

Overview of Electronics and Their Applications  
Electric Current, Voltage, and Resistance  
Conductors and Insulators  
Ohm's Law and Its Applications  
Kirchhoff's Law and Its Applications  
Conclusion

# Introduction to Electronics

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## Overview of Electronics and Their Applications

Electric Current, Voltage, and Resistance

Conductors and Insulators

Ohm's Law and Its Applications

Kirchhoff's Law and Its Applications

Conclusion

Era of Electronics (Part 1)

Overview of Electron

Applications of Electronics in Various Fields

# Overview of Electronics and Its Applications

- We will begin by understanding what electronics is and explore its various applications in our daily lives, such as communication devices, entertainment systems, medical equipment, and more.

# Era of Electronics (Part 1)

**Table 1** Short Historical of Electronics Evolution

Era	Year	Scientists
<b>Early Discoveries</b>		
Electromagnetism	1800	Hans Christian Ørsted, Michael Faraday
Electricity Generation	1820	Alessandro Volta, André-Marie Ampère
<b>Vacuum Tube</b>		
Vacuum Tube	1904	John Ambrose Fleming
Transistor	1947	John Bardeen, Walter Houser Brattain, William Shockley

## Integrated Circuit

## Era of Electronics (Part 2)

**Table 1** Brief History of Electronics Evolution (Continued)

Era	Year	Scientists
<b>Digital Revolution</b>		
Personal Computer	1976	Steve Wozniak, Steve Jobs, Bill Gates
Internet	1989	Tim Berners-Lee, Vinton Cerf
<b>Current and Future Developments</b>		
Nanotechnology	1981	Richard Feynman, Eric Drexler
Artificial Intelligence	1956	John McCarthy, Marvin Minsky

## Overview of Electronics - The Past

- Discovery of Electricity: Observations of static electricity phenomena by ancient civilizations.
- Invention of Batteries: Alessandro Volta's invention of the Voltaic Pile, providing a continuous source of electric current.
- Development of Electric Telegraph: Samuel Morse and Alfred Vail's invention of the electric telegraph for long-distance communication.
- Invention of Vacuum Tubes: Development of vacuum tubes for signal amplification and control.

## Overview of Electronics - The Present

- Integrated Circuits (ICs): Invention of the integrated circuit enabling miniaturization and complex electronic systems.
- Digital Electronics: Widespread adoption of digital technology enabling computers, smartphones, and digital devices.
- Semiconductor Technology: Advances in silicon-based materials and fabrication techniques.
- Internet of Things (IoT): Interconnection of objects and devices through the internet.

## Overview of Electronics - The Future

- Nanotechnology and Quantum Computing: Advancements in nanoscale devices and quantum computing.
- Flexible and Wearable Electronics: Integration of electronics into flexible and wearable forms.
- Renewable Energy and Energy Storage: Electronics' role in optimizing renewable energy and improving energy storage.
- Artificial Intelligence (AI) and Robotics: Integration of AI and robotics with electronics for intelligent machines and automation.



## Summary

Electronics has evolved from the discovery of electricity to the invention of batteries, development of telegraphy, and the introduction of vacuum tubes in the past. In the present, integrated circuits, digital electronics, semiconductor technology, and the Internet of Things have shaped the field. Looking to the future, nanotechnology, quantum computing, flexible and wearable electronics, renewable energy, and AI-driven robotics hold great promise. These advancements continue to revolutionize various aspects of our lives and drive innovation in the field of electronics.

## Communication Systems

- Telecommunications (e.g., telephony, mobile networks)
  - Mobile phones rely on telecommunications networks to enable voice calls and data communication.
- Wireless communication (e.g., Wi-Fi, Bluetooth)
  - Wi-Fi and Bluetooth technologies allow for wireless connectivity between devices, enabling internet access and data transfer.
- Satellite communication
  - Satellite communication systems enable global communication through television broadcasts, weather monitoring, and navigation systems.

## Entertainment Systems

- Television and radio broadcasting
  - Television broadcasting delivers a wide range of entertainment, news, and educational content to households worldwide.
- Audio systems (e.g., speakers, headphones)
  - Speakers and headphones use electronic components to convert electrical signals into sound waves for immersive audio experiences.
- Gaming consoles and multimedia devices
  - Gaming consoles and multimedia devices provide interactive entertainment experiences through the integration of electronics and software.

