Al-Mustaqbal University
College Of Engineering Technology
Department Of Cyber Security Techniques Engineering
Class: 1st
Subject: fundamental of electrical engineering
Lecturer: Dr. Rami Qays Malik
1st term – Lecture: 4- Kirchhoff's law

الكلية التقنية الهندسية

قسم هندسة تقنيات الامن السيبراني

Lecture: 4- Kirchhoff's law

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Introduction

Using Kirchhoffs circuit law relating to the junction rule and his closed loop rule, we can calculate and find the currents and voltages around any closed circuit providing we know the values of the electrical components within it.

We saw in the Resistors tutorial that a single equivalent resistance, (RT) can be found when two or more resistors are connected together in either series, parallel or combinations of both, and that these circuits obey Ohm's Law.

However, sometimes in complex circuits such as bridge or T networks, we can not simply use Ohm's Law alone to find the voltages or currents circulating within the circuit. For these types of calculations we need certain rules which allow us to obtain the circuit equations and for this we can use Kirchhoffs Circuit Law.

In 1845, a German physicist, Gustav Kirchhoff developed a pair or set of rules or laws which deal with the conservation of current and energy within electrical circuits. These two rules are commonly known as: Kirchhoffs Circuit Laws with one of Kirchhoffs laws dealing with the current flowing around a closed circuit, Kirchhoffs Current Law, (KCL) while the other law deals with the voltage sources present in a closed circuit, Kirchhoffs Voltage Law, (KVL).

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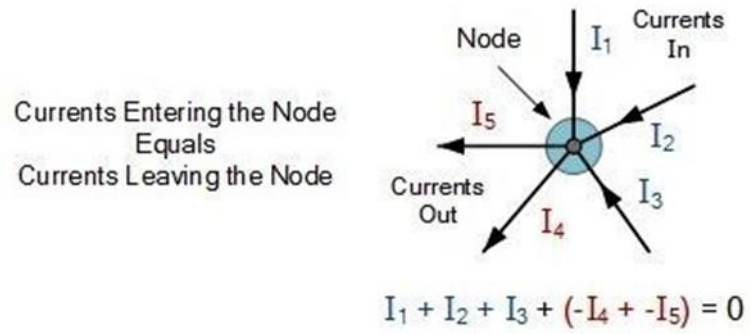
Kirchhoff's First Law – The Current Law, (KCL)

Kirchhoffs Current Law or KCL, states that the "total current or charge entering a junction or node is exactly equal to the charge leaving the node as it has no other place to go except to leave, as no charge is lost within the node". In other words the algebraic sum of ALL the currents entering and leaving a node must be equal to zero, I(exiting) + I(entering) = 0. This idea by Kirchhoff is commonly known as the Conservation of Charge.

Kirchhoffs Current Law



Here, the three currents entering the node, I1, I2, I3 are all positive in value and the two currents leaving the node, I4 and I5 are negative in value. Then this means we can also rewrite the equation as:

I1 + I2 + I3 – I4 – I5 = 0

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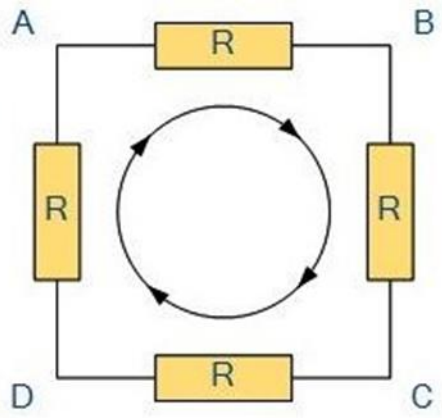
Kirchhoff's Second Law – The Voltage Law, (KVL)

Kirchhoff's Voltage Law or KVL, states that "in any closed loop network being driven by a voltage source, the total voltage around the loop is equal to the sum of all the voltage drops within the same loop" which is equal to zero. In other words the algebraic sum of all voltage sources and voltage drops within a closed loop must be equal to zero since the algebraic sum of the voltage drops equals the algebraic sum of the voltage sources. This idea by Kirchhoff is known as the Conservation of Energy.

