Presentation on

D.C. CIRCUITS

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INTRODUCTION

What is D.C. Circuit ?

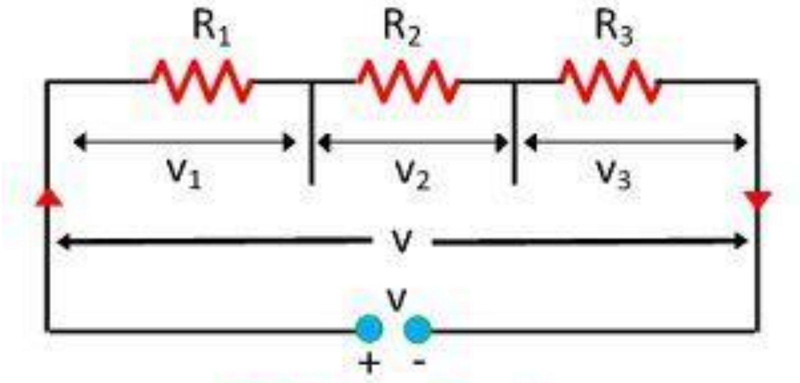
The closed path in which the direct current flows is called the DC circuit. The current flows in only one direction and it is mostly used in low voltage applications. The resistor is the main component of the DC circuit.

A simple DC circuit is shown in the figure below which contains a DC source (battery), a load lamp, a switch, connecting leads, and measuring instruments like ammeter and voltmeter. The load resistor is connected in series, parallel or series-parallel combination as per requirement.

A circuit that can be AC or DC is the combination of active elements (power supply sources) and passive elements (resistors, capacitors and inductors). Thus, the circuit theory or analysis helps to understand the circuit behavior or characteristics by finding out the voltages and currents in various elements in a circuit by using different techniques. So let us discuss in brief about basic concepts of electricity before we could deal with DC circuit theory in later articles.

1. DC Series Circuit

The circuit in which have DC series source, and the number of resistors are connected end to end so that same current flow through them is called a DC series circuit. The figure below shows the simple series circuit. In the series circuit the resistor R1, R2, and R3 are connected in series across a supply voltage of V volts. The same current I is flowing through all the three resistors.



DC Series Circuit

If V1, V2, and V3 are the voltage drop across the three resistor R1, R2, and R3 respectively, thendc-circuit-equation-1Let R be the total resistance of the circuit then,dc-equation-2Total resistance = Sum of the individual resistance.

$$V = V_1 + V_2 + V_3$$

$$V = IR_1 + IR_2 + IR_3$$

Let R be the total resistance of the circuit then,

$$IR = IR_1 + IR_2 + IR_3$$

$$R = R_1 + R_2 + R_3$$

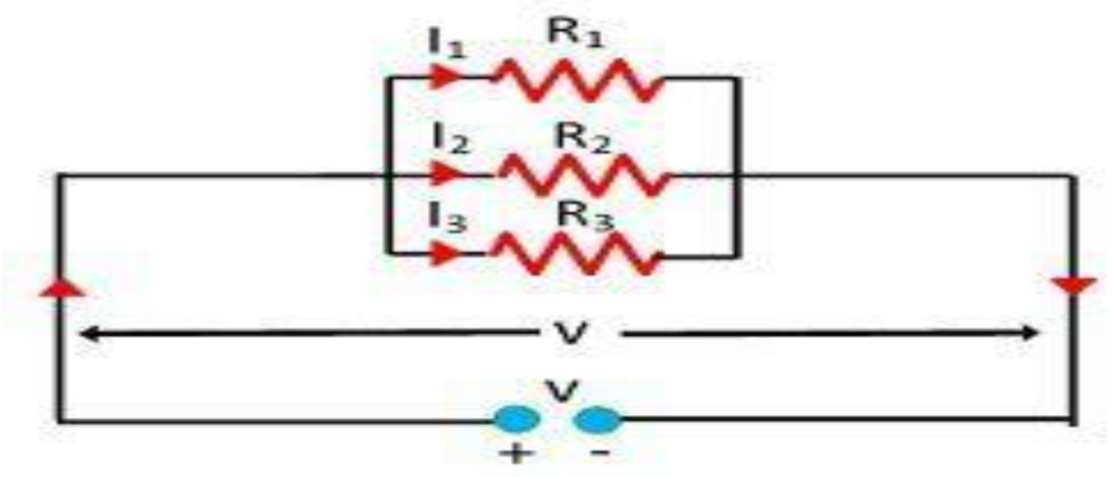
Total resistance = Sum of the individual resistance.