## Computing and Information Technology

- Computers and laptops
  - Personal computers and laptops utilize electronic components to process and store data, enabling various computational tasks.
- Mobile devices (e.g., smartphones, tablets)
  - Smartphones and tablets combine communication, computing, and multimedia capabilities into portable electronic devices.
- Data storage and cloud computing
  - Cloud computing services store and process data using vast electronic data centers, providing scalable and accessible computing resources.

## Medical and Healthcare

- Medical imaging (e.g., X-ray, MRI)
  - Medical imaging technologies, such as X-ray and MRI machines, use electronics to generate detailed images for diagnostic purposes.
- Diagnostic devices (e.g., ECG, blood glucose meters)
  - Electronic diagnostic devices like electrocardiograms (ECGs) and blood glucose meters aid in monitoring and diagnosing medical conditions.
- Prosthetics and medical implants
  - Electronic prosthetic limbs and medical implants, such as pacemakers, restore functionality and improve the quality of life for individuals.

## Automotive and Transportation

- Vehicle control systems and sensors
  - Electronic control systems and sensors in vehicles enable functions such as anti-lock braking, stability control, and collision avoidance.
- Navigation and GPS technology
  - GPS technology utilizes electronics to provide real-time navigation and location services for vehicles and mobile devices.
- Electric vehicles and autonomous driving
  - Electric vehicles rely on advanced electronics for power management, motor control, and autonomous driving features.

## Summary

**Electronics** plays a crucial role in various fields.

**Communication** systems rely on electronics for telephony, wireless communication, and satellite communication. **Entertainment** systems utilize electronics for broadcasting, audio systems, and gaming consoles. Computing and information technology benefit from electronics in computers, mobile devices, and cloud computing. **Medical and healthcare** fields utilize electronics for imaging, diagnostics, and medical implants. **Automotive and transportation** industries incorporate electronics in vehicle control systems, navigation, and electric vehicles. These applications highlight the diverse and extensive use of electronics in modern society.

## Basic Concepts of Electronics

- We will delve into the basic concepts of electronics, including electric charge, electric current, voltage, and resistance. You will learn about the flow of electric charges in a circuit, the potential difference that drives the flow, and the opposition to the flow provided by resistance.



# Electrical Quantities

**Table 3** Electrical quantities, symbols, units, and symbols for units

Electrical Quantities	Symbol	Unit	Symbol Unit
Electric Charge	<b>Q</b>	Coulomb	C
Electric Current	<b>I</b>	Ampere	A
Voltage (Electric Potential Difference)	<b><math>\Delta V</math></b>	Volt	V
Resistance	<b>R</b>	Ohm	$\Omega$
Capacitance	<b>C</b>	Farad	F
Inductance	<b>L</b>	Henry	H
Impedance	<b>Z</b>	Ohm	$\Omega$
Conductance	<b>G</b>	Siemens	(S)
Reactance	<b>X</b>	Ohm	$\Omega$
Power	<b>P</b>	Watt	W
Energy	<b>E</b>	Joule or Watt-hour	J or Wh

# Electrical Quantities - Part 1

- \* **Electric Charge:** Electric charge is a fundamental property of matter that can be positive or negative. It is responsible for electrical phenomena and interactions.
- \* **Electric Current:** Electric current is the flow of electric charge in a conductor. It represents the rate at which charge moves through a given point in a circuit. It is measured in Amperes (A).
- \* **Voltage (Electric Potential Difference):** Voltage, also known as electric potential difference, is the measure of electric potential energy per unit charge between two points in an electric circuit. It is the driving force that causes electric current to flow. Voltage is measured in Volts (V).
- \* **Resistance:** Resistance is the measure of opposition to the flow of electric current in a conductor. It determines how easily or difficultly the current can pass through a material. Resistance is measured in Ohms ( $\Omega$ ).
- \* **Capacitance:** Capacitance is the ability of a component or circuit to store electrical energy in an electric field. It is represented by the letter C and measured in Farads (F).

## Electrical Qualities - Part 2

- \* **Inductance:** Inductance is the property of a component or circuit to oppose changes in current flow. It is typically associated with coils or solenoids and is represented by the letter L. Inductance is measured in Henrys (H).
- \* **Impedance:** Impedance is the overall opposition to the flow of alternating current in a circuit. It takes into account both resistance and reactance (inductive and capacitive components). Impedance is measured in Ohms ( $\Omega$ ).
- \* **Conductance:** Conductance is the reciprocal of resistance and represents the ease with which current can flow through a material. It is measured in Siemens (S).
- \* **Reactance:** Reactance is the opposition to the flow of alternating current caused by inductance (inductive reactance) or capacitance (capacitive reactance). It is measured in Ohms ( $\Omega$ ).