Kirchhoff's Voltage Law

The sum of all the Voltage Drops around the loop is equal to Zero



$$V_{AB} + V_{BC} + V_{CD} + V_{DA} = 0$$

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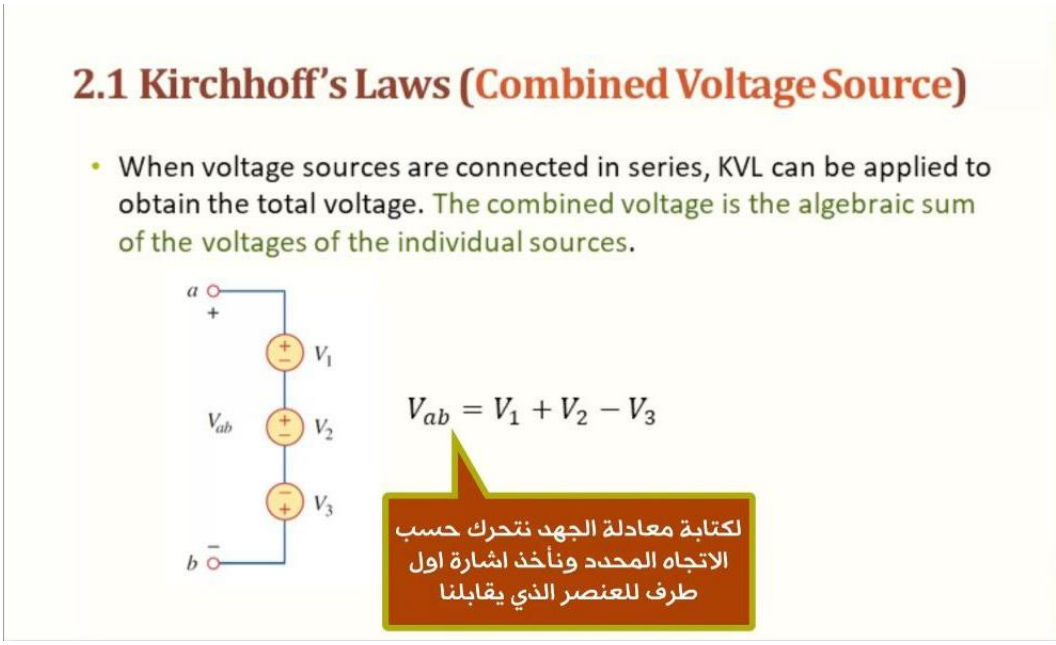

Common DC Circuit Theory Terms:

• Circuit – a circuit is a closed loop conducting path in which an electrical current flows.

• Path – a single line of connecting elements or sources.

• Node – a node is a junction, connection or terminal within a circuit were two or more circuit elements are connected or joined together giving a connection point between two or more branches. A node is indicated by a dot.

• Branch – a branch is a single or group of components such as resistors or a source which are connected between two nodes.

• Loop – a loop is a simple closed path in a circuit in which no circuit element or node is encountered more than once.

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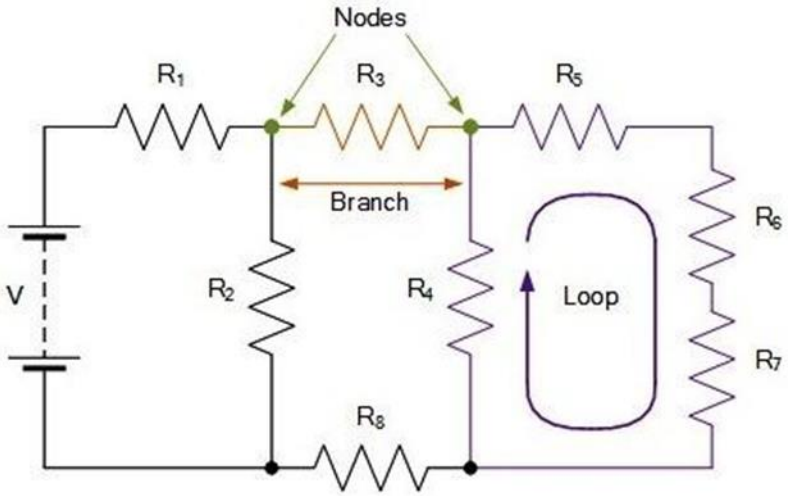
A Typical DC Circuit



