Algebraic sum of power in all components in the circuit is zero. $\Sigma p = 0$

Energy:

- The electrical energy $W = Pxt$, is measured in **Watt-Hour**
- 1 kWh is one unit in the EB meter reading.

Question 1

What is the unit of energy?

a) Watts.

b) Watt-Hour.

c) Joules

d) both b and C

1. Introduction to Basic Terms: Problems

1. Determine the current at t=0.5 seconds if the total charge entering a terminal is given by $q = (10-10e^{-2t})$ mC.

Ans: $I = dq/dt = 20e^{-2t} = 7.35$ mA

2. If a charge of 25C passes a given point in a circuit in a time of 125mS. Determine the current in the circuit.

$I = q/t = 25/(125m) = 200$ A

1. Introduction to Basic Terms: Problems

3. A motor gives the output power of 20 kW and operates with an efficiency of 80%. If the constant input voltage to the motor is 200V, what is the constant supply current?

Given: Po = 20kW, Efficiency η = 80%, Vin=200V

Calculation:

Input power, Pin = Po / η = 20kW/0.8 = 25kW

Current , I = Pin/ Vin = 25kW / 200 = 125A

1. Introduction to Basic Terms: Problems

4. How much electrical energy does a 100W electrical bulb consume in 2 hours.

W = P*t = 100*2= 200 Watts-Hour

= 100* 2 * 60 * 60 = 720 k Joules

1. Introduction to Basic Terms: Problems

5. A stove element draws 15A when connected to 120V line. How long does it take to consume 30kJoules?

P = 120*15

W = p*t = 30 kJoules = 120 * 15 * t

t = 16.66 Seconds

1. Introduction to Basic Terms: Problems

6. A p.d. of 12V is applied to a 7.5 Ohm resistors for a period of 5 seconds. Calculate the electric charge transferred in this time.

$I = V/R = 12/7.5$

$q = I \times t = I \times 5 = 8\ C$

2. Introduction to basic Circuit elements

- Electrical Network consists of combination of electrical elements such as resistor, capacitor, etc connected in series or parallel along with the sources.
- There are two broad category of circuit elements

1. **Active elements** (energy sources such as generators, battery)

a) The values vary according to the other elements present in the system.
b) Example: Voltage and current sources

2. **Passive elements**

a) They transforms or dissipate energy.
b) The values of these elements does not vary where it is connected.
c) The value is based on the design.
d) Example: Resistor, capacitor and inductor.

