SOURCES OF POWER

The basic purpose of a source is to supply electrical power to a load. The source may supply either Direct current) or AC (Alternating current). The DC source provides an output which is steady unchanging and unidirectional in nature. AC source provides an output which is alternating in nature i.e. its magnitude is changing in both the positive and negative directions with time.

Examples:

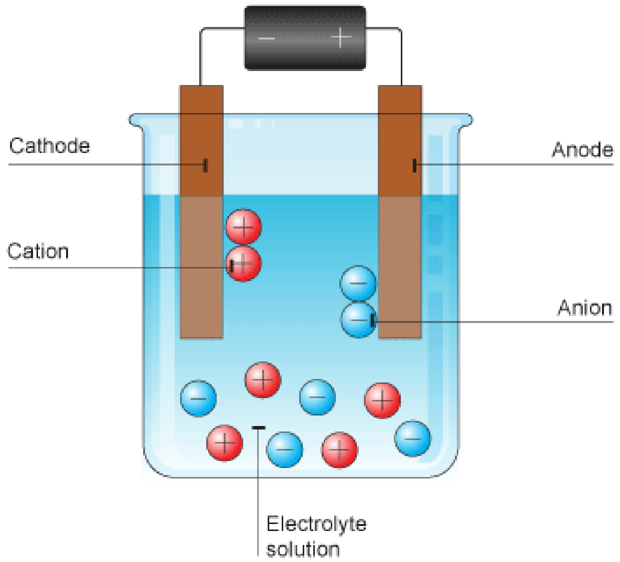
DC sources: a) Battery b) Generator c) Rectification-type DC supply.

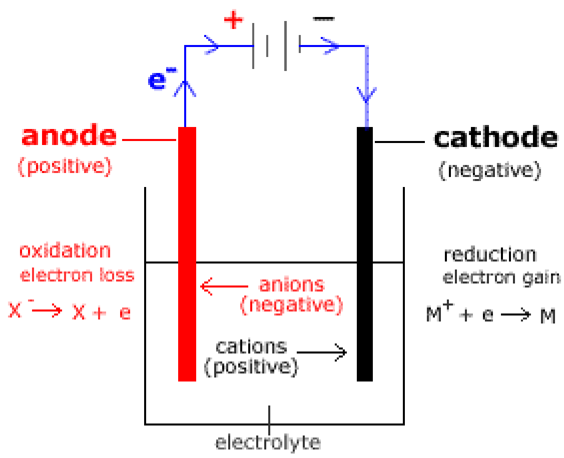
AC sources: a) Alternators b) Oscillators c) Signal generators d) Mains supply

1) Battery: The battery is the most common DC voltage source. A battery consists of two or more cells connected in either in series or parallel or both. A cell is a fundamental source of electrical energy. Cells are of two types:

a) Primary cell in which the chemical reaction is irreversible and hence cannot be recharged back to their original condition. ex Cells used in a torch.

b) Secondary cell in which the chemical reaction is reversible and hence is rechargeable. ex. Car battery.

