Chapter 1

General Electric System

CHAPTER-01 : General electric system

1. Constituent part of an electric system(source,load and control)
2. Current flow in the circuit
3. Electromotive force and potential difference
4. Ohms law
5. Resistor and resistivity
6. Temperature rise and temperature coefficient of resistance
7. Voltage and current sources

Electrical current

- The rate of flow of charge per unit time is known as electric current.

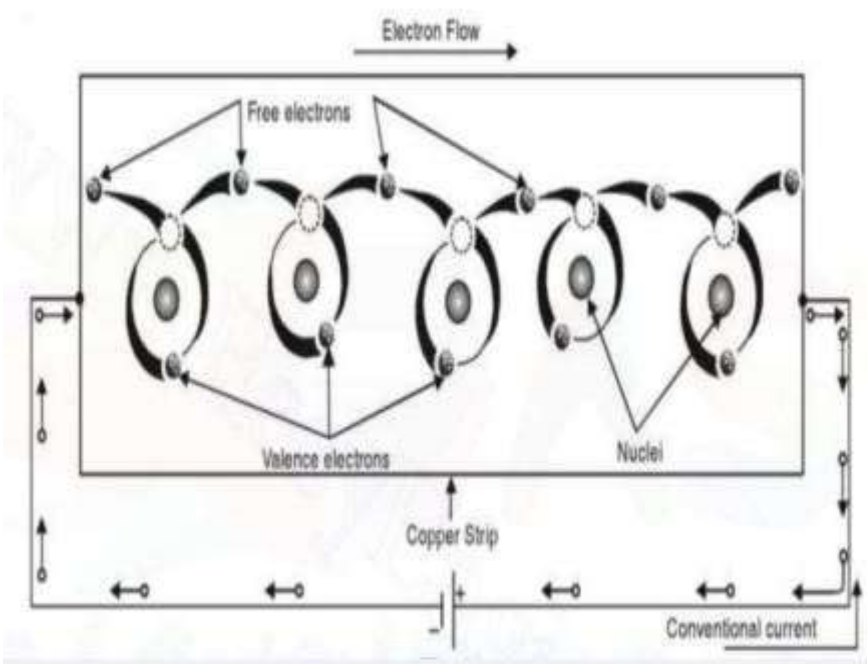
  Current (i)= charge(Q) / time(t)

- Its unit is coulomb per sec which is called as Ampere (A).
- When electric pressure or voltage is applied , free electrons being negatively charged starts moving towards the positive terminal round the circuit as in figure below.
- Conventionally, the direction of electric current is taken along the direction motion of positive charge. When the current is caused by electrons (eg in metals),the direction of current is opposite to the direction of electron flow.
- When q = 1 and t=1 then I = 1

Now we can define one Ampere as the current flow through a wire at any section, one coulomb of charge flow in one second.

- When n number of electrons are passing through any cross section of wire in time t then

$$I = ne/t$$



Condition of current flow

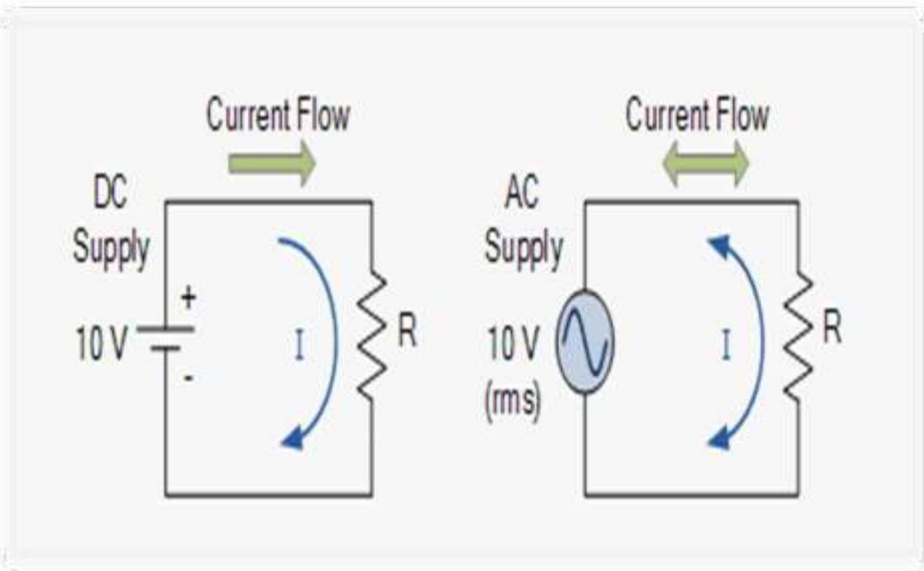
- The circuit or network must have potential difference.
- It must have closed path and also have return path.

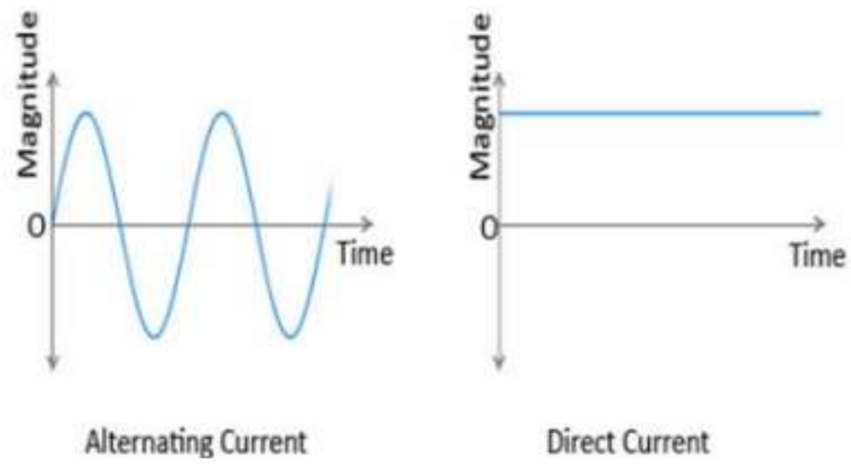
➢ Must satisfy above condition for current flow(if not then such circuit is called dead circuit)

Types of Electric current

a) Alternating current (AC)

b) Direct current (DC)





Difference between AC and DC

Electric potential

- Just as a body above the ground has gravitational potential energy.
- Similarly charged body has electrical potential energy.
- When a body is charge ,work is done in charging the body and this work done is stored in the form of electrical potential energy.
- Electrical potential at a point is the electrical potential energy per unit charge .

electrical potential (V) = electrical potential energy / charge

$$V = w / Q$$

- Potential of 10v,it means 1 coulomb charge at any point will have electric energy of 10J.
- Its unit is volt (v).

Potential difference

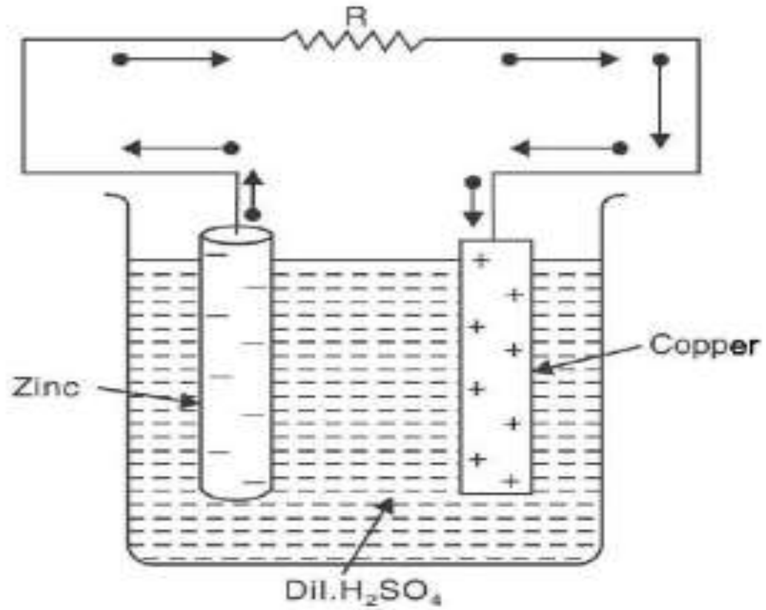
- The difference in the potential of two charged bodies is called potential difference.
- Consider two bodies bodies A and B having potential of 5v and 3v respectively.
- Each coulomb of charge on body A has 5 joules energy while each coulomb of charge on body B has 3 joules.
- If the body are joined through a conductor then electrons will flow from body B to body A.
- When the body attains the same potential the flow of electrons stops.

Potential difference

- Therefore arrive at a very important point that current will flow in a circuit if there is potential difference exists.
- No potential difference(p.d), no current will flow.
- P.d is the workdone in moving unit charge from one point to other in circuit.
- Its unit is volt (v).

Electromotive force (emf)

- A device that maintains potential difference between two points is said to develop electromotive force (emf).