3. Active elements: Voltage and Current sources

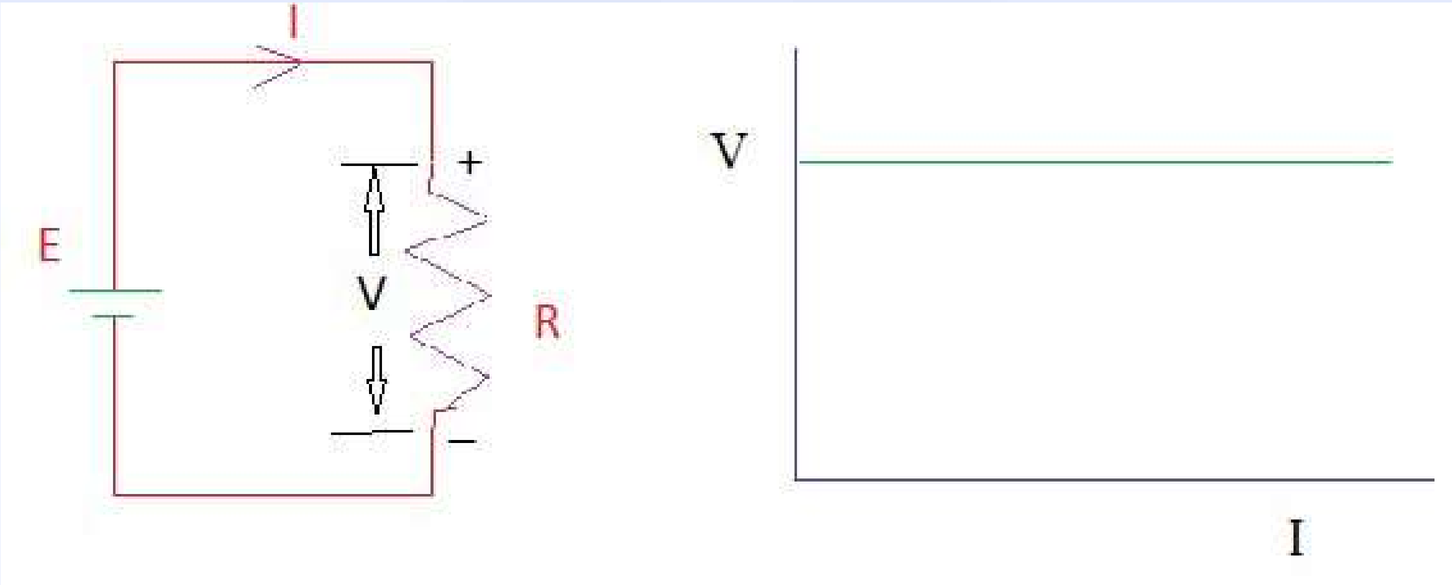
There are two major categories in active elements

1. **Voltage sources**
   a) Ideal voltage source
   b) Practical voltage source
2. **Current sources**
   a) Ideal current source
   b) Practical current source

3. Active elements: Voltage and Current sources

Ideal voltage source

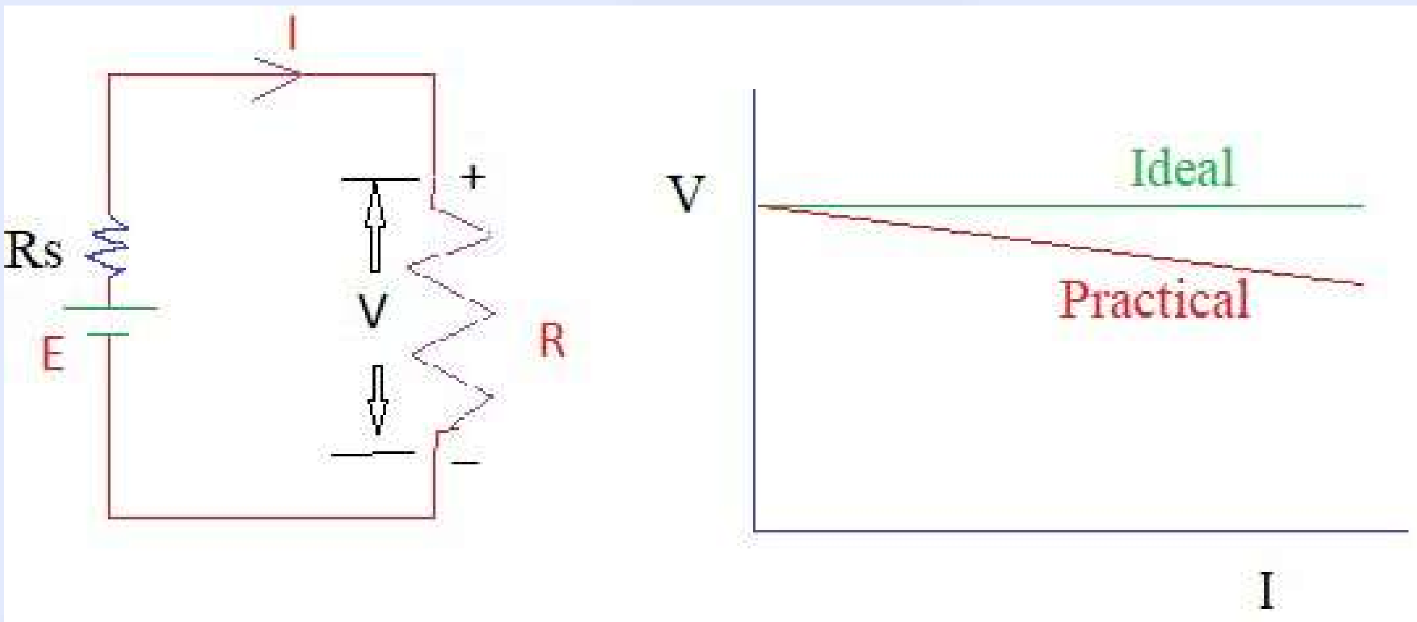
- Capable of delivering power to the load at constant voltage irrespective of current flowing through its terminals.
- Irrespective of the value of resistance R (current will vary), the voltage supplied to load is constant at V volts.