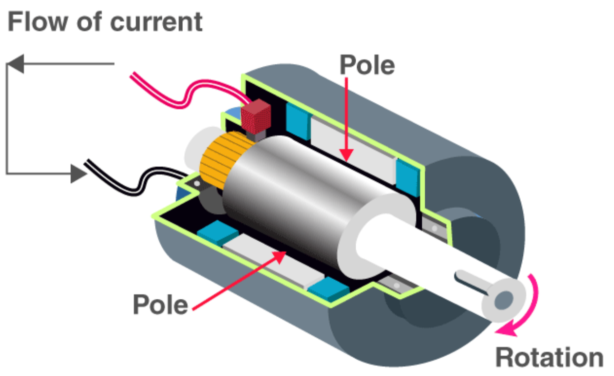


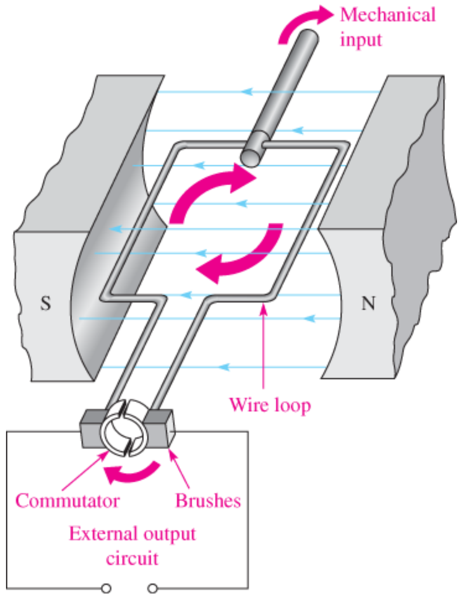


Cells and batteries convert chemical energy into electrical energy. Each cell has two electrodes (one positive and one negative). They are immersed in an electrolyte which is made up of chemical compounds. When dissolved in the solution, they decompose into positive and negative ions. These ions carry the charges inside the cell from one electrode to the other.

Applications - Car batteries, Torches, Radios, TV sets, tape recorders, Cordless phones, electronic watches etc.

ii) DC Generators

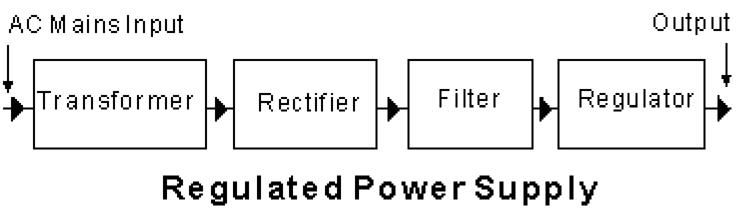




A DC generator is capable of giving higher voltage and power than a battery. It has a rotating shaft. When this shaft is rotated at the specified speed by a steam turbine or a water turbine, a voltage of rated value appears across its terminals. The output is taken with the help of Split slip-rings and brushes.

Applications: Industrial applications

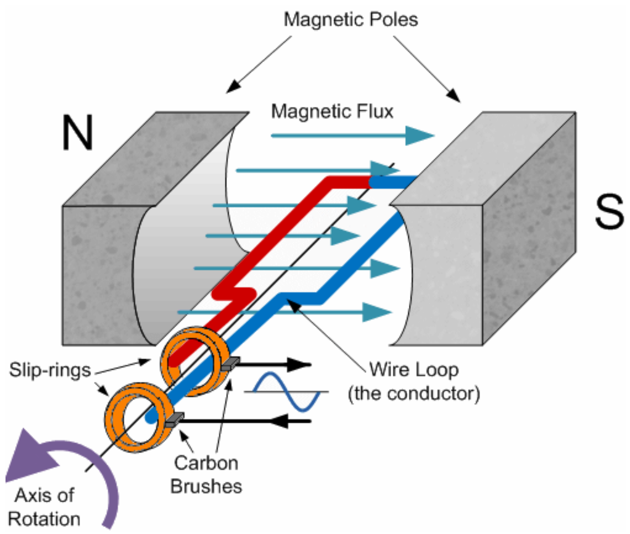
iii) Rectification type DC supply



In this type of supply, a rectifier is used to convert AC from the mains into a voltage of fixed value i.e. DC. A battery eliminator is also a rectification type DC supply. The AC is given to a transformer which steps up or steps down the voltage to the required value which is then given to the rectifier. The rectifier converts AC into DC which is then given to the load.

Applications: Electronic instruments, TV sets, radios etc.

iv) Alternators



Alternators provide AC voltage. It is similar in construction to a DC generator. It consists of an armature placed in a strong magnetic field. When this armature (shaft) is rotated, it cuts the magnetic lines of force and hence induces an emf in the armature according to Faraday's law of electromagnetic induction. The magnitude of this induced voltage depends on the rate at which the armature cuts the magnetic flux lines. The AC voltage which is generated is then taken out via slip rings and brushes and then given to the load.