## Electrical Qualities - Part 3

- \* **Power:** Power is the rate at which work is done or energy is transferred in an electric circuit. It is calculated as the product of voltage and current or the square of current multiplied by resistance. Power is measured in Watts (W).
- \* **Energy:** Energy is the ability to do work or cause a change. In electrical systems, it is associated with the stored or transferred electrical potential energy. Energy is measured in Joules (J) or Watt-hours (Wh).

# Introduction

- Electronics is a fascinating field that encompasses the study of electrical circuits and devices.
- Understanding the fundamental concepts of electric charge, electric current, voltage, and resistance is crucial for building a strong foundation in electronics.
- In this presentation, we will explore these concepts and their interrelationships, shedding light on the underlying principles of electronics.

## Definition of Electric Charge

Electric charge refers to the fundamental property of matter that determines its electromagnetic interactions. It exists in two forms: positive and negative. Protons carry a positive charge ( $+q$ ), while electrons carry a negative charge ( $-q$ ). The charge of an electron is denoted by  $-e$ , where  $e = 1.602 \times 10^{-19}$  Coulombs.

## Electric Charge

- Electric charge is an intrinsic property of matter.
- It exists in two forms: positive and negative.
- Protons carry a positive charge, while electrons carry a negative charge.
- The electric charge of an electron is  $-1.602 \times 10^{-19}$  Coulombs.
- The electric charge of a proton is  $1.602 \times 10^{-19}$  Coulombs.
- The total electric charge of a system is determined by the net amount of positive and negative charges present.

## Total Electric Charge

The total electric charge ( $Q_{\text{total}}$ ) of a system can be determined by the equation:

$$Q_{\text{total}} = n_p \cdot q_p + n_e \cdot q_e \quad (1)$$

where  $n_p$  is the number of protons,  $n_e$  is the number of electrons,  $q_p$  is the charge of a proton, and  $q_e$  is the charge of an electron.



## Example : Electric Charge

Let's determine the amount of electric charge corresponding to an electric current of 1 Ampere.

Given:

$$I = 1 \text{ A}$$

We can use the formula for electric current to solve for the electric charge ( $Q$ ):

$$I = \frac{Q}{\Delta t} \quad (2)$$

## Example : Electric Charge (Continued)

Continuing from the previous calculation:

$$I = \frac{Q}{\Delta t}$$

Since we are considering a constant current, we can assume a time interval ( $\Delta t$ ) of 1 second. Therefore,  $\Delta t = 1$  s.

Rearranging the equation, we can solve for  $Q$ :

$$Q = I \cdot \Delta t \quad (3)$$

## Example : Electric Charge (Continued)

Continuing from the previous calculation:

$$\begin{aligned}Q &= I \cdot \Delta t \\ &= 1 \text{ A} \cdot 1 \text{ s}\end{aligned}$$

Using a calculator, we can determine the value of  $Q$ :

$$Q = 1 \text{ C}$$

Therefore, an electric current of 1 Ampere corresponds to an electric charge of 1 Coulomb.

## Example: Total Electric Charge

Let's consider a sample of matter composed of  $n$  number of protons and  $n$  number of electrons.

The charge of a proton is  $+e$  and the charge of an electron is  $-e$ , where  $e = 1.602 \times 10^{-19}$  Coulombs.

The total charge of the matter can be calculated using the equation:

$$Q = n \cdot e \quad (4)$$

## Example: Total Electric Charge

For example, if we have 10 billion protons and 10 billion electrons, the total charge of the matter would be:

$$Q = (10 \times 10^9 + 10 \times 10^9) \cdot 1.602 \times 10^{-19} \text{ C} \quad (5)$$

Calculate the value to find the total charge.

## Definition of electric Current

Electric current is the flow of electric charge through a conductor. It is measured in Amperes (A) and represents the rate of charge flow per unit time. The current ( $I$ ) can be calculated using the equation:

$$I = \frac{\Delta Q}{\Delta t} \quad (6)$$

where  $\Delta Q$  is the change in charge and  $\Delta t$  is the change in time.