Kirchhoff's Circuit Law Example No1

For the circuit in the Figure, find voltages v_1 and v_2.

Solution:

- Assume the current i flows through the loop.
- From Ohm's law

$$v_1 = 2i \quad and \quad v_2 = -3i$$

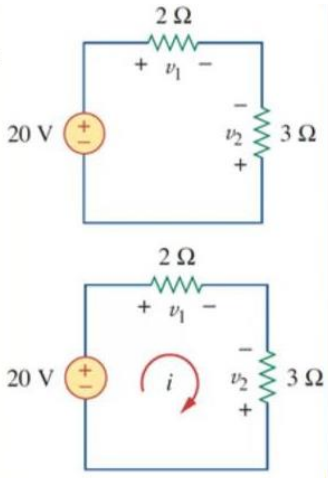
- Applying KVL

$$-20 + v_1 - v_2 = 0$$

- Substituting for v_1 and v_2

$$-20 + 2i + 3i = 0 \implies 5i = 20 \implies i = 4A$$

$$v_1 = 2i = 8V \quad and \quad v_2 = -3i = -12V$$



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Kirchhoff's Circuit Law Example No2

Determine v_o and i in the circuit

Solution:

- Apply KVL around the loop

$$-12 + 4i + 2v_o - 4 - v_o = 0 \qquad (1)$$

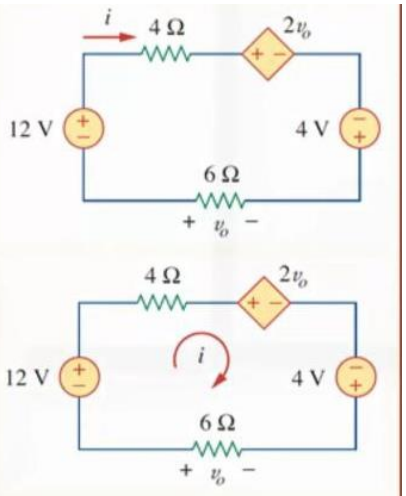
- Applying Ohm's law to the 6-Ω resistor gives

$$v_o = -6i \qquad (2)$$

- Substituting Eq. (2) into Eq. (1) yields

$$-16 + 4i - 6i = 0 \quad \Rightarrow \quad i = -8\ \text{A}$$

$$\therefore v_o = 48\ V$$



Application of Kirchhoffs Circuit Laws

These two laws enable the Currents and Voltages in a circuit to be found, ie, the circuit is said to be "Analyzed", and the basic procedure for using Kirchhoff's Circuit Laws is as follows:

1. Assume all voltages and resistances are given (If not label them V1, V2,..R1, R2, etc(.

2. Assigns a current to each branch or mesh (clockwise or anticlockwise(

Label each branch with a branch current. (I1, I2, I3) etc.

3. Find Kirchhoff's first law equations for each node.

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4. Find Kirchhoff's second law equations for each of the independent loops of the circuit.

5. Use Linear simultaneous equations as required to find the unknown currents.

As well as using Kirchhoffs Circuit Law to calculate the various voltages and currents circulating around a linear circuit, we can also use loop analysis to calculate the currents in each independent loop which helps to reduce the amount of mathematics required by using just Kirchhoff's laws. In the next tutorial about DC circuits, we will look at Mesh Current Analysis to do just that.