Applications: In electric power stations to produce 50 Hz mains supply.

v) Oscillators or Signal generators

An oscillator is an equipment which supplies AC voltage. This voltage is used as a signal to test the working of different electronic circuits like amplifiers. The frequency of this AC signal output can be varied for different applications. Signal generators are capable of providing other types of wave forms such as triangular, square ware saw-tooth etc. in addition to the sinusoidal waveform.

Applications:

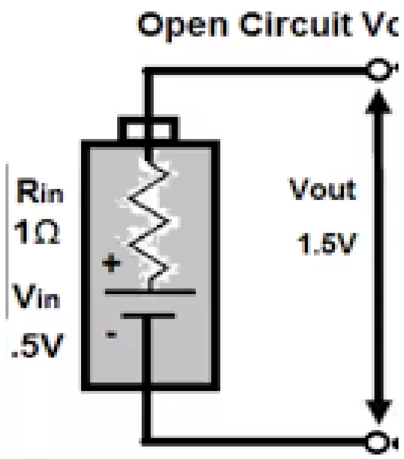
1) In medical applications for testing hearing efficiency

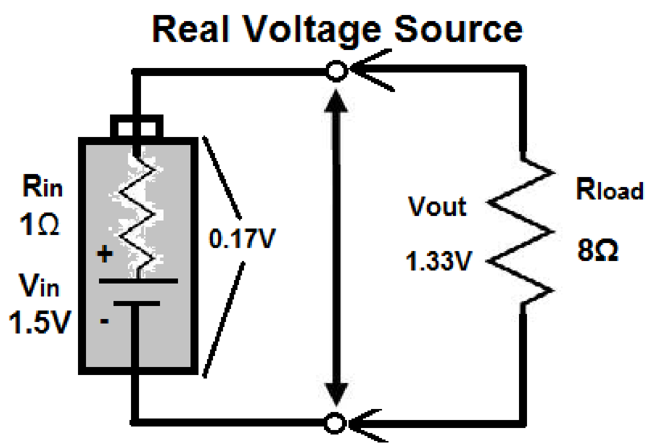
2) In T.V. and radio servicing

3) Testing of electronic circuits like amplifiers 4) In computers etc.

Internal impedance of a DC source:

All electrical energy sources have some internal impedance (resistance in DC sources). In a DC source like a battery or a cell, the internal resistance is due to the electrolyte between the electrodes. The value of this internal resistance is very less as compared to the load resistance. Due to this internal resistance, there is a small voltage drop across it when a load is connected across the output terminals of a cell. Hence, there is a reduction in the terminal voltage of a cell when a load is connected.





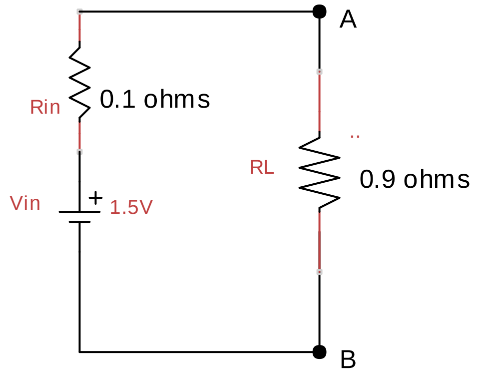
The internal resistance **R_{in}** is represented as a resistance connected in series with the voltage source as shown in fig (a). A and B are the two output terminals (or electrodes) across which the output is available. Let the voltage available across the output terminals of a cell be 1.5V.

When there is no load connected between A and B, the voltage across the output terminals is 1.5V since no load current flows in an open circuit. With no current, the voltage drop across **R_{in}** is zero. Then the full generated voltage in the cell i.e. 1.5V is available across the output terminals. This voltage is called as **Open-circuit emf or voltage or No-load voltage V_{NL}.**

When a load (ex. bulb) having resistance of **RL** is connected across the output terminals A and B, it comes in series with the internal resistance of the cell. A load current flows through the internal resistance and also the load resistor RL. A small voltage drop occurs across the internal resistance **Rin** and the remaining voltage is available across the load or output terminals. The voltage drop across **Rin** is in opposite direction to that of the voltage source and hence it is subtracted from the voltage source **Vin** to get the load voltage. Greater the internal resistance, greater would be the voltage drop across it and hence a lesser voltage would be available at the output terminals. This voltage is called as Load voltage **VL**. The internal resistance **Rin** is given by

$$R_{in} = \frac{V_{NL} - V_L}{I_L}$$

Examples: The open circuit voltage of a cell is 1.5V its internal resistance is 0.1Ω. Find the voltage across its output terminals when a load of 0.9Ω is across the terminals?