## Electric Current

- Electric current refers to the flow of electric charge in a circuit.
- Contrary to popular belief, current is the flow of positive charge from higher potential to lower potential.
- This convention, known as conventional current, simplifies calculations and analysis.
- The actual movement of electrons is in the opposite direction.

$$I = \frac{\Delta Q}{\Delta t} \quad (7)$$

## Example : Electric Current

Let's calculate the number of electrons corresponding to an electric current of 1 Ampere.

Given:

$$I = 1 \text{ A}$$

We can use the equation for electric current to determine the charge ( $\Delta Q$ ) passing through a cross-section of the conductor per unit time ( $\Delta t$ ).



## Example (Continued)

Continuing from the previous calculation:

$$I = \frac{\Delta Q}{\Delta t}$$

Since we are considering a constant current, we can assume a time interval ( $\Delta t$ ) of 1 second. Therefore,  $\Delta t = 1$  s.

Rearranging the equation, we can solve for  $\Delta Q$ :

$$\Delta Q = I \cdot \Delta t \tag{8}$$

## Example (Continued)

Continuing from the previous calculation:

$$\begin{aligned}\Delta Q &= I \cdot \Delta t \\ &= 1 \text{ A} \cdot 1 \text{ s}\end{aligned}$$

Using a calculator, we can determine the value of  $\Delta Q$ :

$$\Delta Q = 1 \text{ C}$$

Therefore, an electric current of 1 Ampere corresponds to a charge of 1 Coulomb passing through a cross-section of the conductor per second.

## Example (Continued)

Now, let's determine the number of electrons corresponding to a charge of 1 Coulomb.

Given:

$$Q = 1 \text{ C}$$

We can use the formula to calculate the number of electrons ( $n_e$ ) involved in the charge  $Q$ .

$$n_e = \frac{Q}{q_e} \quad (9)$$

where  $q_e$  is the charge of an electron.

## Example (Continued)

Continuing from the previous calculation:

$$\begin{aligned}n_e &= \frac{Q}{q_e} \\ &= \frac{1 \text{ C}}{-1.602 \times 10^{-19} \text{ C}}\end{aligned}$$

Using a calculator, we can determine the value of  $n_e$ :

$$n_e \approx -6.24 \times 10^{18}$$

Therefore, an electric current of 1 Ampere corresponds to approximately  $-6.24 \times 10^{18}$  electrons passing through a cross-section of the conductor per second.

## Example: Calculation of Electric Current

Consider a wire through which a charge of 2 Coulombs passes in 5 seconds. We need to calculate the electric current. The formula for electric current is:

$$I = \frac{Q}{t} \quad (10)$$

where  $Q$  is the charge and  $t$  is the time.

Plugging in the values from the example, we have:

$$I = \frac{2\text{ C}}{5\text{ s}} \quad (11)$$

Calculate the value to find the electric current.

## Definition of Voltage

Voltage, also known as electric potential difference, is a measure of the electric potential energy per unit charge between two points in a circuit. It is measured in volts (V). The voltage ( $V$ ) can be calculated using the equation:

$$V = \frac{W}{Q} \quad (12)$$

where  $W$  is the electric potential energy and  $Q$  is the charge.

# Voltage

- Voltage, or electric potential difference, measures the electrical potential energy per unit charge between two points in a circuit.
- It is responsible for driving the flow of electric current.
- Voltage is measured in volts (V).
- It can be visualized as the force pushing charges through a circuit.

$$V = \frac{W}{Q} \quad (13)$$

## Example : Calculation of Voltage

Suppose we have a circuit with an electric potential energy of 50 Joules and a charge of 10 Coulombs. We want to determine the voltage across the circuit. The equation for voltage is given by:

$$V = \frac{W}{Q} \quad (14)$$

where  $V$  is the voltage,  $W$  is the electric potential energy, and  $Q$  is the charge. Substituting the given values, we have:

$$V = \frac{50 \text{ J}}{10 \text{ C}} \quad (15)$$

Calculate the value to find the voltage across the circuit.



## Example : Voltage

Let's calculate the voltage given the electric potential energy and charge.

Given:

$$W = 50 \text{ J}$$

$$Q = 10 \text{ C}$$

We can use the equation for voltage to determine the value.

