

Limitations of Ohm's Law

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Ohm's Law is a relationship between three physical phenomena: current, voltage, and resistance. This relationship was introduced by German physicist George Simon Ohm. That is why the law is well known as Ohm's law. It states that the amount of steady current through a large number of materials is directly proportional to the potential difference, or voltage, across the materials. Thus, if the voltage V (in units of volts) between two ends of a wire made from one of these materials is tripled, the current I (in amperes) also triples; and the quotient V/I remains constant. The quotient V/I for a given piece of material is called its resistance, R , measured in units named ohms. Although, Ohm's Law is valid to a large extent however it has some limitations. In this article we will learn in detail about Limitation's of Ohm's Law and its applications with having some brief introduction about the basics of Ohm's Law.

What are Current, Voltage, and Resistance?

- **Current**: Current is defined as the flow of positive charge from a source to a negative charge source. The units for current are C/s for the amount of charge (C/Coloumb) that travels per unit of time (second). The ampere (A) is the common unit of current equal to 1 C/s and the symbol for current is I .
- **Voltage**: Voltage is the driving force of the current, it is the electromotive force that pushes free electrons from one atom to another in the same direction. It is also known as potential difference. Voltage is measured by the unit Volt(V).
- **Resistance**: The electrical resistance of an object is a measure of its opposition to the flow of electric current. Its reciprocal quantity is electrical conductance. The unit of resistance is Ohm.

Statement of Ohm's Law

At constant temperature, the current through an ideal resistor is directly proportional to the voltage applied across the resistor. The constant of proportionality is written as R and this is the resistance value of the resistor. Mathematically it can be represented as

$$V = I \cdot R$$

The following diagram shows the water hose analogy of Ohm's Law.

Electricity is Like a Water Hose

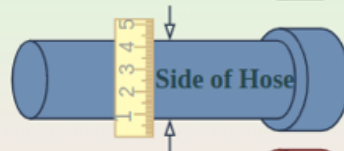
Voltage

Volts (V)



Current

Amps (A)



Resistance

Ohm (Ω)



The main criteria for Ohm's law are to keep the resistance constant because the proportionality constant in the relationship is resistance R . But we know that the variation of temperature affects the value of resistance so to keep the resistance constant during experiments of Ohm's law the temperature is considered constant.

There are various limitations of the Ohm's Law, some of which are as follows:

- Ohm's law is not applicable to unilateral electrical elements like diodes and transistors as they allow the current to flow through in one direction only.
- For non-linear electrical elements with parameters like capacitance, resistance, etc. the voltage and the current won't be constant with respect to time making it difficult to use Ohm's law. Non-linear elements are those which do not have current exactly proportional to the applied voltage, which means the resistance value of those elements changes for different values of voltage and current. Examples of non-linear elements are thyristors, electric arcs, etc.
- The relation between V and I depends on the sign of V (+ or -). In other words, if I is current for a certain V , then reversing the direction of V keeping its magnitude fixed, does not produce a current of the same magnitude as I in the opposite direction. This happens for example in the case of a diode.
- Ohm's law is only applicable to metallic conductors. So it won't work in the case of non-metallic conductors.

Applications of Ohm's Law in Daily Life

Ohm's Law can determine the voltage applied in a circuit, the value of resistance, and the current flowing through the circuit. With the help of the above three values, we can find the value of other factors like resistivity and many more. Some daily applications of Ohm's law:

- **In fuses:** In order to protect a circuit, fuses and circuit breakers are used. These are connected in series with the electrical appliances. Ohm's law allows us to find the value of the current which could flow through the fuses. If the current value is too large, then it could damage the circuit and even lead to the explosion of the electronic device.
- **To know power consumption:** The electrical heaters have a high-resistance metal coil that allows a certain amount of current to pass across them to provide the heat needed. Using this law, the power to be given to the heaters is determined.
- **To control the speed of fans:** By shifting the regulator to the end from the start, we can regulate the speed of the fans in our houses. By controlling the resistance via the regulator, the current flowing through the fan is managed here. We can measure the resistance, current, and thus power flowing via Ohm's Law for any particular value of the input.
- **For deciding the size of resistors:** Electric appliances like electric kettles and irons have a lot of resistors inside them. In order to provide the necessary amount of heat, the resistors restrict the amount of current that can flow through them. By using Ohm's law, the size of resistors included in them is defined.