Concept of a voltage source

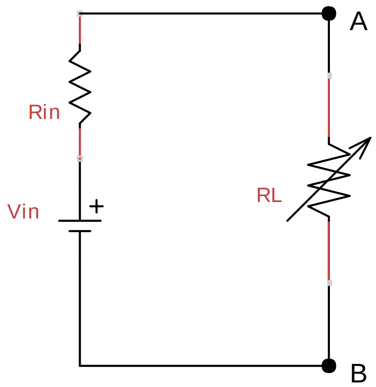
Consider a DC voltage source.

V_{NL} **=** Open circuit voltage when no load is connected

V_L = Voltage at output terminals when load is connected

R_{in} = Internal resistance of DC source

R_L = Load resistance which can be varied



When terminals A and B are open i.e. $R_L = \infty\ \Omega$, no current flows in the circuit. Therefore, the load voltage V_L is the same as V_{NL} since there is no voltage drop across R_{in}.

when terminals A and B are connected by the load resistance R_L, the terminal voltage V_L drops as current flows through R_{in} and R_L. As we go n reducing R_L, the current in the circuit goes on increasing. The voltage drop across R_{in} also goes an increasing and hence the load voltage V_L across the terminals goes on decreasing.

For a given value of $\boldsymbol{R_L}$, the current in the circuit is given by,

$$\boldsymbol{I_L} = \frac{\boldsymbol{V_{NL}}}{\boldsymbol{R_{in}} + \boldsymbol{R_L}}$$

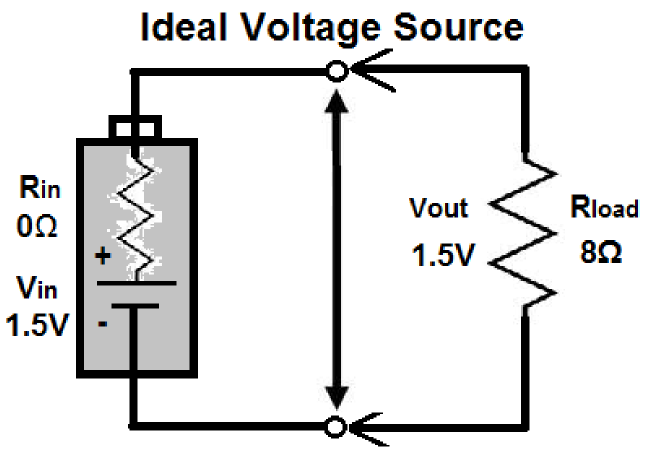
The terminal voltage is given by, $V_L = \boldsymbol{I_L} \text{ x } R_L$

$$V_L = \frac{V_{NL}}{R_i + R_L} \text{ x } R_L \quad \text{Hence,} \quad V_L = \frac{V_{NL}}{1 + \frac{Rin}{R_L}}$$

From the above equations, we can find out the terminal voltage and the current that is going to be available across the terminals when the load is connected. In the above equation, the if the ratio of $\frac{Rin}{R_L}$ is small compared to unity(1), then the terminal voltage remains almost the same as the Open - circuit voltage $\boldsymbol{V_{NL}}$ **.**

For a good voltage source, the ratio $\frac{\boldsymbol{Rin}}{\boldsymbol{R_L}}$ should be as small as possible so that even if the load resistance changes, the terminal voltage of the source remains practically constant.