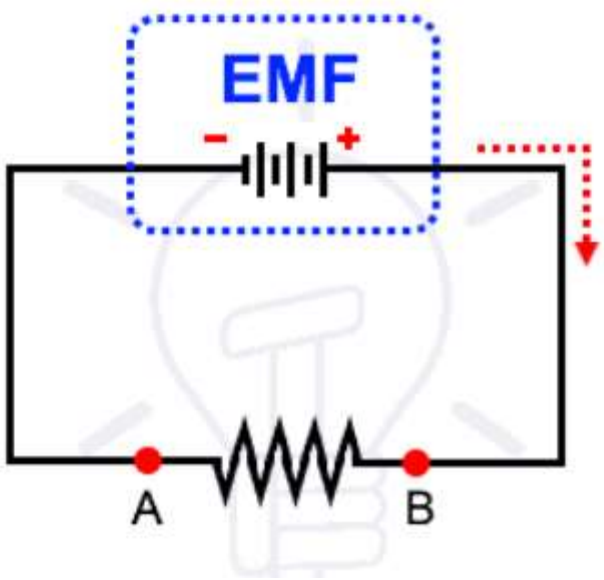


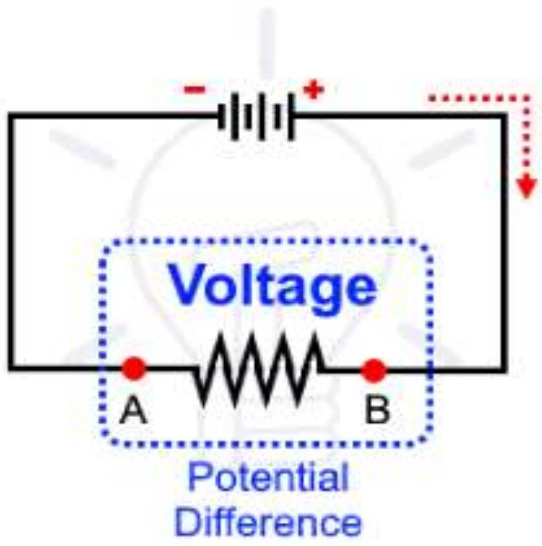
Electromotive force (emf)

- Zinc rod (cathode) and copper plate (anode) immersed in dilute Sulphuric acid.
- The chemical reaction taking place in a cell removes electrons from copper plate and transfer to zinc rod. This transference of electrons takes place through the agency of dilute sulphuric acid (called electrolyte).
- Consequently copper plate attains positive charge and zinc rod attains negative charge.
- The chemical action of the cell now transfer an equal amount of electrons from copper plate to zinc rod internally through the cell to maintain original potential difference.
- The two plates are joined through the wire ,some electrons will be attracted through the wire to copper plate.
- The flow of electrons takes place in the the external wire(external circuit).
- Thus potential difference causes current to flow and emf maintains the p.d.
- Although both emf and p.d have same units of measurements in volt,they do not mean exactly the same.

Concept of emf and potential difference

- Emf of a device (say a battery) is a measure of energy ,the battery gives to a each coulomb of charge. Thus if a batteries supplies 4 joules of energy per coulomb we say it has an emf of 4 volt.
- The p.d between two points say A and B is a measure of energy used by one coulomb in moving from from A to B .Thus if potential difference between two points is 2 volts,it means that each coulomb will give an energy of 2 joules in moving from A to B.





Difference between Emf and P.d

EMF	**P.D**
The potential difference between the two terminal of cell when it is open circuit.	It is the work done in moving unit charge from one point to other point in circuit.
It is causes which maintains p.d.	It is the effect of emf.
It is constant and is independent of circuit resistance.	It is not constant as it depends upon resistance of the circuits.
It is always greater than p.d	It can not be greater than emf .
Applied for electric field	Applied for electric field, gravitational and magnetic.

Drift Velocity (Vd)

- A drift velocity is the average velocity attained by charged particles, such as electrons, in a material due to an electric field.
- When a potential difference is applied across a conductor, free electrons gain velocity in the direction opposite to the electric field between successive collision(loose velocity when travelling in the direction of the field) thus acquiring a velocity. A s a result there is definite small drift velocity of electrons which superimposed on the random motion of free electrons.
- Due to drift velocity, there is a net flow of electrons opposite to the direction of field.

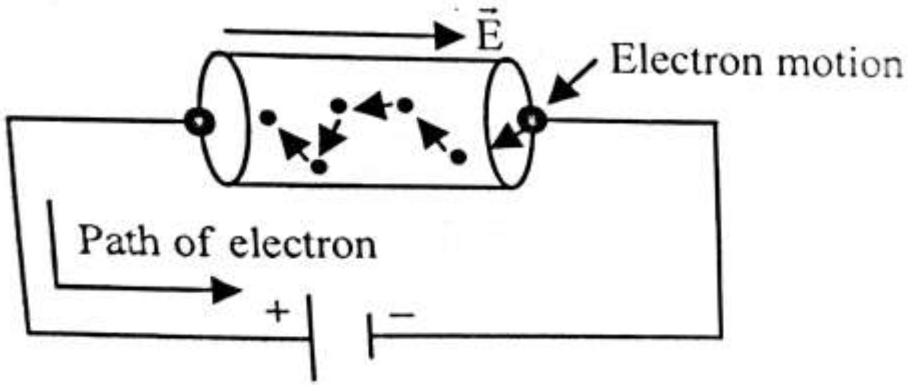


Fig. Resultant motion of electron inside conductor under influence of electric field

Derivation

Force experience by an electron,

$$F = -eE$$

where –ve sign indicates electrons will experience force in opposite direction of electric field

Acceleration of electron, a=F/m

$$a = -eE/m$$

where m= mass of electron

Let λ be the mean free path(avarage distance travelled by electron between successive collisions)

τ be the relaxation time (avarage time that an electrons spend between successive collisions)

$$V_d = u + a\tau = 0+(-eE/m)\tau$$

$$V_d = (-eE/m)$$

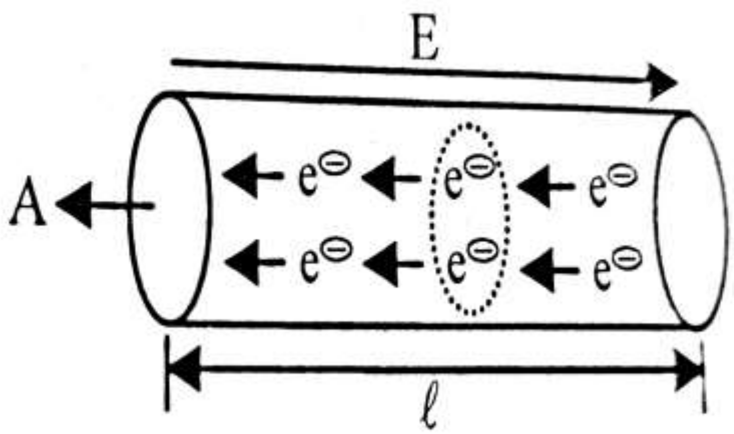


Fig. Electron flow in conductor

Consider,

Conductor of length(L)

uniform cross section area (A)

number of free electrons per unit volume (n)

electrons moving with velocity (Vd)

In small time interval (Δt) each electron moves a distance of (Δt*Vd) and cover volume

$$V = A * Vd * \Delta t$$

Number of free electron in the this volume is,

$$N = n * V = n*(A * V* \Delta t)$$

Charge crossing the area (A) in time Δt will be

$$\Delta Q = Ne = n*e*A*Vd*\Delta t$$

As current is given by rate of flow of charge for interval Δt,

$$I = \Delta Q/\Delta t$$

$$=(neAVd\Delta t)/\Delta t$$

$$I = Vd*e*n*A \quad \ldots\ldots\ldots\ldots(1)$$

which is relation between electric current and drift velocity we know ,

$$I = J * A \quad \ldots\ldots\ldots\ldots(2)$$

Comparing eqn(1) and (2),we get

$$J = Vden \quad \ldots\ldots\ldots\ldots(3)$$

where J = current density

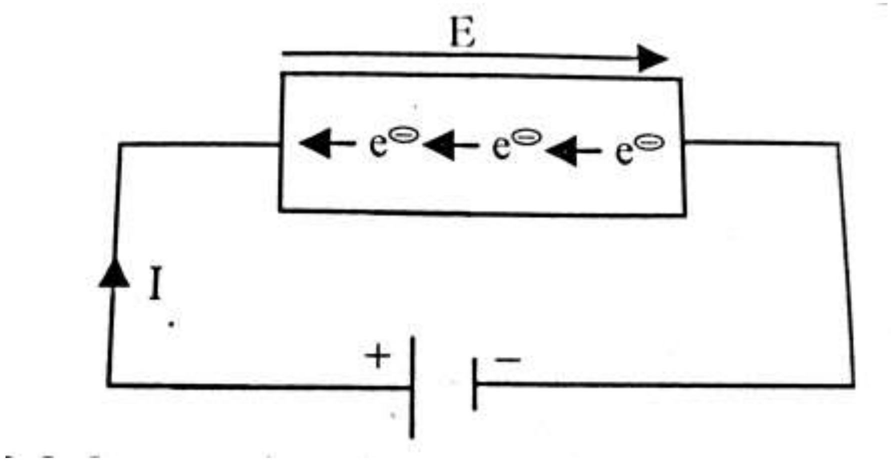


Fig. Conventional current and electron flow

Q.1 In a copper of cross section 2 mm^2,a drift velocity of electrons $7.35*10^{-5}$ m/s.If free electron density in copper is $8.5*10^{22}$ cm^{-3}.Calculate

i. Amount of current in wire and

ii. Current density

Solution:

We have given

Area (A) = 2 mm^2 = $2*10^{-6}$ m^2

Drift velocity (V_d) = $7.35*10^{-5}$ m/s

nu,ber of free electrons (n) = $8.5*10^{22}$ cm^{-3} = $8.5*10^{28}$ m^{-3}

i. Amount of current in wire

$I = V_d *enA = 7.35*10^{-5} *1.6*10^{-19} * 8.5*10^{28} *2*10^{-6}$

$I = 1.99 = 2A$

ii. Current density

$J = I/A = 2/2*10^{-6} = 10^6 A/m^2$

Ohms Law

- George Simon ohm (German mathematician)

Statement :- under physical condition (i.e temperature,pressure constant),current flowing to the conductor is directly proportional to Potential difference applied across its ends.

