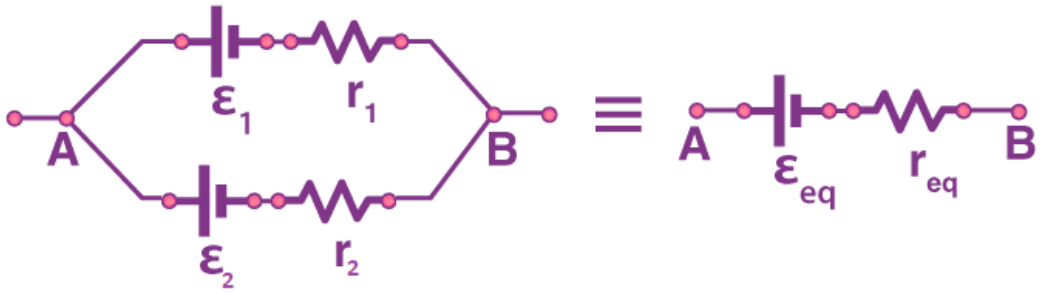
Parallel Combination of Cells

A cell is an important device in an electrical circuit, it is used to transfer electrical energy to the circuit. The cells are connected to the two terminals: Anode and Cathode. The anode is the positive terminal and the cathode is the negative terminal. The current flows out of the anode and enters the cathode. The difference in the charge of the two terminals of the cell will create a potential difference across the circuit. The potential difference produced is called the electromotive force or EMF of the cell. This EMF causes the flow of electric current in the circuit.

More than one cell connected together is called the battery. The cells are connected either in series or parallel. In a series combination, there is only a single path between the terminals of the cell. The positive terminal of the cell is connected to the negative terminal of the other cell in a series combination. Parallel combination circuits have multiple paths between the terminals. In a parallel combination of cells, all the positive terminals of the cells are connected together and the negative terminals of the cells are connected together.

Parallel Combination of Cells

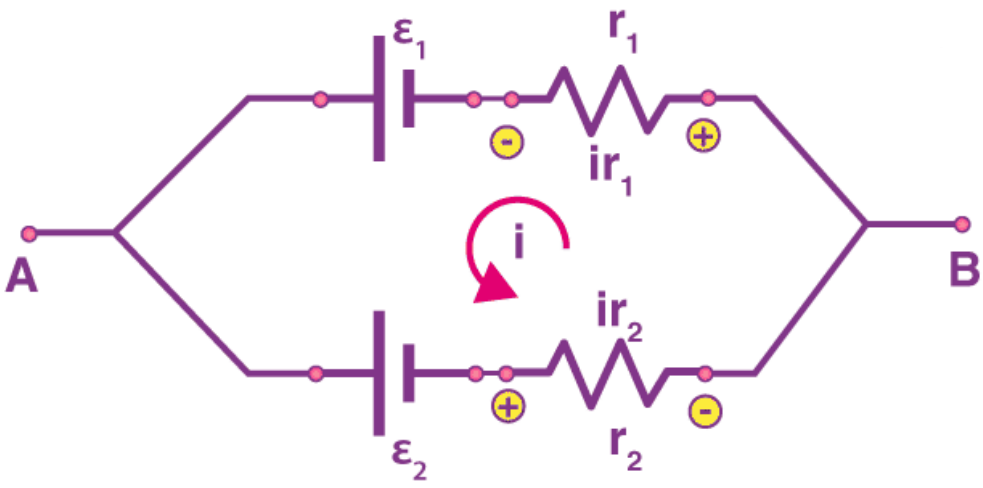


When the cells are connected in parallel, the current will be divided among the various cells. From the figure, we can see that two cells are connected in parallel. The emf of cell 1 is ε_1 and the emf of cell 2 is ε_2. The internal resistance of cell 1 is r_1 and cell 2 is r_2. The current is split into i_1 and i_2. The total current $i = i_1 + i_2$

The resultant internal resistance of the combination is

1requa=1r1+1r2

The equivalent EMF (ε_{eq}) is equal to the potential difference between A and B ($V_A - V_B$) when it is not in use. To determine the equivalent EMF we should apply Kirchoff's loop rule.



From the figure above, we get

$– \varepsilon_1 + ir_1 + ir_2 + \varepsilon_2 = 0$

$\Rightarrow i = \varepsilon_1 – \varepsilon_2/(r_1 + r_2)$ ——(1)

The potential difference $V_A – V_B = \varepsilon_1 – ir_1$

Or $V_A – V_B = \varepsilon_2 + ir_2$

Substituting the value of 'i' in either of the two equations above we get

$V_A – V_B = \varepsilon_2 + ir_2$

$= (\varepsilon_2 r_1 + \varepsilon_1 r_2)/(r_1 + r_2)$

Considering the equation of resultant internal resistance, the above expression can be written as

ϵ eq = r (ϵ1r1+ϵ2r2)

Advantages of Cells Connected in Parallel

(1) If any one of the cells connected in parallel is damaged, the other cells are not affected.