Ideal voltage source



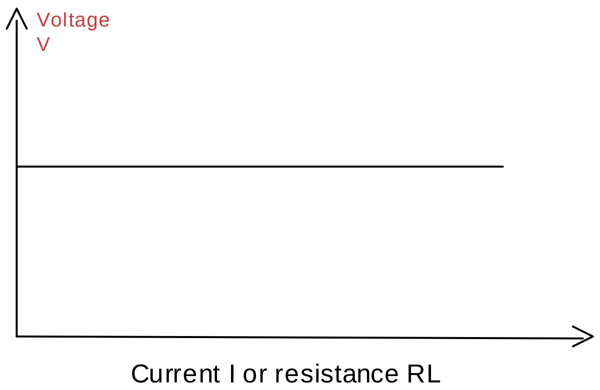
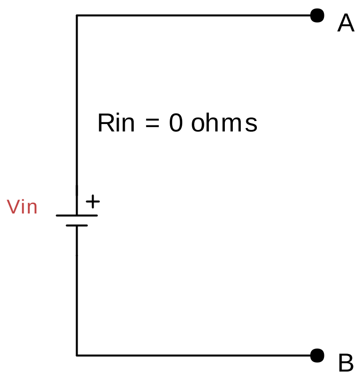


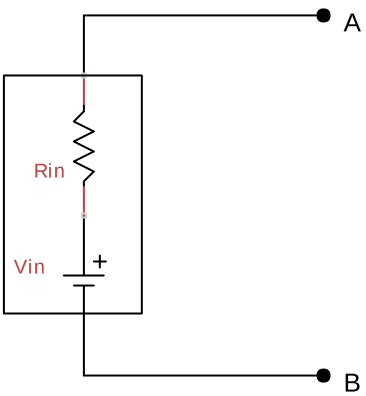
Fig.b. V-I characteristics of Ideal voltage source

The voltage source in which the terminal voltage remains fixed whatever be the load connected to it is called an Ideal voltage source. In other words, the ideal voltage source should provide a fixed terminal voltage even though the load current may vary. An ideal voltage source has **Zero internal resistance**. Hence, when a load is connected to it, the voltage across the load is same as the voltage of the source. However, in practice an ideal voltage source does not exist.

Fig (b) shows the **V-I** Characteristics of an Ideal voltage source. The terminal voltage is seen to be constant for all values of load current and load resistance. The symbols of an ideal voltage source and a practical voltage source are given below.



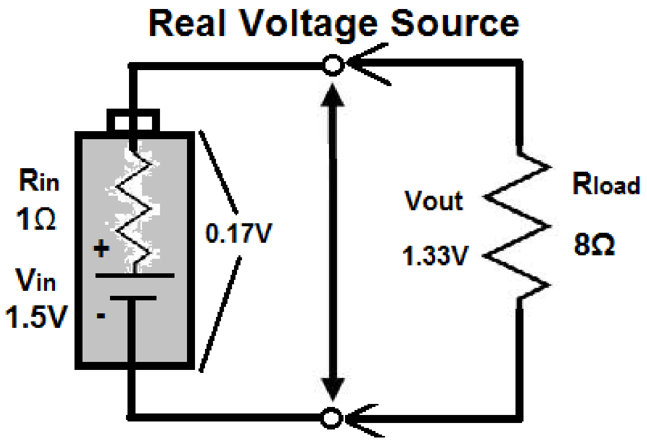
. Symbol of Ideal voltage source



Symbol of Practical voltage source

Practical or Real voltage source

An ideal voltage is not practically possible. A Practical voltage source can be considered to consist of an ideal voltage source in series with internal resistance Rin. When a practical voltage source is connected to a load, current flows through Rin and R. There will be some small voltage drop across Rin and hence we get less output voltage across the load terminals.