3. Active elements: Voltage and Current sources

Practical voltage source

- The voltage across the terminal falls as current through it increases, because of the small internal resistance coming in series with the voltage source.

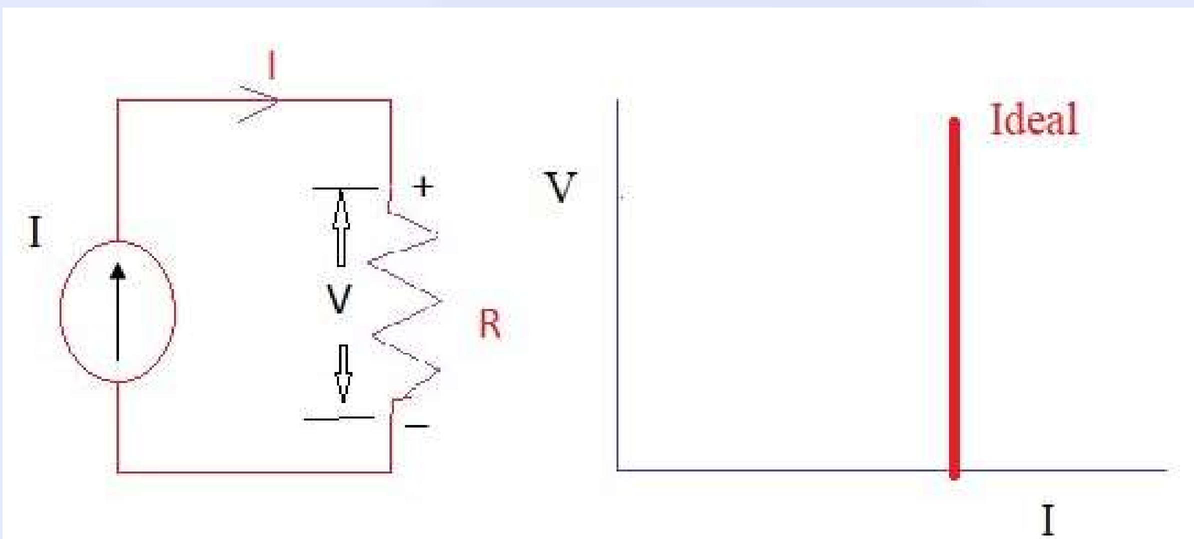


- Rs= 0 for ideal voltage source

3. Active elements: Voltage and Current sources

Ideal Current source

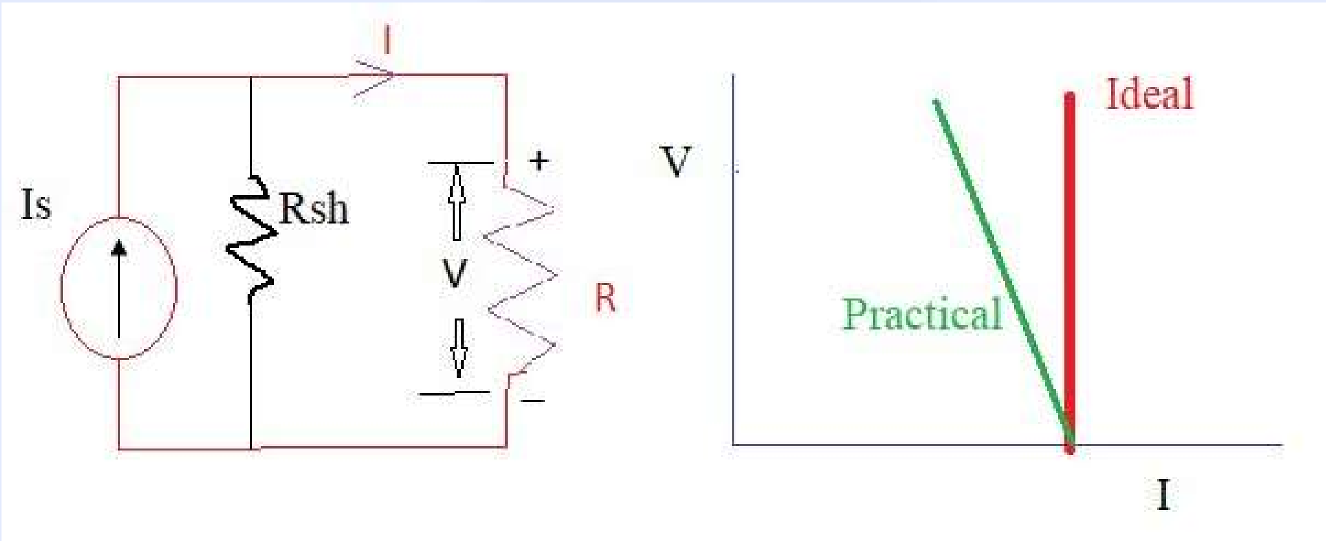
- Capable of delivering power to the load at constant current irrespective of the load resistance.
- Irrespective of the value of resistance R (voltage *V* varies), the current supplied to load is constant at I amps.



3. Active elements: Voltage and Current sources

Practical current source

- The current flowing through load terminal falls as voltage increases, because of the large internal resistance coming in parallel with the current source.