Let I be the current flowing through a conductor when p.d of v volts is applied across its ends then,

$$\mathbf{I \propto V} \quad \ldots\ldots\ldots\ldots.(1)$$

$$\mathbf{I = V/R} \quad \ldots\ldots\ldots\ldots(2)$$

where 1/R is the proportionality constant and R is the resistance of conductor

From equation(2),we can write

$$\mathbf{V = IR} \quad \ldots\ldots\ldots\ldots\ldots\ldots(3)$$

Equation (3) is derived form of ohms law

$$\mathbf{V/I = R = constant}$$

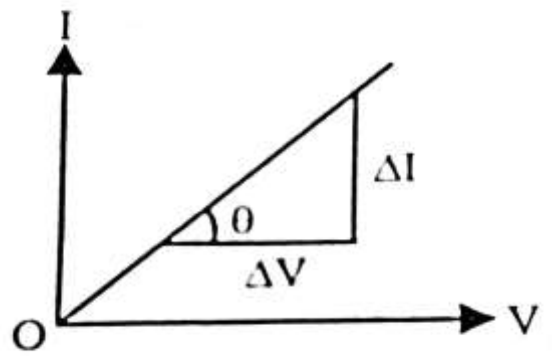


Fig. I-V characteristics

- Nature of graph is straight line passing through origin
- Slope of straight lines gives resistance of conductor
- Ohm can be viewed as the cause and effect relationship with voltage as cause and current as the effect.

Ohmic and Non Ohmic conductor

Ohmic conductor –

- The conductor which obey ohms law(Iαv) are called ohmic conductor.eg-metals.
- V-I graph is linear(straight line passing through origin)

Non ohmic conductor –

- The conductor which doesnot obey ohms law are called non ohmic conductors.
- E.g- vaccum tubes,transistor etc. V-I graph is nonlinear.

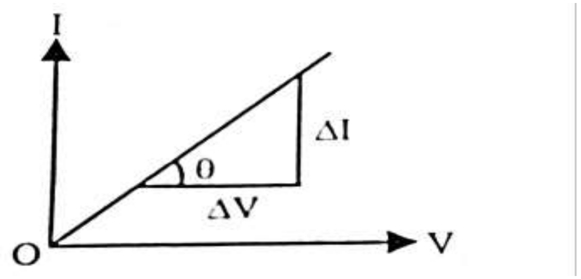


Fig. I-V characteristics of ohmic conductors

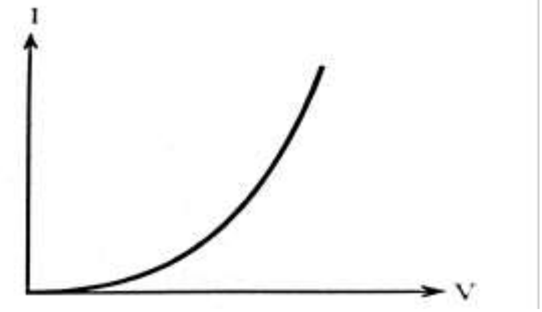


Fig. I-V characteristics of non-ohmic conductors

Limitation of ohms law

- It can not be applied when temperature,pressure etc changes.
- It can not be applied for semi-conducting devices such as diode transistor, vaccum tubes etc.

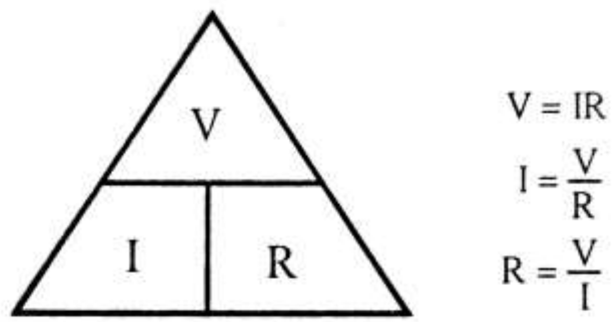


Fig. Representation of ohm's laws in triangle

Resistance and resistivity

***Resistance*:-**It is the property of conductor by virtue of which it opposes any flow of current through it. Its unit is ohm(Ω).

Resistance depends upon –

- It varies directly with the length of conductor

  R α L ....(1)

- It is inversely proportional to the cross section area of conductor

  Rα1/A...............(2)

  combining equation (1) and (2)

  R α L/A

  R= ϱL/A ....(3)

Where

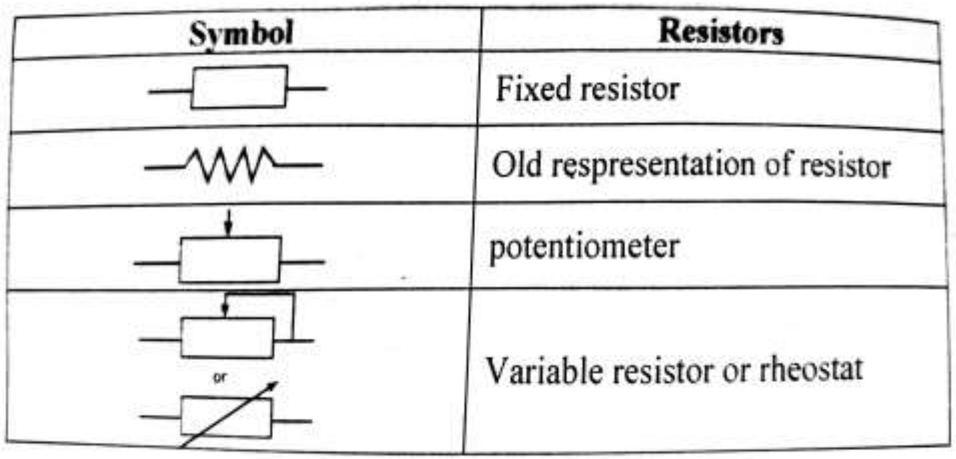
L = length of conductor

A = cross section area of conductor

ϱ = proportionality constant and known as resistivity

- ϱ depends upon nature of material and temperature and its unit is Ωm
- When L= 1m, A=1m^2 then R==ϱ (resistivity is equal to the resistance of unit cube)

Symbol of resistance



Symbol	Resistors
	Fixed resistor
	Old respresentation of resistor
	potentiometer
or	Variable resistor or rheostat

Temperature rise and temperature coefficient of resistance

- Generally resistance of all material changes (some increases and some decreases with rise in temperature)
- The resistance of conductor or metal increases with rise in temperature (positive temperature coefficient) however the resistance of semiconductor and insulator decreases with increase in temperature (negative temperature coefficient).

