

Difference Between Ohm's Law and Kirchhoff's Law

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Key Difference – Ohm's Law vs Kirchhoff's Law

When it comes to understanding the [electricity](#), it is highly crucial to understand the relationship between the primitive parameters, [voltage and current](#). The basic principle that describes this relationship is Ohm's Law. Kirchhoff's Law, on the other hand, is a theory that describes properties of these parameters individually. Thus, the key difference between Ohm's law and Kirchhoff's law is that **Ohm's Law describes the relationship between voltage and current across a resistive element while Kirchhoff's law describes the behaviour of current and voltage in a circuit branch.**

What is Ohm's Law?

Ohm's Law states that the current flowing through a [conductor](#) is proportional to the voltage across it and vice versa. This principle was founded by the German physicist Georg Ohm and is given by $V = I \times R$.

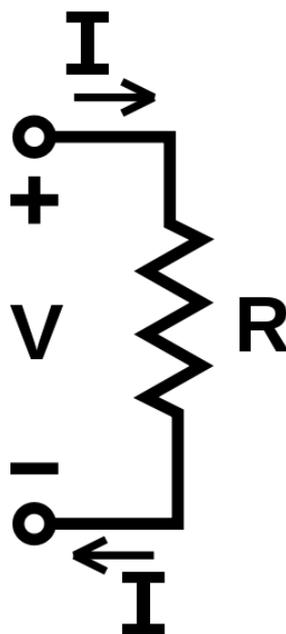


Figure 01: Ohm's Law

Ohm's Law can be represented by the flow of water in a pipe. The potential difference between the two ends drives the water through the pipe like the current which is driven by the voltage difference across the resistive element. Moreover, the reduced resistance which increases the current is equivalent to a reduced cross section area of the pipe which reduces the water flow.

With regard to a single equipment or a circuit of elements as a whole, Ohm's Law is used to calculate the total resistance across the element or the circuit, with the measured current and the voltage. With the calculated resistance, the power consumption of the circuit could be determined or predicted if the resistance value is changed by any mean such as temperature.

The complex form of Ohm's Law is applicable to AC circuits where V and I are complex variables. In that case, R refers to the impedance of the circuit (Z). Impedance is also a complex number in which only the real part contributes to active power dissipation.

What is Kirchhoff's Law?

Kirchhoff's law was proposed by the German physicist Gustav Kirchhoff. Kirchhoff's Law has two forms: Kirchhoff's Current Law (KCL) and Kirchhoff's Voltage Law (KVL). KCL and KVL describe the conservations of current flow and voltage, respectively.

Kirchhoff's Current Law (KCL)

KCL states that the total current that enters a node (a connection point of several branch circuits) and the total current that flows out of the node are equal.

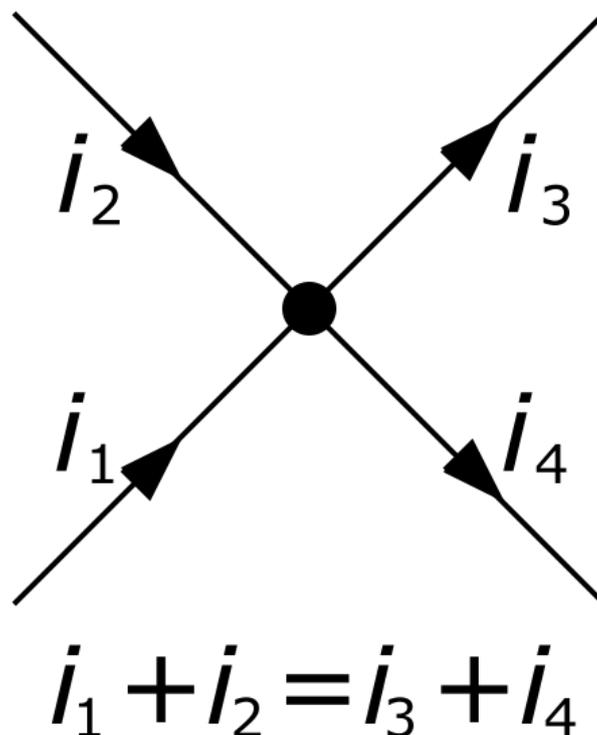


Figure 02: Kirchhoff's Current Law

Kirchhoff's Voltage Law (KVL)

KVL, on the other hand, states that the sum of voltages across a closed loop is zero.