- Rsh= Infinity for ideal current source

4. Passive elements: R, L and C:

1. **Resistance:**
   - It is the measure of the opposition to current flow in circuit.
   - Measured in Ohms and denoted by symbol Ω.
2. **Inductance:**
   - Time varying current flow induces emf on coil.
   - Measured in Henry (H), usually in milli Henrys (mH)
3. **Capacitance**
   - Time varying voltage across capacitor causes the current to flow between plates.
   - Measured in Farads (F), usually in micro Farads (μF).

4. Passive elements: R, L and C:

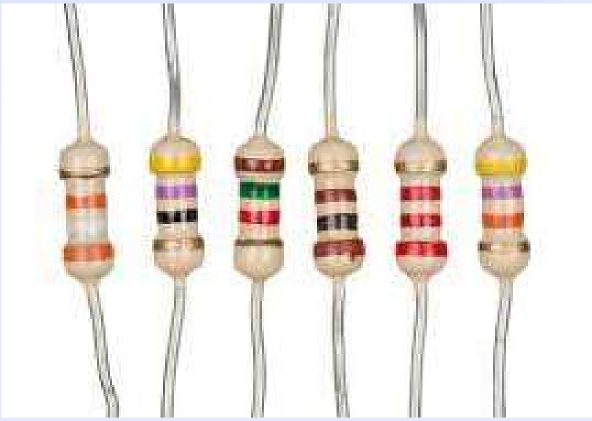
1. **Resistance:**

– When a voltage is applied across as resistor, the electrical current will flow through it.

– The applied voltage is directly proportional to the current.

– The constant of proportionality is called resistance.

– $V = I R$, where R is the resistance offered to oppose the current flow.