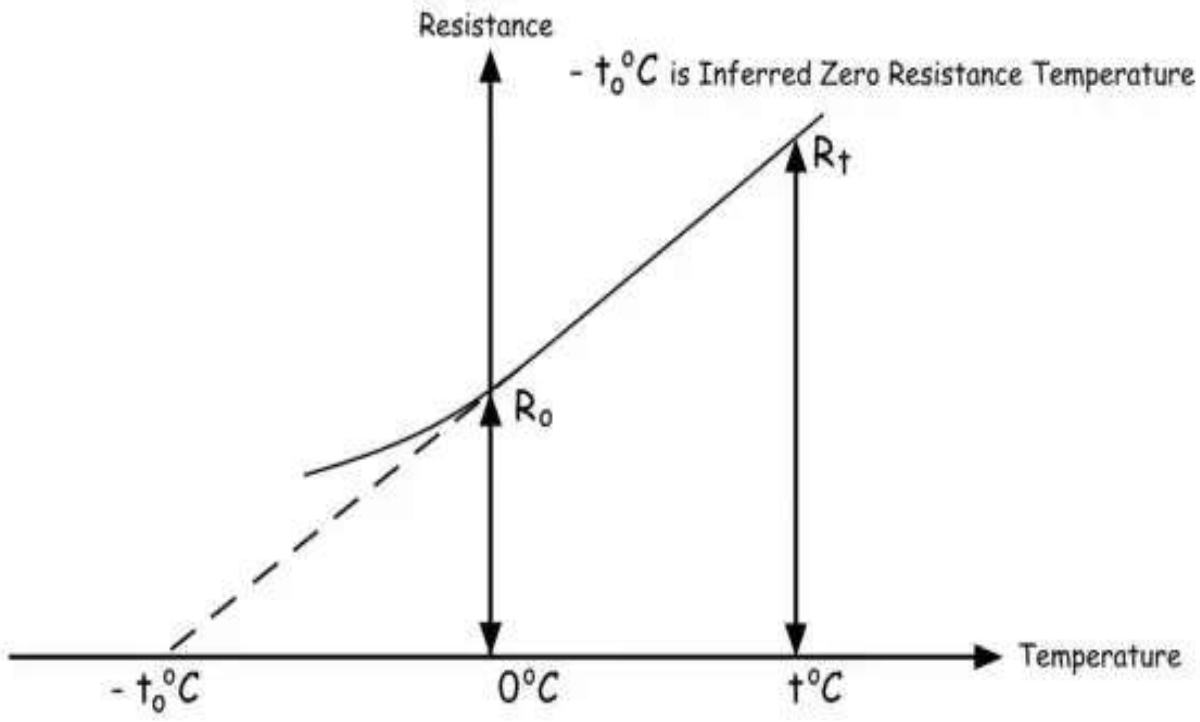


Fig. Variation of resistance with temperature

Let

R_O be initial resistance at 0 ^oC

R_T be the final resistance at T ^oC

Change in resistance is given by

$\Delta R = R_T - R_O$ ....(1)

Change in resistance depend upon following factors

$\Delta R \alpha R_O$ ....(2)

$\Delta R \alpha \Delta T$ ....(3)

Combining equation (2) and (3)

$\Delta R \alpha \Delta T R_O$

$\Delta R = \alpha_O \Delta T R_O$ ....(4)

Where α_O is the constant and known as temperature coffiecient of resistance

From equation(4)

$\alpha_O = \Delta R/R_O/\Delta T$

$\alpha_O = (R_T - R_O)/R_O/\Delta T$ ....(5)

Thus temperature coffiecient of resistance (TCR) is defined as the per unit change in resistance to per unit change in temperature.

From equation (5)

$\alpha_O \Delta T = (R_T - R_O)/R_O$

$\alpha_O \Delta T R_O = (R_T - R_O)$

$R_T = R_O (1+ \alpha_O \Delta T)$ ....(6)

where $\Delta T = T - 0$

Effect of Temperature on α

Let

R_O be the resistance at 0^OC

α_O be the TCR at $0\ ^OC$

R_T be the fresistance at $T\ ^OC$

α_T be the TCR at $T\ ^OC$

Let us consider a conductor is heated from $0\ ^OC$ to $T\ ^OC$ such that α_O be the TCRat 0^OC. then

$R_T = R_O(1+ \alpha_O \Delta T)$ ....(7)

Now let the same conductor be cooled from T^OC to 0^OC sucvh that α_T be TCR at T^OC then

$R_O = R_T(1 - \alpha_T \Delta T)$ ....(8)

Where $\Delta T = 0\text{-}T$

From equation (8)

$\alpha_T = (R_T - R_O)/ (\Delta T\ R_T)$ ....(9)

Subtituting the value R_T from equation(7) in equation(9)

$\alpha_T = \{R_O(1+ \alpha_O \Delta T)- R_O)\} / [\Delta T\{R_O(1+ \alpha_O \Delta T)\}]$

$\alpha_T = (R_O\ \alpha_O \Delta T)/ [\Delta T\ R_O(1+ \alpha_O \Delta T)]$

$\alpha_T = (R_O\ \alpha_O \Delta T)/ [\Delta T\ R_O(1+ \alpha_O \Delta T)]$

$\alpha_T = \alpha_O / (1+ \alpha_O \Delta T)$ ....(10)

Numericals

1. If the resistance of coil is 3 Ω at 20 ^{0}C and α = 0.004/^{0}C then determine its resistance at 100 ^{O}C.
2. Resistance of a material at 10^{o}C and 40^{o}C are 45 Ω and 85 Ω respectively. Find its temperature coefficient of resistance.
3. A 60 w,240V incandescent lamp is switched on at 20 ^{o}C.The operating temperature of filament is 2000^{0}C .determine the current taken by the lamp of resistance of filament material is 0.0048/^{0}C at 0 ^{O}C.
4. A coil is connected across a dc source of 120V.It draws a current of 12A at room temperature of 25 ^{O}C. After 3hrs of operation ,its temperature to 65 ^{o}C and current reduces to 8A.

i. Current when its temperature has increased to 80 ^{O}C.

ii. Find temperature coefficient of resistance (TCR) at 30 ^{O}C.

Q.1 If the resistance of coil is 3 Ω at 20 ^{0}C and $\alpha = 0.004/^0C$ then determine its resistance at 100 ^{0}C.

- Solution

  $R_0 = 3\ \Omega$, $T = 100\ ^oC$, $T_0 = 20\ ^oC$

  $\alpha_0 = 0.004\ /^oC$, $R_T = R_{100} = ?$

  $R_T = R_0(1 + \alpha_0(T-T_0))$

  $R_{100} = 3(1 + 0.004 \times 80)$

  $R_{100} = 3(1 + 0.32)$

  $R_{100} = 3(1.32)$

  $R_{100} = 3.96\ \Omega$

Q.2 Resistance of a material at 10ºC and 40ºC are 45 Ω and 85 Ω respectively. Find its temperature coefficient of resistance.

- **Solution** $T_0 = 10^oC$, $T = 40^oC$, $R_0 = 45\ \Omega$, $R = 85\ \Omega$
- $\alpha = 1/R\ .\ \Delta R/\Delta T$

$$\alpha = \frac{1}{R_0}\frac{\Delta R}{\Delta T}$$

$$\alpha = \frac{1}{45}\left(\frac{85-45}{40-10}\right) = \frac{1}{45}\left(\frac{40}{30}\right)$$

$$\alpha = 0.0296\, per\ ^\circ C$$

Q.3 A 60W,240V incandescent lamp is switched on at 20 ^{o}C.The operating temperature of filament is 2000 ^{0}C .determine the current taken by the lamp of resistance of filament material is 0.0048 /^{0}C at 0 ^{O}C.

Solution:

$\alpha_O = 0.0048$ /^{O}C

Power(P) = 60 W

We know that

$P = V^2/R_{2000}$

$\Longrightarrow$ $60 = (240)^2/R_{2000}$

$\Longrightarrow$ $R_{2000} = 960\ \Omega$

$\alpha_{20} = \alpha_O / (1+ \alpha_O\ \Delta T) = 0.0048/[1+ 0.0048*(20-0)] = 0.00437$ /^{O}C

The change in resistance with temperature is given by

$R_{2000}= R_{20}[1+\alpha_{20}(\Delta T)]$

$960 = R_{20}[1+0.00437(2000-20)]$

$R_{20} = 99.45\ \Omega$

Current at swtiching

$I = V/R_{20}$

$\Longrightarrow$ $I = 240/99.45$

$\therefore I = 2.413$ A

Q.4 A coil is connected across a dc source of 120V.It draws a current of 12A at room temperature of 25 ^{O}C. After 3hrs of operation ,its temperature to 65 ^{O}C and current reduces to 8A.

i. Current when its temperature has increased to 80 ^{O}C.

ii. Find temperature coefficient of resistance (TCR) at 30 ^{O}C.

Solution :

Initial voltage = 100 V (DC)

I = 12 A at 25°C

I = 8 A at 65 ^{o}C

$R_{25} = 100/12 = 10\ \Omega$

$R_{65} = 100/8 = 15\ \Omega$

$R_{25} = R_0\,[1+\alpha_0(\Delta T)]$

$10 = R_0\,[1+\alpha_0(25)]$ ....(1)

$R_{65} = R_0\,[1+\alpha_0(\Delta T)]$

$15 = R_0\,[1+\alpha_0(65)]$ ....(2)

Dividing equation (1) by (2)

$(10/15) = R_0\,[1+\alpha_0\,(25)] / R_0\,[1+\alpha_0(65)]$

By solving we get

$\alpha_0 = 0.018\ /^{O}C$

$R_O = 6.912\ \Omega$ [By putting value of $\alpha_0 = 0.018\ /^{O}C$ in any equation (1) or (2)]

i. Current when its temperature has increased to 80 ^{O}C.

- I_{80} =?

$R_{80} = R_0 [1+\alpha_0 (80)] = 6.912 [1+ 0.08*80] = 16.84\ \Omega$

$I_{80} = V/R_{80} = 120/ 16.84 = 7.126$ A

ii. Find temperature coefficient of resistance (TCR) at 30 ^{O}C.

- α_{30} = ?

We know that

$\alpha_{30} = \alpha_O / (1+ \alpha_O \Delta T)$

$= 0.018/ (1+ 0.018 * 30)$

$= 0.0117\ /^{O}C$

Open circuit,close circuit and short circuit

1. ***Open circuit*** –

- open circuit is one where the continuity has been broken by an interruption in the path for current to flow.
- No current flow in the circuit.