This is expressed in another form as the sum of voltages between two nodes of a circuit is equal to every branch circuit between those two nodes. It can be depicted as in the following figure.

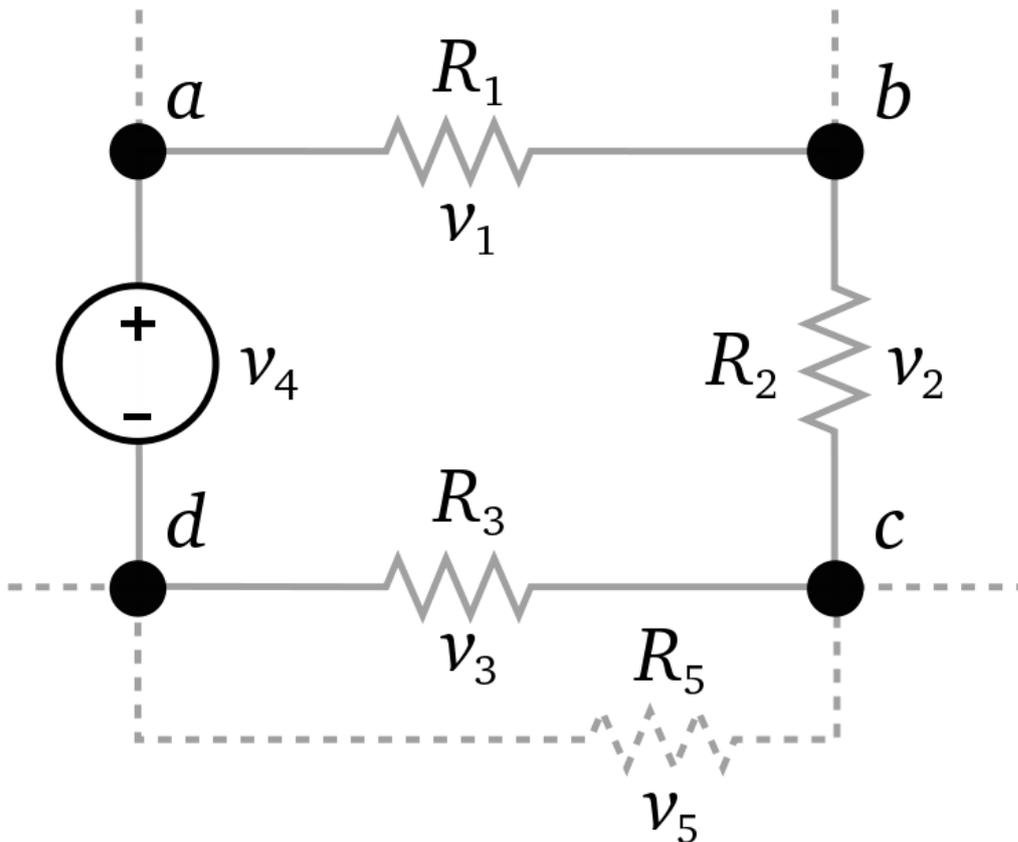
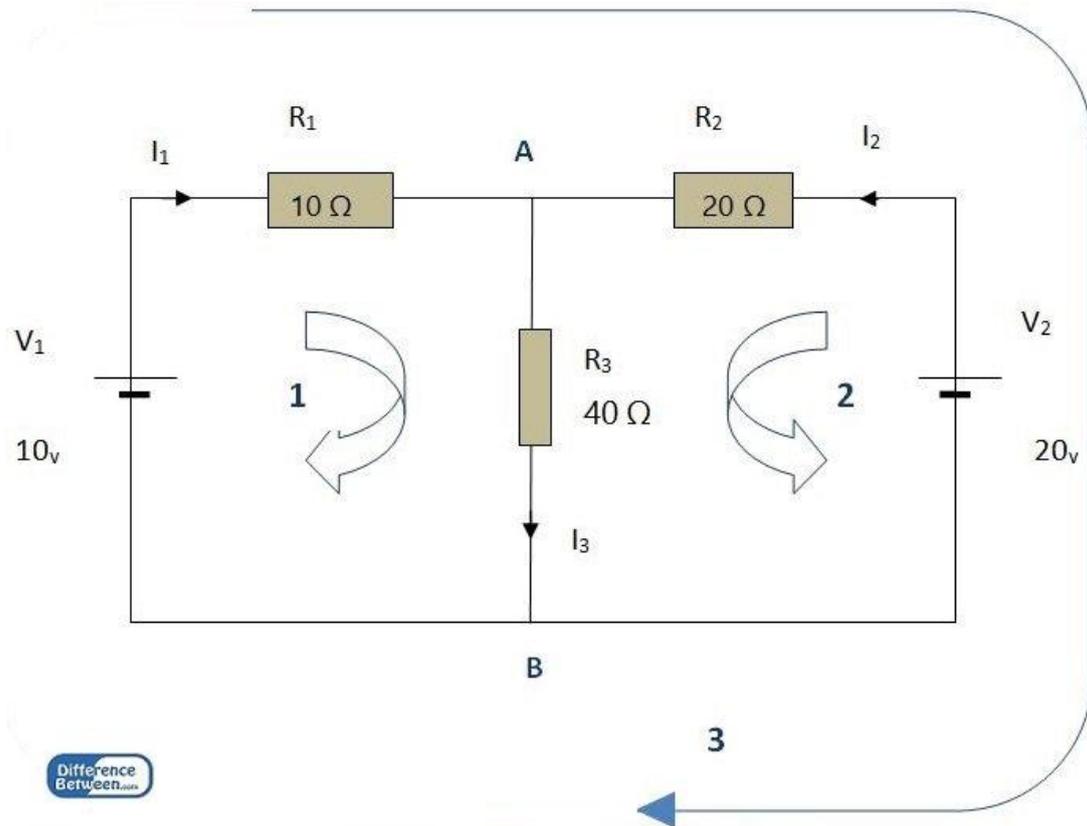