In such type of circuit all the lamps are controlled by the single switch and they cannot be controlled individually. The most common application of this circuit is for decoration purpose where a number of low voltage lamps are connected in series.

2. DC Parallel Circuit

The circuit which have DC source and one end of all the resistors is joined to a common point and other end are also joined to another common point so that current flows through them is called a DC parallel circuit.

The figure shows a simple parallel circuit. In this circuit the three resistor R1, R2, and R3 are connected in parallel across a supply voltage of V volts. The current flowing through them is I1, I2 and I3 respectively.



DC Parallel Circuit

The total current drawn by the circuit

$$I = I_1 + I_2 + I_3$$

$$I = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

Let R be the total or effective resistance of the circuit, then

$$\frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

Reciprocal of total resistance = sum of reciprocal of the individual resistance..

All the resistance is operated to the same voltage, therefore all of them are connected in parallel. Each of them can be controlled individually with the help of a separate switch.

Kirchhoff's circuit laws

Kirchhoff's circuit laws are two equalities that deal with the current and potential difference (commonly known as voltage) in the lumped element model of electrical circuits. They were first described in 1845 by German physicist Gustav Kirchhoff.[1] This generalized the work of Georg Ohm and preceded the work of James Clerk Maxwell. Widely used in electrical engineering, they are also called Kirchhoff's rules or simply Kirchhoff's laws. These laws can be applied in time and frequency domains and form the basis for network analysis.

Both of Kirchhoff's laws can be understood as corollaries of Maxwell's equations in the low-frequency limit. They are accurate for DC circuits, and for AC circuits at frequencies where the wavelengths of electromagnetic radiation are very large compared to the circuits.

1. Kirchhoff's current law

This law, also called Kirchhoff's first law, Kirchhoff's point rule, or Kirchhoff's junction rule (or nodal rule), states that, for any node (junction) in an electrical circuit, the sum of currents flowing into that node is equal to the sum of currents flowing out of that node; or equivalently:

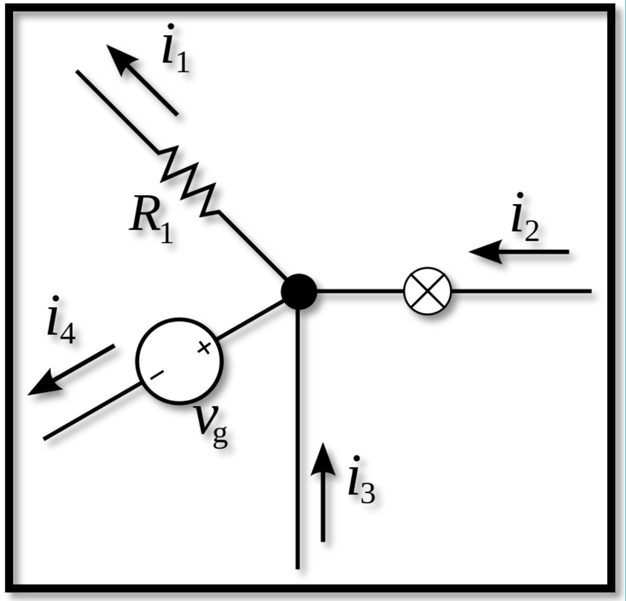
The algebraic sum of currents in a network of conductors meeting at a point is zero.

Recalling that current is a signed (positive or negative) quantity reflecting direction towards or away from a node, this principle can be succinctly stated as:

$$\sum_{k=1}^{n} I_k = 0$$

where n is the total number of branches with currents flowing towards or away from the node.

The law is based on the conservation of charge where the charge (measured in coulombs) is the product of the current (in amperes) and the time (in seconds). If the net charge in a region is constant, the current law will hold on the boundaries of the region. This means that the current law relies on the fact that the net charge in the wires and components is constant.



The current entering any junction is equal to the current leaving that junction. i2 + i3 = i1 + i4

2. Kirchhoff's voltage law

This law, also called Kirchhoff's second law, Kirchhoff's loop (or mesh) rule, or Kirchhoff's second rule, states the following:

The directed sum of the potential differences (voltages) around any closed loop is zero.