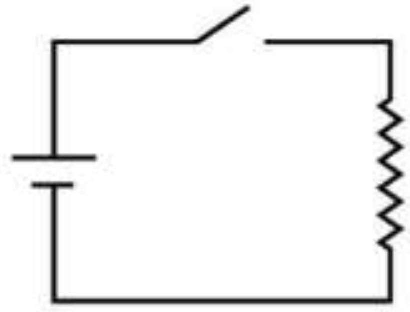


Fig. Open Circuit

2. ***Closed circuit*** –

- A closed circuit is one that is complete with good continuity throughout.
- Current flow in the circuit.

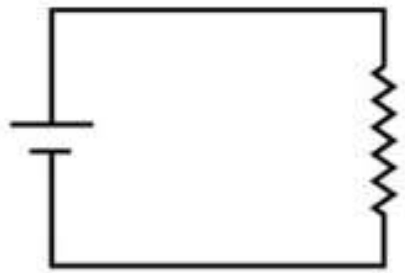


Fig. Closed circuit

3. ***Short circuit*** –

- The short circuit is an electric which offers very low or no resistance (impedance) to the flow of current.
- Very high current flow in the circuit

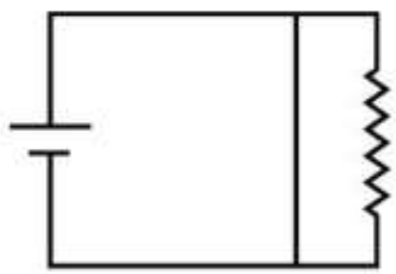
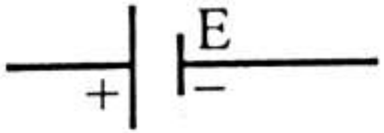


Fig. Short Circuit

Sign convention



Direction of movement (i)→ = fall in potential = **- E**

(ii)← = rise in potential = **+E**

Direction of movement (i)→ = fall in potential = **- IR**

(ii)← = rise in potential = **+ IR**

Types of electrical energy sources

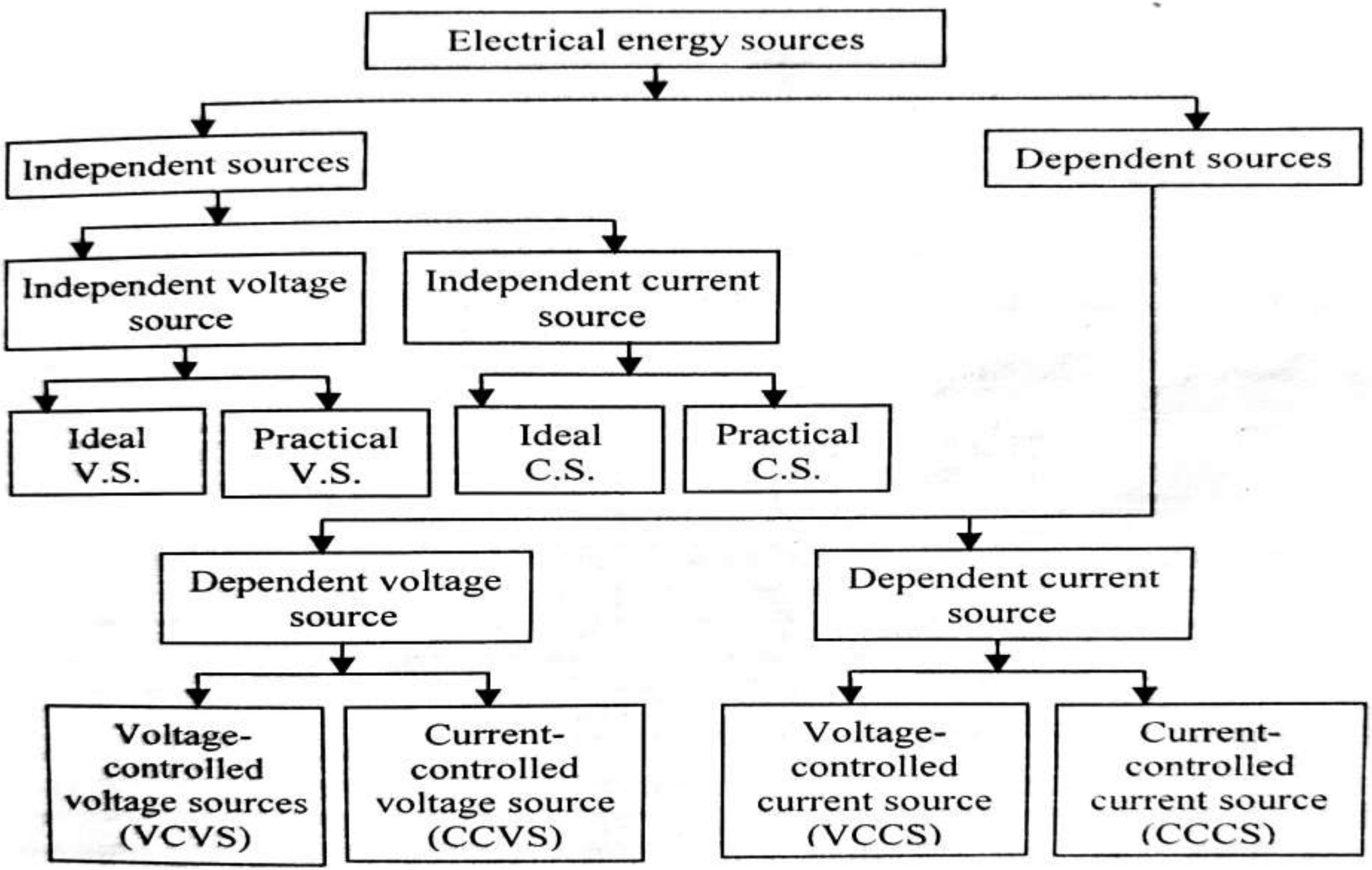


Fig. Classification of electrical energy sources

Independent sources

- These are independent because their voltage and current are not dependent on voltage drop or current or any other quantity.
- It is classified into voltage (ideal and practical) sources and current (ideal and practical) sources.

Ideal and practical voltage sources

Ideal voltage sources :–

- An ideal voltage sources is that voltage sources which gives a fixed or constant load voltage despite of infinite variation in load (or load current).
- An ideal voltage sources possesses zero internal resistance or impedance (means zero voltage drop).
- Draws no power or power drawn by sources is zero.

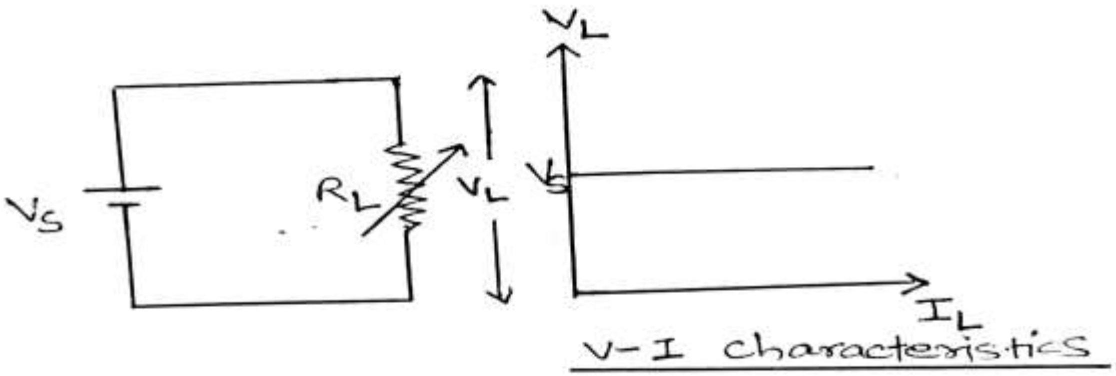
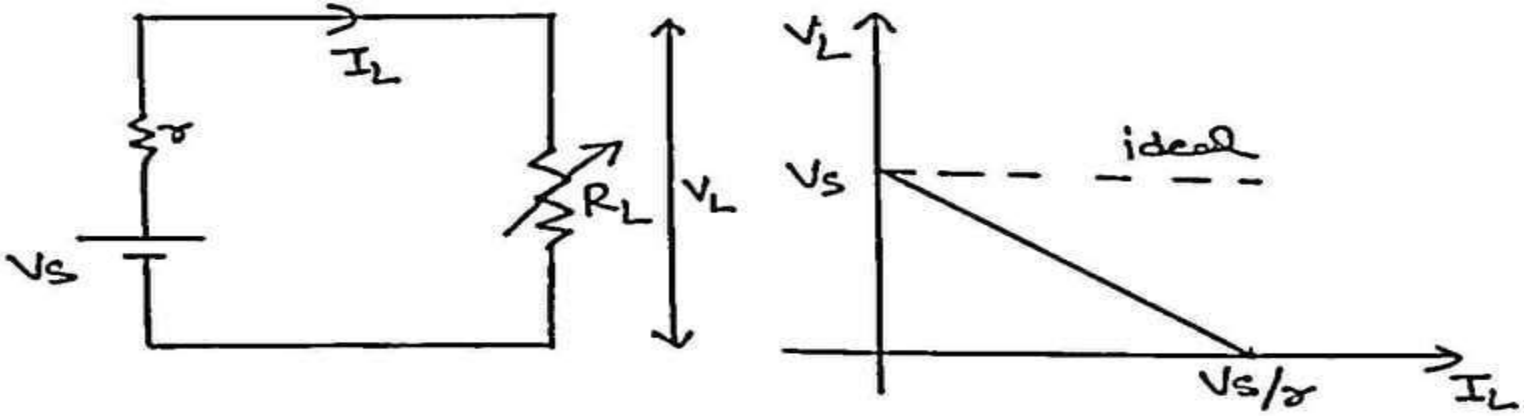


Fig. Ideal voltage source

Practical voltage sources :-

- In fact an ideal voltage sources are not possible. Every practical sources has some internal resistance ,which makes the load voltage vary with the load.