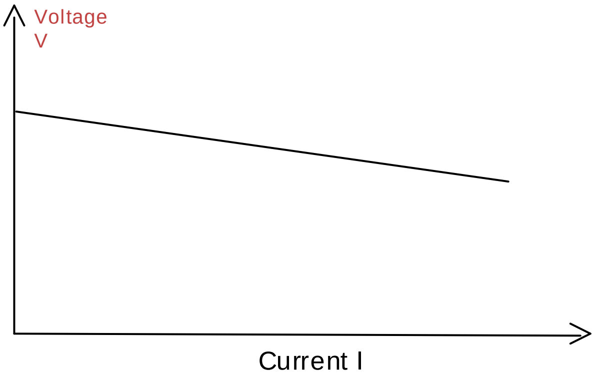


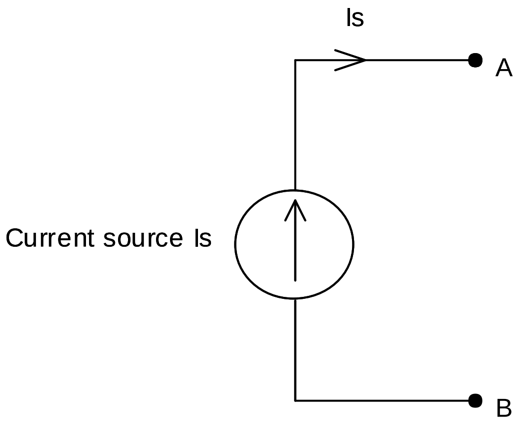
Fig.b. V-I characteristics of Practical voltage source

Fig (b) shows the **V-I** characteristics of a practical voltage source. From it, we find that as the load current increases i.e. load resistance decreases, the voltage at the terminals goes on reducing.

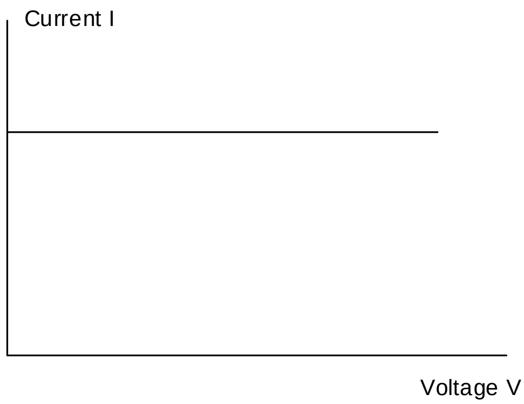
Concept of Current source

A current source is a device which provides constant current to the load when it is connected across the terminals of the current source.

Ideal current source: An ideal current source is a device which provides the constant current to load at any time and is independent of the voltage supplied to the circuit. Practically, an ideal current source is not available. The ideal current source provides a constant current irrespective of the load resistance. In an ideal current source, the **input impedance is infinite.** Hence, when load is connected, all the source current is available to the load.



Ideal current source

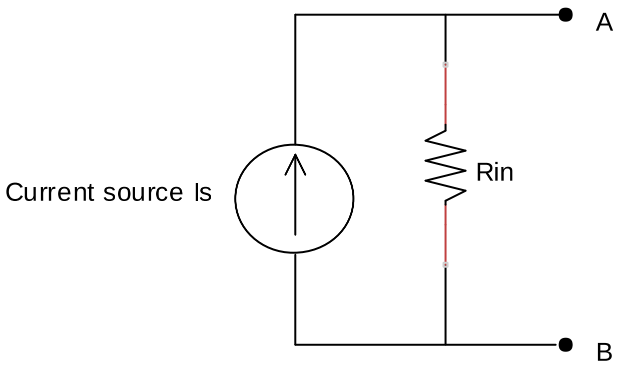


V-I characteristics of Ideal current source

A symbol for an ideal current source is shown. The arrow inside the circle indicates the direction of the current flow when load is connected to the source. Here, the internal resistance is infinite and hence not shown.

The **V - I** characteristics of an ideal current source is shown in fig. b.