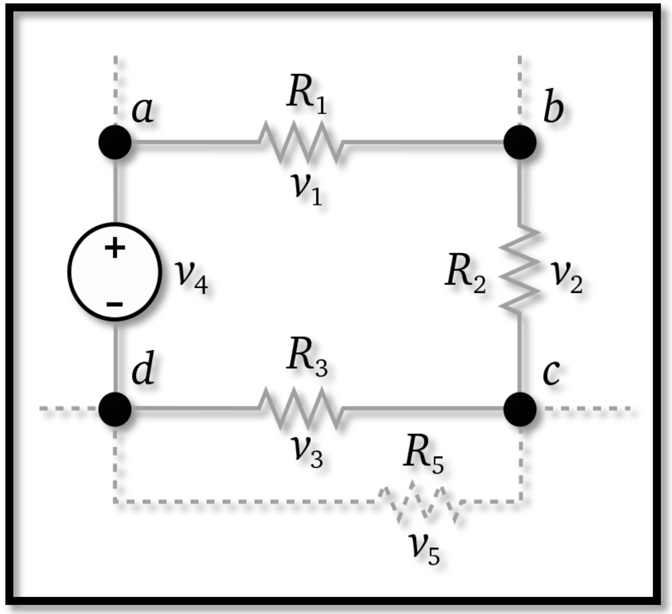
Similarly to Kirchhoff's current law, the voltage law can be stated as:

$$\sum_{k=1}^{n} V_k = 0$$

Here, n is the total number of voltages measured.

In the low-frequency limit, the voltage drop around any loop is zero. This includes imaginary loops arranged arbitrarily in space – not limited to the loops delineated by the circuit elements and conductors. In the low-frequency limit, this is a corollary of Faraday's law of induction (which is one of Maxwell's equations).

This has practical application in situations involving "static electricity".

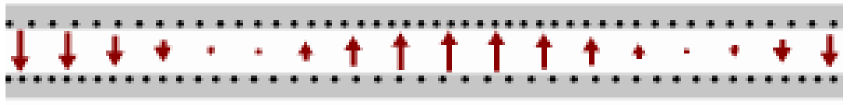


The sum of all the voltages around a loop is equal to zero.
v1 + v2 + v3 +v4 = 0

Limitation of Kirchhoff's circuit laws

Kirchhoff's circuit laws are the result of the lumped-element model and both depend on the model being applicable to the circuit in question. When the model is not applicable, the laws do not apply.

The current law is dependent on the assumption that the net charge in any wire, junction or lumped component is constant. Whenever the electric field between parts of the circuit is non-negligible, such as when two wires are capacitively coupled, this may not be the case. This occurs in high-frequency AC circuits, where the lumped element model is no longer applicable. For example, in a transmission line, the charge density in the conductor will constantly be oscillating.



In a transmission line, the net charge in different parts of the conductor changes with time. In the direct physical sense, this violates KCL.

On the other hand, the voltage law relies on the fact that the action of time-varying magnetic fields are confined to individual components, such as inductors. In reality, the induced electric field produced by an inductor is not confined, but the leaked fields are often negligible.

REAL TIME APPLICATIONS

1. **Domestic and commercial buildings** :- Domestic DC installations usually have different types of sockets, connectors, switches, and fixtures from those suitable for alternating current. This is mostly due to the lower voltages used, resulting in higher currents to produce the same amount of power.

2. **Automotive** :- Most automotive applications use DC. An automotive battery provides power for engine starting, lighting, and ignition system. The alternator is an AC device which uses a rectifier to produce DC for battery charging.

3. **Telecommunication** :- Telephone exchange communication equipment uses standard −48 V DC power supply. The negative polarity is achieved by grounding the positive terminal of power supply system and the battery bank. This is done to prevent electrolysis depositions. Telephone installations have a battery system to ensure power is maintained for subscriber lines during power interruptions.

4. **High-voltage power transmission** :- High-voltage direct current (HVDC) electric power transmission systems use DC for the bulk transmission of electrical power, in contrast with the more common alternating current systems. For long-distance transmission, HVDC systems may be expensive and suffer lower electrical losses.

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ANY QUERIES?

THANK YOU !