V-I characteristics

Fig practical voltage Source.

From circuit diagram

$$V_S - I_L r - I_L R = 0$$

$$V_S - I_L r - V_L = 0$$

$$\therefore \; V_L = V_S - I_L r$$

$V_L = V_S - I_L\, r$ ....(1)

where

r is the internal resitance of violtage sources

From equation(1) we can see that I_L increases ,V_L decreases and vice versa.

Thus practical voltage sources provides that load voltage(V_L) depend on load or load current(I_L)

Elaborate:

Suppose,

V_S = 10 V

r = 1 Ω

R_L = (1-5) Ω

$V_L = V_S - I_L\, r = 10 - I_L * r$

when R_L = 5 Ω

I_L = 10/(1+5) = 1.667 A

V_L = 10 - 1.667*1 = 8.83 V

when R_L = 2 Ω

I_L = 10/(1+2) = 3.33 A

V_L = 10 - 3.33*1 = 6.67 V

From above,it is verified that load volatage (V_L) decreases with inctrease in load current (I_L).

Ideal and practical current sources

Ideal current sources:-

- An ideal current source is that which having constant or fixed load current despite of infinite variation in load (or load voltage).
- Possesses infinite internal resistance (or impedance)
- is capable of supplying infinity power

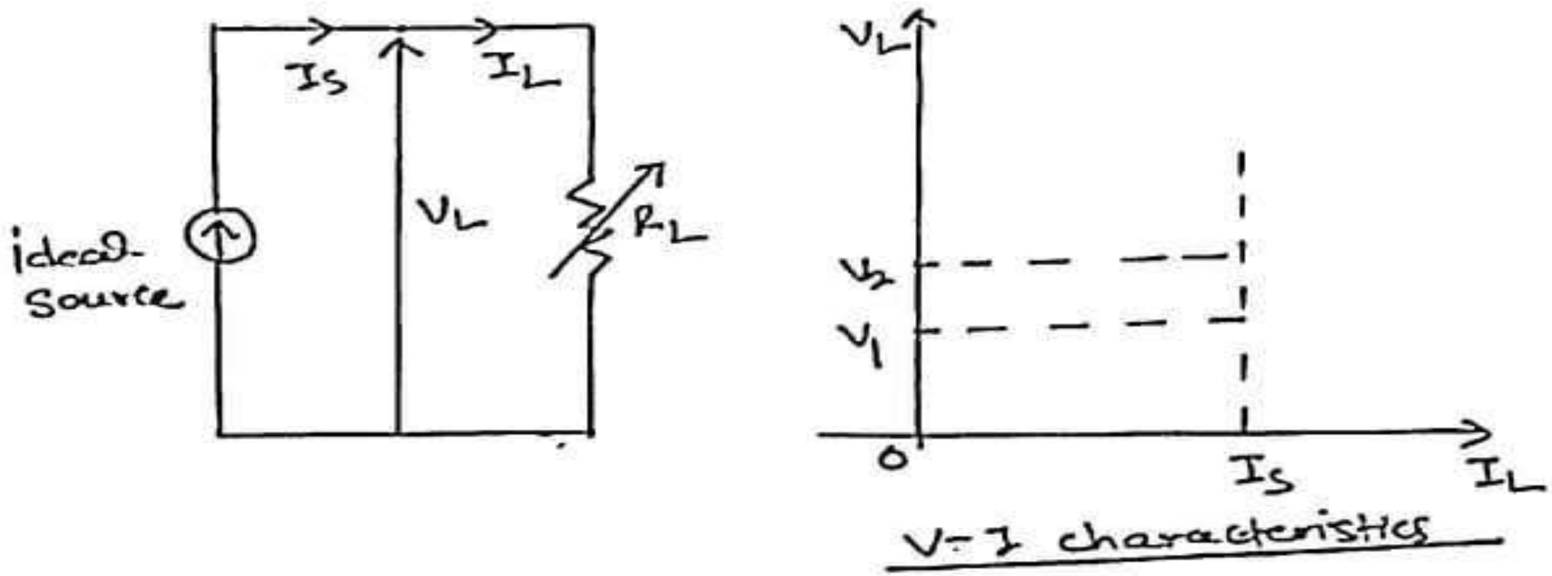


Fig. Ideal current sources

Practical current sources :-

- Practical current sources has some internal resistance so it will not give constant current as ideal current sources.

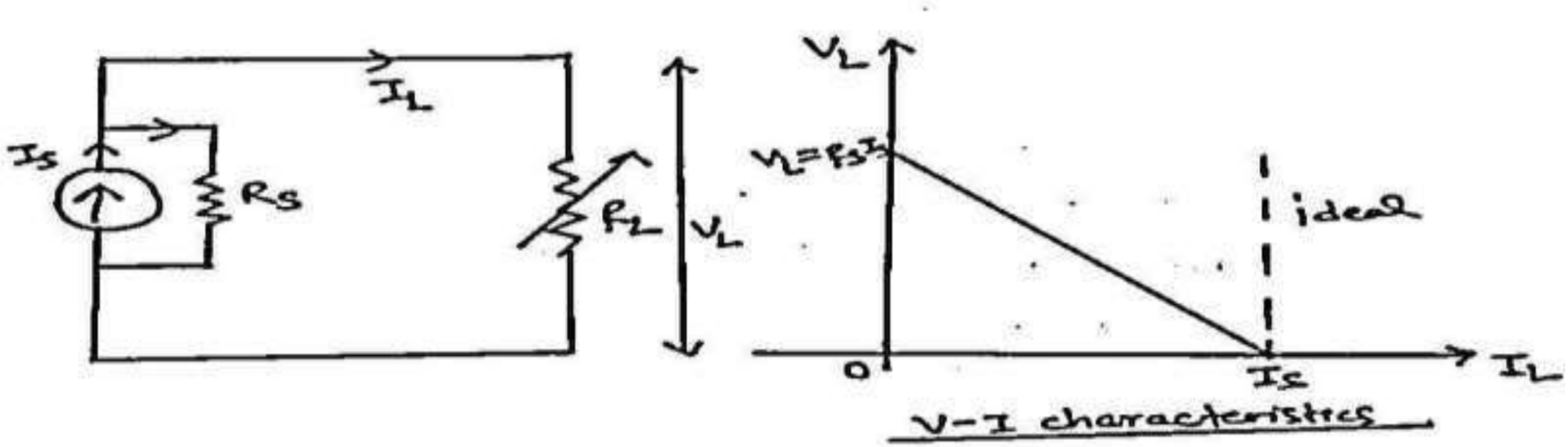


Fig. practical current source

$$I_L = I_s - V_L / R_s$$

Two extreme cases

when $R_L = 0$, $V_L = 0$

$I_L = I_s$

when, $R_L = \infty$, $I_L = 0$

$V_L = I_s R_s$

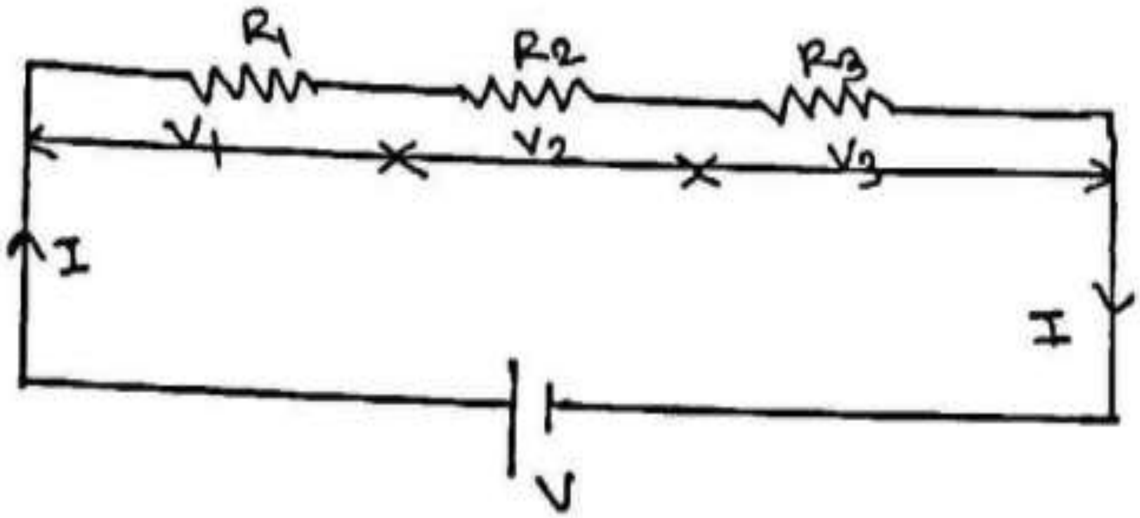
Series and parallel circuit

1. **Series circuit :** A number of resistors are said to be connected in series if the same current flow through each elements and there is only one path for the flow of current throughout.