## Example (Continued)

Continuing from the previous calculation:

$$\begin{aligned} V &= \frac{W}{Q} \\ &= \frac{50 \text{ J}}{10 \text{ C}} \end{aligned}$$

Using a calculator, we can determine the value of  $V$ :

$$V = 5 \text{ V}$$

Therefore, the voltage is 5 volts.

## Resistance of Materials

- Resistance is a fundamental property of materials that determines the ease with which electric current can flow through them.
- It depends on various factors, including the resistivity ( $\rho$ ) of the material, the length ( $L$ ) of the conductor, and the cross-sectional area ( $A$ ) of the conductor.
- Resistivity measures the inherent resistance of a material to the flow of electric current. It is measured in ohm-meters ( $\Omega \cdot \text{m}$ ).

## Resistance of Materials

- The longer the conductor, the higher the resistance. The relationship between resistance and length is given by:

$$R = \rho \frac{L}{A} \quad (16)$$

where  $R$  is the resistance,  $\rho$  is the resistivity,  $L$  is the length ( $m$ ), and  $A$  is the cross-sectional area of the conductor ( $m^2$ ).

## Resistivity of Some Materials

**Table 4** Resistivity of some materials

Material	Resistivity ( $\rho$ ) [ $\Omega \cdot \text{m}$ ]
Copper	$1.68 \times 10^{-8}$
Aluminum	$2.65 \times 10^{-8}$
Silver	$1.59 \times 10^{-8}$
Iron	$9.71 \times 10^{-8}$
Nichrome	$1.10 \times 10^{-6}$
Carbon (Graphite)	$3.50 \times 10^{-5}$
Glass	$10^{10} - 10^{14}$
Rubber	$10^{12} - 10^{16}$

## Resistivity of Some Materials

The table 4 shows the resistivity values for some common materials. Resistivity is a measure of how strongly a material opposes the flow of electric current. Materials with higher resistivity values have higher resistance and vice versa.

## Example: Calculation of Resistance

Consider a copper wire with a length of 2 meters and a cross-sectional area of  $3 \times 10^{-6}$  square meters. The resistivity of copper is  $1.68 \times 10^{-8}$  ohm-meters. We need to calculate the resistance of the wire. The equation for resistance is:

$$R = \rho \frac{L}{A} \quad (17)$$

where  $R$  is the resistance,  $\rho$  is the resistivity,  $L$  is the length, and  $A$  is the cross-sectional area.

## Example: Calculation of Resistance

Plugging in the values, we have:

$$R = (1.68 \times 10^{-8} \Omega \cdot \text{m}) \frac{2 \text{ m}}{3 \times 10^{-6} \text{ m}^2} \quad (18)$$

Calculate the value to find the resistance of the wire.



## Resistance and Temperature (Part 1)

- The resistance of a material is not constant; it changes with temperature.
- Most materials exhibit an increase in resistance as temperature increases.
- This behavior can be quantified by the temperature coefficient of resistance ( $\alpha$ ), which measures the rate of change of resistance with temperature.

## Resistance and Temperature (Part 2)

- The relationship between resistance and temperature is given by:

$$R_T = R_{\text{ref}} [1 + \alpha(T - T_{\text{ref}})]$$

where  $R_T$  is the resistance at temperature  $T$ ,  $R_{\text{ref}}$  is the resistance at the reference temperature  $T_{\text{ref}}$ , and  $\alpha$  is the temperature coefficient of resistance.

- The temperature coefficient of resistance is typically specified in units of ohms per degree Celsius ( $\Omega/^\circ\text{C}$ ).

## Resistance and Temperature (Example)

**Example:** Calculate the change in resistance for a copper wire with a temperature coefficient of resistance ( $\alpha$ ) of  $0.00393 \Omega/^{\circ}\text{C}$  when the temperature increases by  $50^{\circ}\text{C}$ .

**Solution:** Given:  $\alpha = 0.00393 \Omega/^{\circ}\text{C}$ ,  $\Delta T = 50^{\circ}\text{C}$ .  
We can use the formula:

$$\Delta R = R_{\text{ref}} \cdot \alpha \cdot \Delta T$$

Since we are only interested in the change in resistance, we can assume  $R_{\text{ref}} = 1$  (arbitrary reference resistance value).

## Resistance and Temperature (Example)

Plugging in the values, we have:

$$\Delta R = 1 \cdot 0.00393 \cdot 50 = 0.1965 \Omega$$

Therefore, the change in resistance is  $0.1965 \Omega$ .