Figure 03: Kirchhoff's Voltage Law

Here, $v_1 + v_2 + v_3 - v_4 = 0$

KVL and KVC are extremely useful in circuit analysis. However, Ohm's Law must be used together with them in solving circuit parameters. For example of such a circuit analysis, the following figure is given.



Considering the nodes A and B, KCL can be applied as follows.

For node A; $I_1 + I_2 = I_3$

For node B; $I_1 + I_2 = I_3$

Then KVL is applied to the closed loop (1)

$$V_1 + I_1 R_1 + I_3 R_3 = 0$$

Then KVL is applied to the closed loop (2)

$$V_2 + I_2 R_2 + I_3 R_3 = 0$$

Then KVL is applied to the closed loop (3)

$$V_1 + I_1 R_1 - I_2 R_2 - V_2 = 0$$

By solving above equations any unknown parameter of the circuit can be found. Note that, Ohm's Law is used when determining the voltages across the resistors.

What is the difference between Ohm's Law and Kirchhoff's Law?

| Ohm's Law vs Kirchhoff's Law | |
|---|---|
| Ohm's Law describes the relationship between voltage and current across a resistive element. | Kirchhoff's Law describes the behaviour of current and voltage respectively in a circuit branch. |
| Law | |
| Ohm's Law states that voltage across a conductor is proportional to the current flows through it. | KCL states that the sum of current flows to a node is equal to zero while KVL states that the sum of voltages in a closed loop is zero. |
| Applications | |
| Ohm's Law is applicable to a single resistive element or set of resistive circuits as a whole. | KCL and KVL are applicable to a series of resistive elements in a circuit. |

Summary – Ohm's Law vs Kirchhoff's Law

Ohm's and Kirchhoff's Laws are two fundamental theories in electrical circuit analysis. They describe the properties and relationship of voltage and current in a single conductive element and a branch of electrical circuit respectively. While Ohm's Law is applicable to a resistive element, Kirchhoff's Laws are applied to a series of elements. This is the most important difference between Ohm's law and Kirchhoff's law. KCL and KVL are usually used in circuit analysis together with Ohm's Law.

References:

1. "Kirchhoffs Circuit Law." Kirchhoffs Circuit Law, [Available here](#). Accessed 4 Sept. 2017.
2. "Kirchhoff's circuit laws." Wikipedia, Wikimedia Foundation, 1 Sept. 2017, [Available here](#). Accessed 4 Sept. 2017.

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