Points to remember

- Same current flow
- Voltage will be different across each resistor

➢ Consider three resistors of resistance R_1,R_2, and R_3 connected in series as shown in figure below:



From Kirchhoff's law,

$V = v_1 + v_2 + v_3$ ....(1)

From Ohm's law,

$v_1 = IR_1$

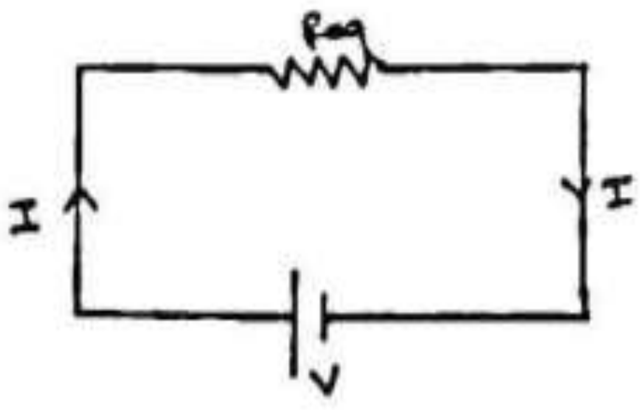
$v_2 = IR_2$

$v_3 = IR_3$

Now substituting the value of v_1,v_2 and v_3 in equation (1)

$V = IR_1 + IR_2 + IR_3$

$V = I(R_1 + R_2 + R_3)$ ....(2)



$V = IR_{eq}$ ....(3)

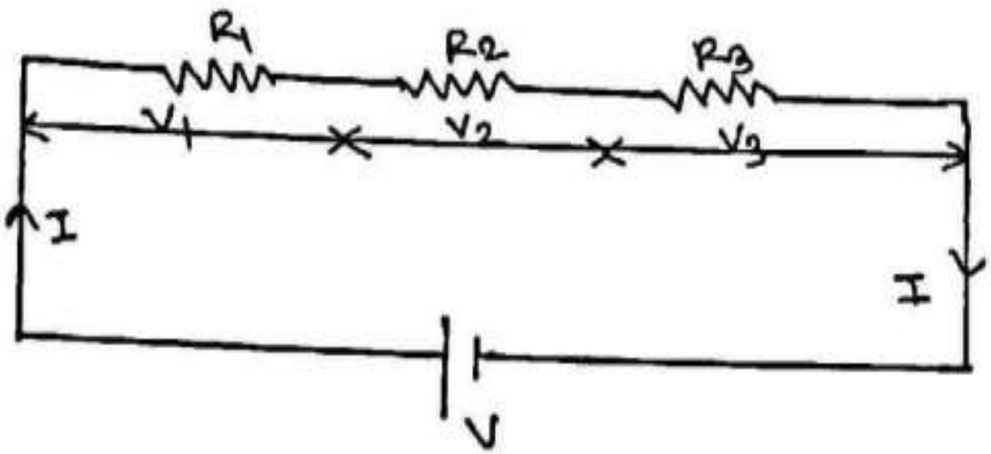
From equation (2) and (3)

$IR_{eq} = I(R_1 + R_2 + R_3)$

$R_{eq} = R_1 + R_2 + R_3$ ....(4)

From equation (4),it is clear that equivalent resistance is equal to sum of individual resistance connected in series.

Voltage Divider Rule



As we know that

$v_1 = I\,R_1 = V/(R_{eq}) *R_1$

$v_1 = V* R_1 / (R_1 + R_2 + R_3)$

Similarly

$v_2 = V*R_2 / (R_1 + R_2 + R_3)$

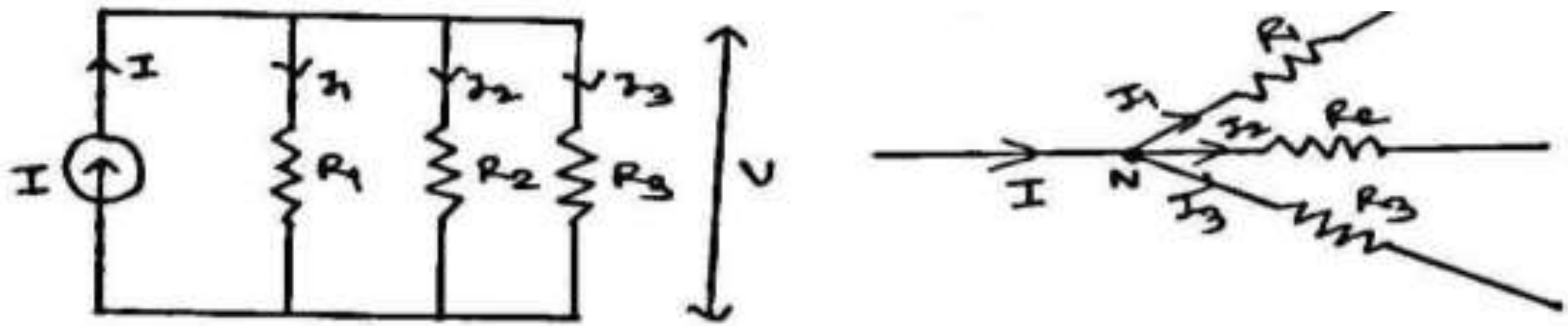
$v_3 = V*R_3 / (R_1 + R_2 + R_3)$

2. Parallel circuit : The resistors are said to be in parallel if same voltage appear across each resistor and resistors are connected across end to end as shown in figure.

Points to remember

- Same voltage appear across each resistor
- Current will divide

➢ Consider three resistors R_1,R_2 and R_3 are connected in parallel as shown in figure below.



Applying KCL

$I = I_1 + I_2 + I_3$ ....(1)

From Ohm's law

$I_1 = V/R_1$

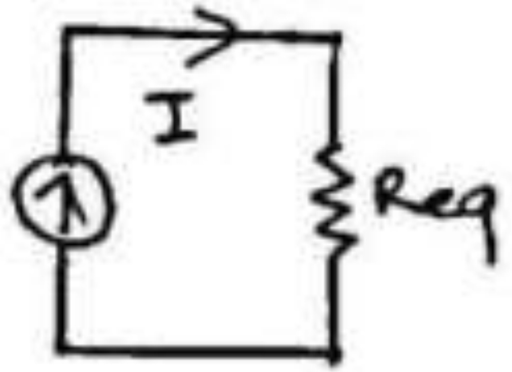
$I_2 = V/R_2$

$I_3 = V/R_3$

Substituting the value of I_1,I_2 and I_3 in equation (1)

$I = V/R_1 + V/R_2 = V/R_3$

$I = V\,(1/R_1 + 1/R_2 + 1/R_3)$ ....(2)



$I = V/R_{eq}$ ....(3)

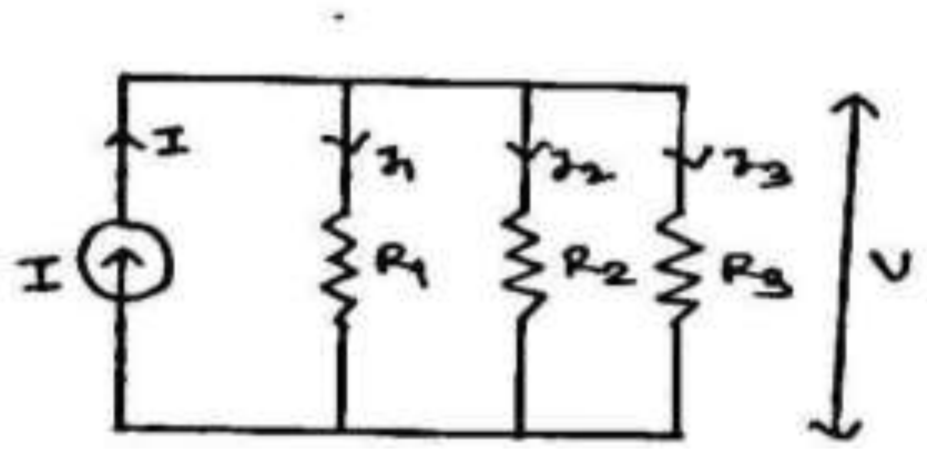
From equation (2) and (3)