## Conclusion

- Understanding the fundamental concepts of charge, current, voltage, and resistance is essential for comprehending the principles of electronics.
- By grasping the relationships between these factors, you can analyze and design complex electronic circuits effectively.
- Whether you are an aspiring engineer or an electronics enthusiast, developing a solid foundation in these concepts will empower you to explore and innovate in the exciting world of electronics.

## Questions - Part 1

- 1 **True** or **False**: An electric current is the flow of positive charges.
- 2 **True** or **False**: Electric potential is the amount of electric charge stored in a capacitor.
- 3 **True** or **False**: Electric field lines always point from positive charges to negative charges.
- 4 **True** or **False**: Magnetic field lines are always circular around a straight current-carrying wire.

## Questions - Part 2

- 6 **True** or **False**: A transformer can only step up the voltage in an electrical circuit.
- 7 **True** or **False**: A voltmeter is always connected in series in a circuit.
- 8 **True** or **False**: A parallel circuit has only one current path for the electric charges.
- 9 **True** or **False**: The resistance of a conductor decreases as its temperature increases.

## Question 1

Electric charge is measured in:

- a) Volts
- b) Amperes
- c) Coulombs
- d) Ohms



## Question 2

The flow of electric charge through a conductor is called:

- a) Voltage
- b) Resistance
- c) Electric current
- d) Capacitance

## Question 3

The charge of an electron is:

- a) Positive
- b) Negative
- c) Neutral
- d) Variable

## Question 4

Voltage is measured in:

- a) Watts
- b) Amperes
- c) Coulombs
- d) Volts

## Question 5

Resistance depends on:

- a) Voltage and current
- b) Charge and time
- c) Length and area
- d) Mass and density

## Question 6

The resistance of a material is measured in:

- a) Watts
- b) Amperes
- c) Ohms
- d) Volts

## Question 7

The relationship between voltage, current, and resistance is given by:

- a) Ohm's law
- b) Faraday's law
- c) Newton's law
- d) Pascal's law

## Question 8

The unit of electric current is:

- a) Watts
- b) Volts
- c) Coulombs
- d) Amperes

## Question 9

The total electric charge in a system is determined by:

- a) Voltage and current
- b) Length and area
- c) The net amount of positive and negative charges
- d) Ohm's law



## Question 10

The resistivity of a material depends on:

- a) Voltage and current
- b) Charge and time
- c) Temperature and composition
- d) Length and area

## Answers Key True or False Questions- Part 1

- ❶ False - An electric current is the flow of electric charges, which can be positive or negative.
- ❷ False - Electric potential is the electric potential energy per unit charge.
- ❸ True - Electric field lines point from positive charges to negative charges.
- ❹ True - Magnetic field lines form concentric circles around a straight current-carrying wire.
- ❺ False - Kirchhoff's laws are used to analyze circuits with

## Answers Key True or False Question - Part 2

- 6 False - A transformer can step up or step down the voltage in an electrical circuit.
- 7 False - A voltmeter is always connected in parallel in a circuit.
- 8 False - A parallel circuit has multiple current paths for the electric charges.
- 9 False - The resistance of a conductor generally increases as its temperature increases.
- 10 True - A motor converts electrical energy into mechanical energy.

## Key Answer of 4 choice Questions

1. Electric charge is measured in: Answer: c) Coulombs
2. The flow of electric charge through a conductor is called:  
Answer: c) Electric current
3. The charge of an electron is: Answer: b) Negative
4. Voltage is measured in: Answer: d) Volts
5. Resistance depends on: Answer: c) Length and area

## Key Answer of 4 choice Questions

6. The resistance of a material is measured in: Answer: c) Ohms
7. The relationship between voltage, current, and resistance is given by: Answer: a) Ohm's law
8. The unit of electric current is: Answer: d) Amperes
9. The total electric charge in a system is determined by: Answer: c) The net amount of positive and negative charges
10. The resistivity of a material depends on: Answer: c) Temperature and composition

# Electrical Conductors and Insulators

We will discuss the properties of materials that determine their ability to conduct electricity. You will understand the distinction between electrical conductors, which allow the flow of charges, and electrical insulators, which impede or prevent the flow.