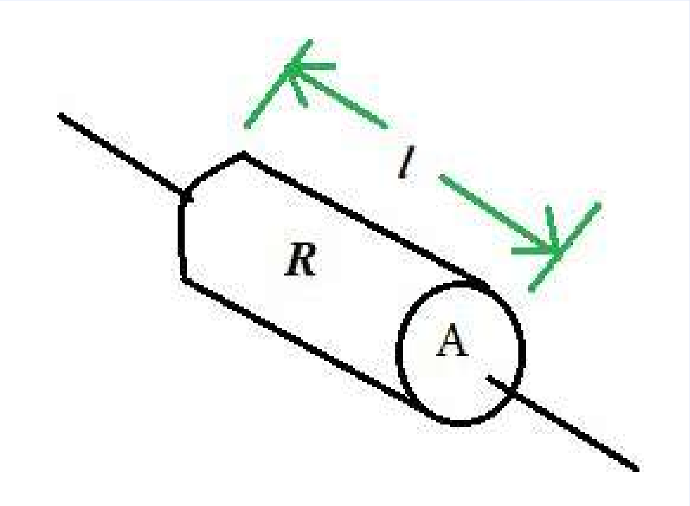


4. Passive elements: R, L and C:

1. **Resistance R:**

– The resistance of any conductor can be calculated as

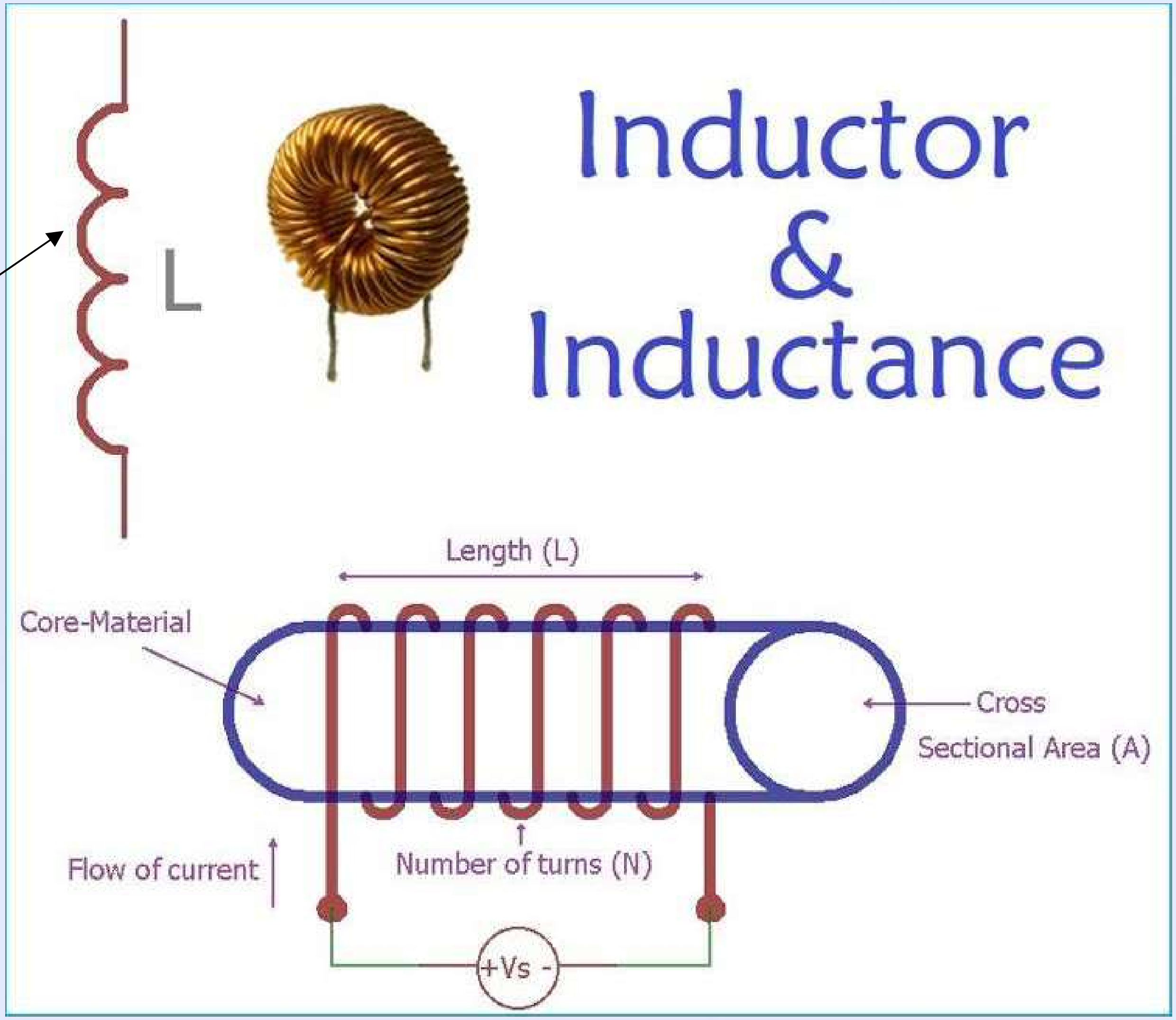
– $R = \frac{\rho l}{A}$, where ρ is resistivity of the material (Ohms meter), l is the length of the conductor (meter) and A is the cross sectional area of the conductor (m^2)