$V/R_{eq} = V\,(1/R_1 + 1/R_2 + 1/R_3)$

$1/R_{eq} = (1/R_1 + 1/R_2 + 1/R_3)$ ....(4)

From equation (4), it is clear that the sum of reciprocal of equivalent resistance is qual to sum of reciprocal of individual resistance

Current Divider Rule



As we know

$I_1 = V / R_1 = (1/R_1)* [I / (1/R_1 + 1/R_2 + 1/R_3)]$

$I_1 = I / [R_1 *\{R_1R_2+R_2R_3+R_1R_3\}]/(R_1R_2R_3)$

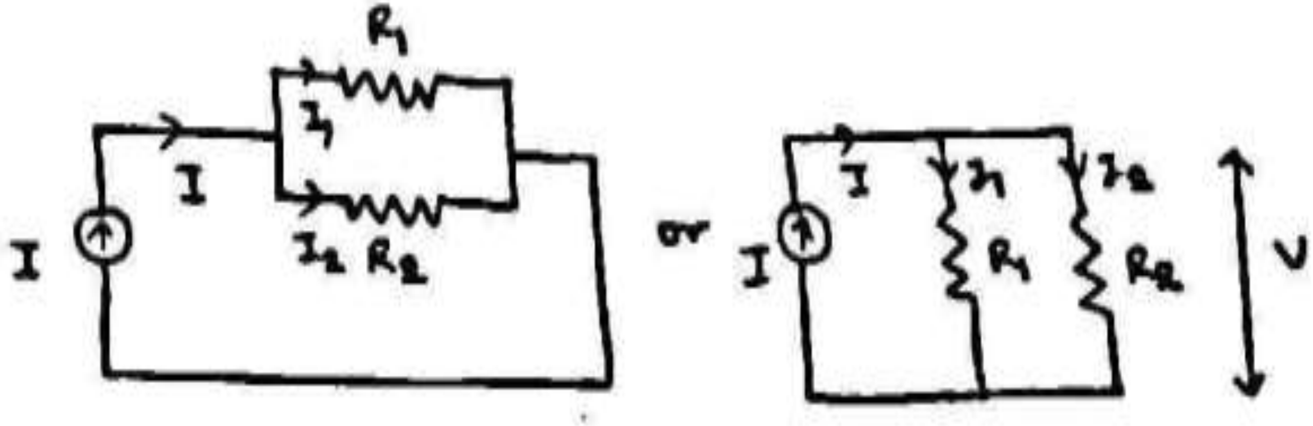
$I_1 = I * R_2R_3 / [R_1R_2+R_2R_3+R_1R_3]$

Similarly,

$I_2 = I * R_1R_3 / [R_1R_2+R_2R_3+R_1R_3]$

$I_3 = I * R_1R_2 / [R_1R_2+R_2R_3+R_1R_3]$

When two resistors in parallel



$1/R_{eq} = 1/R_1 + 1/R_2$

$R_{eq} = R_1 * R_2/(R_1 + R_2)$

R_{eq} = product / sum

$I_1 = V / R_1 = (1/R_1) * [I/(1/R_1+1/R_2)]$

$I_1 = I * R_2 /(R_1 + R_2)$

Similarly

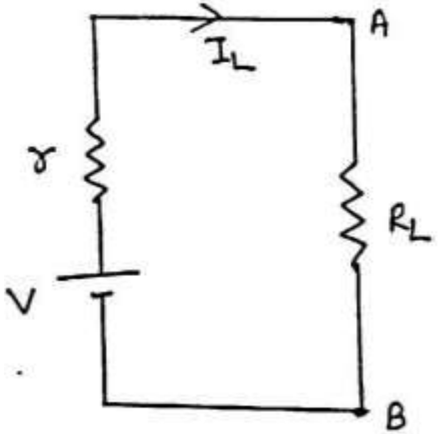
$I_2 = I * R_1 / (R_1 + R_2)$

Current in any branch = (Resistance of other branch * total current) / (Sum of two resistances)

Source conversion

1. Practical voltage source into practical current source
2. Practical current source into practical voltage source

1. **<u>Practical voltage source into practical current source</u> :** Let us consider a practical voltage source of emf (v) and internal resistance (r) in series connected to load resistance R_L as shown in figure below:



Fig(i) PVS

$$I_L = \frac{V}{R_L + r}$$

$$I_L = \frac{V/r}{\frac{R_L + r}{r}}$$

$$I_L = \frac{V}{r} * \frac{r}{R_L + r}$$

$$\boxed{I_L = I * \frac{r}{R_L + r}}$$

CDR Concept

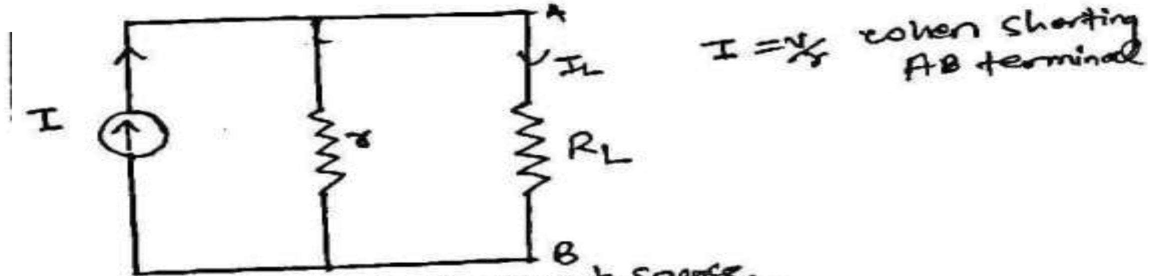
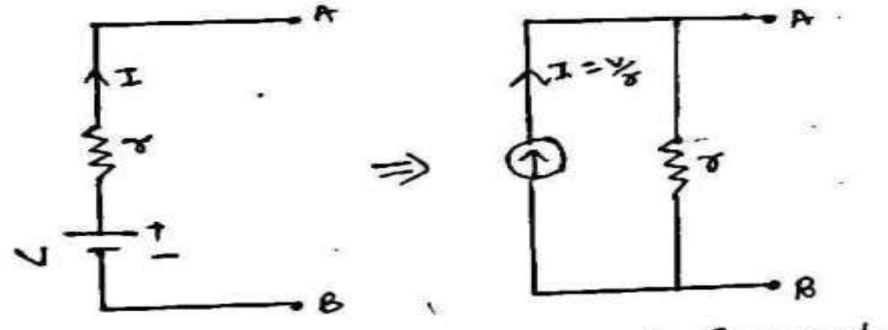


Fig practical current source

So equivalent conversion can be drawn as



practical voltage source

practical current source

2. <u>Practical current source into practical voltage source</u> : Let us consider a practical current source with current (I) and internal (r) in parallel is applying energy to load resistance RL as shown in fig.

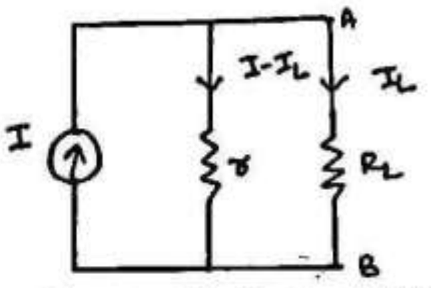


Fig. practical current Source

$V_r = V_{RL}$

or $(I - I_L)r = I_L * R_L$

or $I * r = I_L(R_L + r)$

or $I_L = \frac{I * r}{R_L + r} = \frac{V}{R_L + r}$

$$\boxed{\therefore \quad I_L = \frac{V}{R_L + r}} \quad \text{—— (1)}$$

$V = I_L(R_L + r)$ —— (2)

This formula can be realised in series circuit as, [eqn (2)]

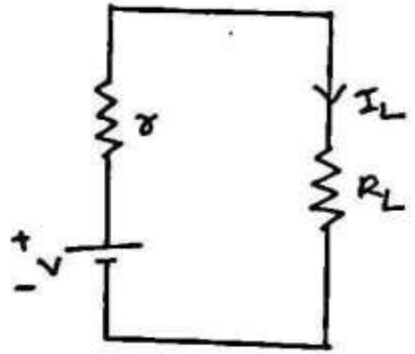
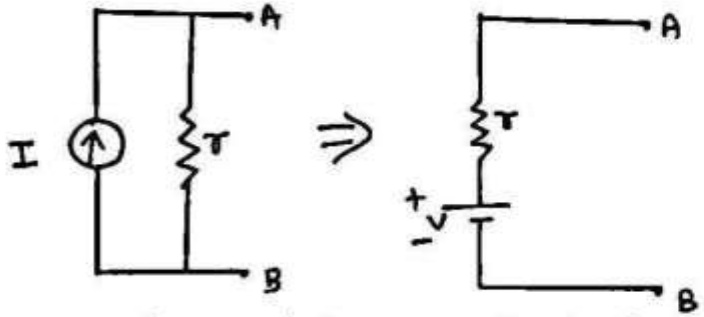


Fig. practical voltage source

So eqn. conversion can be drawn,



practical current Source   Practical voltage source