# Conductors

Electrical conductors are materials that allow the flow of electric charges or current through them with minimal resistance. In conductors, the outermost electrons of atoms are loosely bound and can move freely within the material when an electric potential difference, or voltage, is applied across it. This movement of electrons is what constitutes electric current. Examples of common electrical conductors include metals such as copper, aluminum, silver, and gold. These materials have a high density of free electrons, making them efficient conductors of electricity.

## Conducting Materials

Examples of common electrical conductors include metals such as copper, aluminum, silver, and gold. These materials have a high density of free electrons, making them efficient conductors of electricity.



## Insulators

Insulators, also known as non-conductors, are materials that do not readily allow the flow of electric current through them. Insulating materials have tightly bound electrons, making it difficult for them to move in response to an applied electric field. As a result, insulators have very high electrical resistance and prevent or significantly hinder the flow of electric charges. Examples of insulating materials include rubber, plastic, glass, ceramic, and wood. These materials are commonly used in electrical and electronic applications to provide insulation and prevent unwanted current flow.

**Insulating materials** such as rubber, plastic, glass, ceramic, and wood are commonly used in electrical and electronic applications to provide insulation and prevent unwanted current flow.

**Conductors**, on the other hand, are used to carry electric current and are employed in wiring, power transmission lines, and electronic circuits. Remember that conductors and insulators play crucial roles in electrical systems, with conductors facilitating the flow of current and insulators providing necessary insulation to ensure safety and efficient operation of electrical devices and systems.

The differentiation between conductors and insulators is crucial in electrical systems. Conductors are used to carry electric current and are employed in wiring, power transmission lines, and electronic circuits. On the other hand, insulators are used to isolate conductors and prevent the unintended flow of current, ensuring safety and efficient operation of electrical devices and systems.

It's worth noting that there are also materials called semiconductors, which exhibit properties between those of conductors and insulators. Semiconductors have an intermediate level of electrical conductivity and can be controlled or manipulated to exhibit varying levels of conductivity. Semiconductors form the basis of modern electronics and are used extensively in devices like transistors, diodes, and integrated circuits.

# Ohm's Law and Its Applications

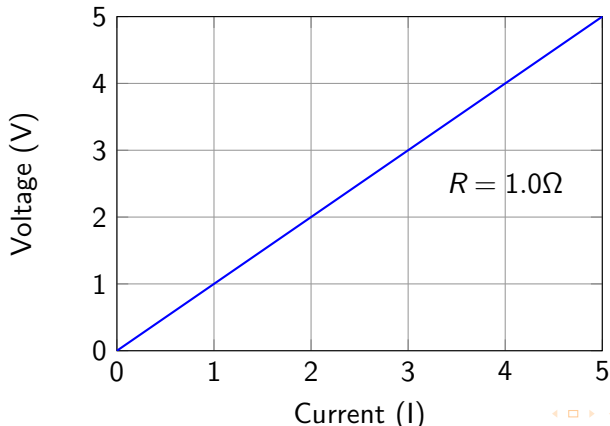
We will introduce Ohm's Law, which relates the current, voltage, and resistance in a circuit. We will explore practical applications of Ohm's Law, including calculating current, voltage, and resistance in simple circuits.

## Ohm's Law

- Resistance is a fundamental property of materials that determines the ease with which electric current can flow through them.
- It is measured in ohms ( $\Omega$ ).
- Resistance can arise from various factors such as the composition, length, and cross-sectional area of a conductor.
- A high resistance restricts the flow of current, while a low resistance allows for easier current flow.

$$R = \frac{V}{I} \quad (19)$$

## I-V Curve Characteristic of Resistor



## Application - Circuit Analysis

- Ohm's Law is used to determine the current, voltage, and resistance in electrical circuits.
- It allows engineers to analyze the behavior of circuits under different conditions.
- **Example:** Suppose we have a circuit with a voltage of 12 volts and a resistance of 4 ohms. By applying Ohm's Law ( $V = I * R$ ), we can calculate the current flowing through the circuit as  $I = \frac{V}{R} = \frac{12V}{4\Omega} = 3A$ . This information helps us understand the current flow and the voltage drop across the circuit.

## Application - Component Design and Sizing

- Ohm's Law helps engineers select the appropriate size and rating of components such as resistors, capacitors, and inductors.
- It ensures that components can handle the expected electrical load without exceeding their limits.
- **Example:** In designing a circuit, we need to select a resistor to limit the current to 2 amps with a voltage of 10 volts. Using Ohm's Law ( $V = I * R$ ), we can calculate the required resistance as  $R = \frac{V}{I} = \frac{10V}{2A} = 5\Omega$ . This allows us to choose a 5-ohm resistor that meets the desired current and voltage requirements.