4. Passive elements: R, L and C:

2. Inductance L:

Circuit symbol



4. Passive elements: R, L and C:

2. Inductance L:

- If a time varying current flowing through a coil there is an emf induced in it.
- The induced emf across the coil is directly proportional to the rate of change of current with respect to time.
- Due to the property inducing emf, all types of electrical coil can be referred as inductor.
- An inductor is an energy storage device which stores energy in form of magnetic field.
- ***Current through the inductor cannot change instantaneously.***

4. Passive elements: R, L and C:

2. Inductance L:

- The inductance value of any inductor depends on the physical dimension
- $L = \frac{\mu N^2 A}{l}$
- Where μ is the permeability of the core material
- N is the no of turns in coil
- A is the cross sectional area of the coil
- l is the length of the coil

4. Passive elements: R, L and C:

2. Inductance L:

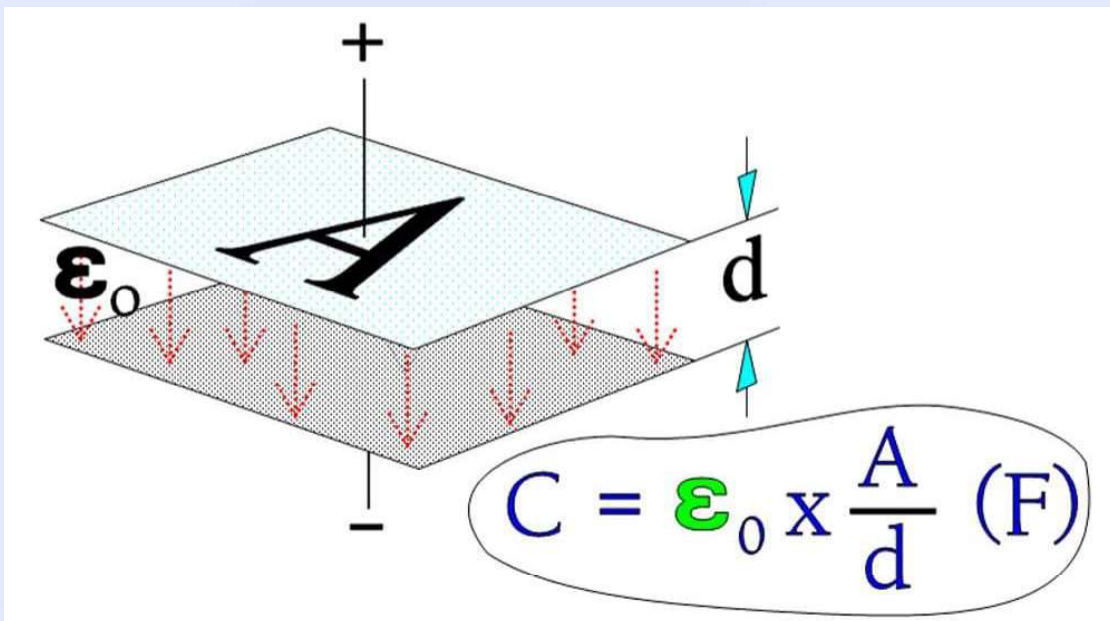
- The induced emf across a coil is directly proportional to the rate of change of current $v \propto \frac{di}{dt}$
- The proportionality constant in that relation is known as inductance. $v = L\,\frac{di}{dt}$
- It can be rearranged as $i = \frac{1}{L}\int v\,dt$
- The energy stored in inductor is given by $w = \frac{1}{2}\,Li^2$