(2) If the cells are connected in parallel they will not exhaust easily.

Disadvantages of Cells Connected in Parallel

(1) The voltage developed will not be increased by increasing the number of cells in the parallel combination.

(2) The output power is based on one cell. Therefore, the brightness of the bulb connected will not be very high.

Kirchhoff's Laws

Gustav Kirchhoff developed a set of laws relating to the conservation of current and energy in the electrical circuits. They are KCL **(Kirchhoff's Current Law)** which deals with the current flowing in the circuit and KVL **(Kirchhoff's Voltage Law)** which deals with the voltage source present in the circuit. His discoveries has also paved the path for quantum theory of electromagnetic induction by Max Planck. Most of his discoveries and researches were dealing with electric current. Among this Kirchhoff's law of circuits is the most important one.

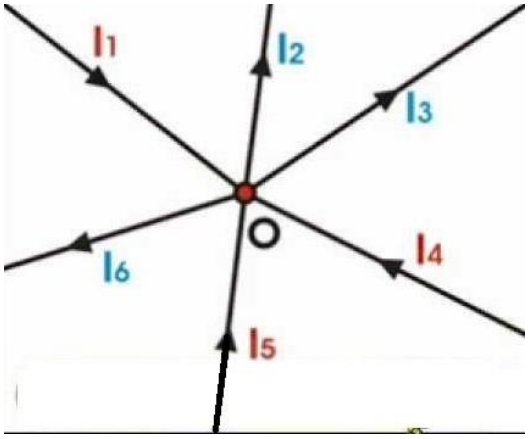
We know that Georg Simon ohm showed the relationship between voltage, current and resistance and formulated the ohm's law. This law is the basis of electricity. The law states that V = I R, where voltage V is in volts, Current I in amps and resistance R in ohms. Thus I = V / R and R = V / I. But in complex circuits it is difficult to find the voltage and current in the circuit by using Ohm's law. Hence for complex circuits Kirchhoff's law of circuits help us to find the value of voltage and current which flows within the circuit.

Circuit terms

A circuit is a closed path through which current flows. A path is a single line which consists of circuit elements and sources. A node is defined as a terminal or junction in which two or more elements will be joined together and thus have a common point for more than one branches. A branch consists of elements like resistors and sources connected between two nodes. A loop is a closed path in which elements are counted just once. A mesh is an open loop and open path with no elements in it. If the elements are connected in series the current which flows through each ones are the same. If the elements are connected in parallel the voltage across each components remains the same.

The First Law - Kirchhoff's Current Law

This law deals with the current flowing in the circuit. It states that the algebraic sum of all the currents meeting at a point is zero. The total current entering a node or junction is equal to the total current or charge leaving the node. This is also known as the **Conservation of Charge**. Consider a node and here three currents are entering the node and three currents are leaving the node. The currents entering the node are taken as positive and the current leaving the node is taken as negative. The law states that the totals current entering the node plus the total currents leaving the node is equal to zero.

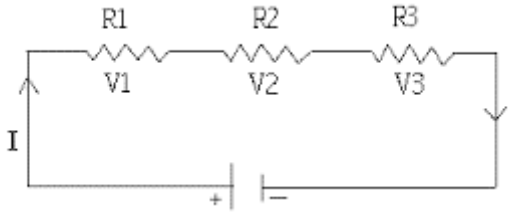


Kirchhoff's current law

Thus $I_1 – I_2 - I_3 + I_4 + I_5 – I_6 = 0$ or $I_1 + I_4 + I_5 = I_2 + I_3 + I_6$. This is the junction rule.
So currents entering to a node = currents leaving the node.

The Second Law – Kirchhoff's Voltage Law

When current travels in a circuit the magnitude of the current changes according to the product of current and resistance or emf which is connected in the circuit. Thus the law states that the algebraic sum of all voltages within the loop will be equal to zero. This is also known as the **Conservation of Energy**. Here the sum of voltage drops is equal to the sum of voltage rise. Consider three voltages V_1, V_2, V_3 which is connected in a circuit.



Kirchhoff's voltage law

The Equation according to the law is written as $V_1 + V_2 + V_3 = 0$.
The direction of the current can be either taken in clockwise direction or in anticlock wise direction. Once selecting the direction of the current we need to maintain the same direction throughout the circuit. If the final value is positive then it is clear that the direction of current assumed is right. If the final value we get is a negative value then it says that the current direction we assumed is reversed. The voltage drops across the resistors when the current flows in clock wise n clockwise direction is considered as positive drops. The voltage drops across the resistors when the current flows in anticlock wise direction is taken as negative drops. This is also known as the **Loop Rule**.