## Application - Power Calculations

- Ohm's Law enables the calculation of power in a circuit using the formula  $P = VI$ .
- It helps assess power dissipation in components, power consumption in devices, and power delivery in electrical systems.
- **Example:** Suppose we have a circuit with a voltage of 24 volts and a current of 2 amps. Using Ohm's Law ( $P = VI$ ), we can calculate the power as  $P = 24V \times 2A = 48$  watts. This information helps us determine the power requirements and ensure that components and devices can handle the specified power levels.

## Application - Troubleshooting and Fault Finding

- Ohm's Law assists in identifying faults and troubleshooting electrical circuits.
- By measuring voltages and currents, engineers can locate faulty components, open circuits, short circuits, and incorrect connections.
- **Example:** If a circuit is not working, we can measure the voltage across a component using a multimeter and measure the current flowing through it. By comparing these values with the expected values calculated using Ohm's Law, we can identify if the component is faulty or if there is an issue with the circuit's connectivity.

## Application - Electrical Safety

- Ohm's Law ensures that electrical systems operate within safe limits.
- It helps calculate safe operating parameters for circuits and prevents overloading and potential hazards.
- **Example:** To ensure electrical safety, we use Ohm's Law to determine the appropriate wire size for a circuit. By considering the expected current and voltage, we can calculate the resistance and select a wire with an adequate cross-sectional area that can handle the current without excessive heating.

## Application - Load Analysis

- Ohm's Law helps analyze the behavior of loads in electrical systems.
- It aids in understanding power consumption, efficiency, and performance characteristics of loads.
- **Example:** In a residential electrical system, we can measure the voltage and current of household appliances to analyze their power consumption. By applying Ohm's Law, we can calculate the resistance of the load and evaluate its efficiency and power requirements.

## Application - Voltage Regulation

- Ohm's Law is used to regulate and control voltage in power supply systems.
- By adjusting the resistance or impedance in a circuit, engineers can control voltage drops across components or sections.
- **Example:** In a voltage regulator circuit, we can use Ohm's Law to determine the required resistance or impedance to control the desired voltage output.

# Kirchhoff's Law and Its Applications

## Overview:

- Introduction to Kirchhoff's laws
- Kirchhoff's current law (KCL) and its applications
- Kirchhoff's voltage law (KVL) and its applications
- Analysis of series and parallel circuits using Kirchhoff's laws
- Nodal and mesh analysis techniques

In this module, we will explore Kirchhoff's laws and their applications in analyzing complex electrical circuits.

**Introduction to Kirchhoff's Laws:** We will start by introducing Kirchhoff's laws, which are fundamental principles used to analyze electrical circuits. Kirchhoff's laws provide a systematic approach to determine currents and voltages within a circuit.

**Kirchhoff's current law (KCL) and its applications:** We will delve into Kirchhoff's current law, which states that the algebraic sum of currents entering and exiting a node in a circuit is zero. You will learn how to apply KCL to solve circuits with multiple current paths and determine unknown currents.

**Kirchhoff's voltage law (KVL) and its applications:** Next, we will explore Kirchhoff's voltage law, which states that the algebraic sum of voltages around any closed loop in a circuit is zero. You

will learn how to apply KVL to analyze circuits with multiple voltage sources and unknown voltages.

### **Analysis of series and parallel circuits using Kirchhoff's laws:**

We will apply Kirchhoff's laws to analyze series and parallel circuits. You will understand how to calculate total resistance, current, and voltage across each component in these circuit configurations.

**Nodal and mesh analysis techniques:** Lastly, we will introduce nodal and mesh analysis techniques, which are systematic methods for solving complex circuits using Kirchhoff's laws. You will learn how to set up and solve equations to determine the unknown currents and voltages in a circuit.

Throughout this module, we will provide examples and practice exercises to reinforce your understanding of Kirchhoff's laws and



their applications. By the end, you will have the necessary skills to analyze and solve more complex electrical circuits using Kirchhoff's laws.

Overview of Electronics and Their Applications  
Electric Current, Voltage, and Resistance  
Conductors and Insulators  
Ohm's Law and Its Applications  
Kirchhoff's Law and Its Applications  
Conclusion

# Conclusion

- conclusion