4. Passive elements: R, L and C:

3. Capacitance C:

– A capacitor in an electrical circuit behaves as a charge storage device.

– It holds the electric charge when we apply a voltage across it, and it gives up the stored charge to the circuit as when required.



4. Passive elements: R, L and C:

3. Capacitance C:

- The most basic construction of a capacitor consists of two parallel conductors (usually metallic plates) separated by a dielectric material.
- When we connect a voltage source across the capacitor, the conductor (capacitor plate) attached to the positive terminal of the source becomes positively charged, and the conductor (capacitor plate) connected to the negative terminal of the source becomes negatively charged.
- Because of the presence of dielectric in between the conductors, ideally, no charge can migrate from one plate to other.

4. Passive elements: R, L and C:

3. Capacitance C:

- The capacitance is the charge gets stored in a capacitor for developing 1 volt potential difference across it.
- Hence, there is a direct relationship between the charge and voltage of a capacitor.
- The charge accumulated in the capacitor is directly proportional to the voltage developed across the capacitor. $Q \propto V$=> $Q = CV$
- Taking derivative with respect to time . $\frac{dQ}{dt} = I = C\,\frac{dV}{dt}$
- It can be rearranged as V = $\frac{1}{C}\int idt$
- The energy stored in capacitor is given by $w = \frac{1}{2}\,CV^2$

4. Passive elements: R, L and C:

TABLE 6.1

Important characteristics of the basic elements.†

Relation	Resistor (R)	Capacitor (C)	Inductor (L)
v-i:	$v = iR$	$v = \dfrac{1}{C}\displaystyle\int_{t_0}^{t} i(\tau)d\tau + v(t_0)$	$v = L\dfrac{di}{dt}$
i-v:	$i = v/R$	$i = C\dfrac{dv}{dt}$	$i = \dfrac{1}{L}\displaystyle\int_{t_0}^{t} v(\tau)d\tau + i(t_0)$
p or w:	$p = i^2R = \dfrac{v^2}{R}$	$w = \dfrac{1}{2}Cv^2$	$w = \dfrac{1}{2}Li^2$
Series:	$R_{eq} = R_1 + R_2$	$C_{eq} = \dfrac{C_1C_2}{C_1 + C_2}$	$L_{eq} = L_1 + L_2$
Parallel:	$R_{eq} = \dfrac{R_1R_2}{R_1 + R_2}$	$C_{eq} = C_1 + C_2$	$L_{eq} = \dfrac{L_1L_2}{L_1 + L_2}$
At dc:	Same	Open circuit	Short circuit
Circuit variable that cannot change abruptly:	Not applicable	v	i

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Dr. A.P.J. Abdul Kalam
Former President of India

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