Practical current source



Practical Current source

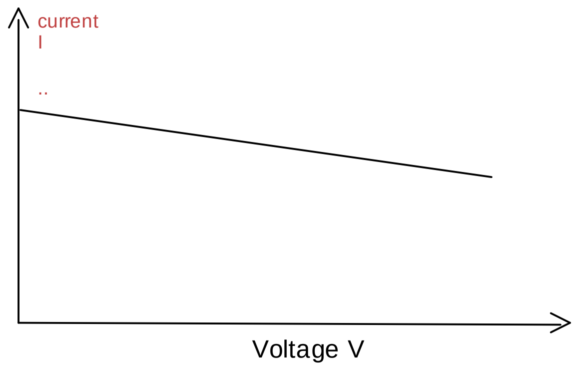
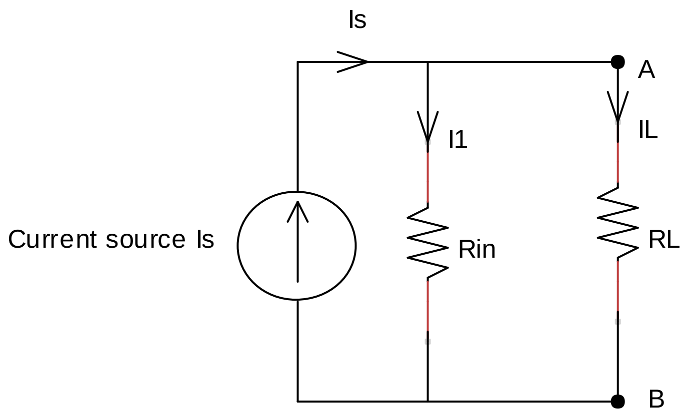


Fig.b. V-I characteristics of Practical current source

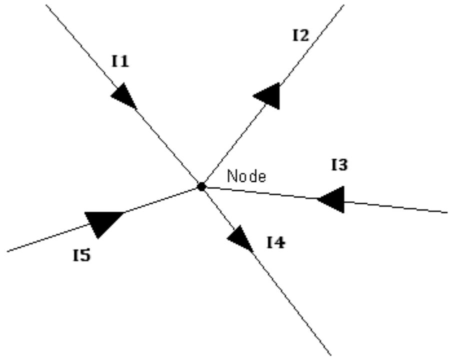


Practical Current source

In a practical current source, full current passes through the source when the terminals are short circuited. Hence this **current I_S** is called as **Short-circuit current**. A practical current source has some finite internal resistance. Hence, as we increase the load resistance, the load current goes on reducing as shown in the V-I Characteristics. A practical current source is represented symbolically as shown in fig. (a). It consists **of internal resistance R_{in} connected in parallel** with the current source. Hence the **current I_S** is divided into two parts, one part I1 flowing through internal resistance and the other current IL through the load. As the load resistance goes on increasing, the current flowing through **R_{in}** increases and the current through decreases. **R_L**

KIRCHHOFF'S LAWS

1) **Kirchhoff's current Law (KCL):** The algebraic sum of the currents entering and leaving any point in a circuit is equal to zero $\Sigma_i = 0$ **OR** The algebraic sum of the currents entering into any point of the circuit must equal the algebraic sum of the currents coming out of that point.



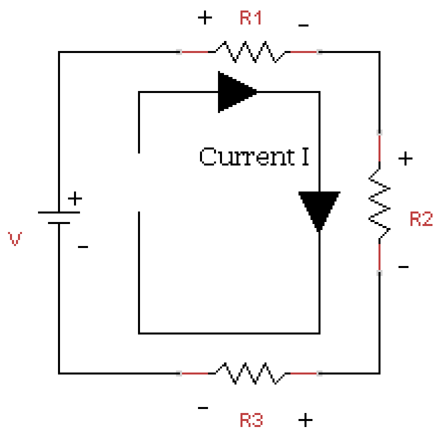
Sign convention: The currents entering the node are taken as positive and **currents leaving from the point are taken as negative.**

In the above circuit, as per KCL, $\Sigma_i = 0$

$$+ I_1 - I_2 + I_3 - I_4 + I_5 = 0$$

$$I_1 + I_3 + I_5 = I_2 + I_4$$

2) Kirchhoff's Voltage Law (KVL): The algebraic sum of the voltages around any closed path or loop is equal to zero $\Sigma_V = 0$ **OR** The source or applied voltage is equal to the **I.R voltage drops** in a closed loop.



Sign convention: In a closed path, the voltage source whose negative terminal is reached first is considered to be negative and the voltage source whose positive terminal is reached first is considered to be positive term.

In the above circuit, as per KVL,

$$\Sigma_V = 0$$

$$-V + IR_1 + IR_2 + IR_3 = 0$$

$$V = IR_1 + IR_2 + IR_3$$