

## SECTION 1

### FUNDAMENTALS OF ELECTRICITY AND ELECTRONICS

#### Basic Concepts of Electricity

##### Introduction to Electricity

Electricity is a form of energy that results from the movement of **charged** particles, such as electrons, through a material.

##### What is Electricity?

Electricity is the flow of electrons through a **conductor**. This flow, or electric **current**, can be used to perform work, such as lighting a bulb, heating a stove, or powering an electric motor. The basic components of electricity are:

- **Charge**: Positive and negative charges carried by particles like protons and electrons.
- **Current**: The movement of electrons through a conductor. Measured in Amperes (A).
- **Voltage**: The force that pushes the electrons through the conductor. Measured in Volts (V).
- **Resistance**: The opposition to the flow of electrons within a conductor. Measured in Ohms ( $\Omega$ ). Materials like rubber and wood have high resistance, while metals like copper have low resistance.

##### Types of Electric Current

There are two types of electric current.

- **Direct Current (DC)**: Electrons flow in one direction, used in devices like batteries.
- **Alternating Current (AC)**: Electrons move back and forth, which is how most household **outlets (sockets)** provide electricity.

Most household electricity is alternating current (AC) because it is more **efficient** for long-distance **transmission**, whereas direct current (DC) is primarily used in electronic devices and **circuits**. Many electronic devices, such as phones, laptops, and TVs, **internally convert** AC to DC using **power adapters**.

##### Invention of Electricity

Electricity wasn't "invented," but rather **discovered**. In ancient Greece, Thales of Miletus discovered **static** electricity. In the 17th and 18th centuries, **pioneers** like Benjamin Franklin and Alessandro Volta advanced the understanding of electricity, leading to practical uses like the electric battery and lightning rods. Thomas Edison and Nikola Tesla invented the light bulb and developed the alternating current (AC) system, respectively.

## Circuit

An electrical **circuit** is a closed path that allows electric current to flow from a power source (like a battery or generator), through conductive materials (**wires**), and back to the power source. A circuit usually contains a power source, conductors, and one or more **devices** (like light bulbs or motors) that use electricity.

There are two main types of circuits:

- **Series Circuit**: Components are connected end to end, so the current flows through all components in sequence.
- **Parallel Circuit**: Components are connected in parallel, allowing current to flow through multiple paths.

## Power

Power (P) is the **rate** at which electrical energy is consumed or produced. It is measured in Watts (W) and is calculated using the formula  $P = V \times I$ , **where** V is voltage and I is current. The higher the power, the more energy is used over time.

## Safety

Electrical safety is very important, as electricity can be dangerous if not handled properly. Common **safety measures** include:

- Using **insulated** tools and wires.
- **Grounding** electrical systems to prevent shocks.
- Installing **fuses** or **circuit breakers** to prevent overloads and fires.
- Ensuring proper **wiring** and preventing exposure to moisture.

## Conductors and Insulators

- **Conductors**: Materials that allow electricity to flow through them easily are called conductors. Metals like copper and aluminum are excellent conductors.
- **Insulators**: Insulating materials, like rubber, wood, and plastic, resist the flow of electricity. These materials are used to coat wires and prevent unwanted current from escaping, ensuring safety.

## Basic Concepts of Electronics

### Introduction to Electronics

Electronics is a branch of physics and engineering. Unlike electricity, which focuses on the flow of electric charge in conductors, electronics is concerned with controlling the flow of electrons in **semiconductors** and other materials. Electronics deals with small-scale currents in precise circuits, often involving the use of semiconductors.

### Applications of Electronics

Some of the most important applications of electronics include:

- Consumer Electronics: Smartphones, laptops, televisions, and gaming consoles.
- Communication Systems: Radio, television, mobile networks, and the internet. **Wireless** communication relies on the **transmission** and **reception** of electromagnetic signals, which is made possible by semiconductors like diodes and transistors.
- Medical Devices: Pacemakers, medical imaging systems (X-rays, MRIs), hearing aids, and diagnostic tools.
- Automobiles: Engine control units (ECUs), entertainment systems, and navigation systems. Advanced driver-assistance systems (ADAS) rely heavily on **sensors** and cameras, which are all powered by electronics.
- Industrial **Automation**: Control systems, **robotics**, sensors, and **programmable logic controllers** (PLCs).
- Energy Systems: Smart grids, renewable energy systems (like solar power inverters), and battery management systems.

### Key Components of Electronics

The most important key components in electronic circuits are **diodes**, **transistors**, and **integrated circuits** (ICs).

### Semiconductors

Semiconductors are materials that have **conductivity** between that of insulators and conductors. The most common semiconductor material is silicon. Semiconductors can be controlled to conduct electricity under certain conditions. Semiconductors are the basis of many modern electronic components, including diodes, transistors, and ICs.

### Diodes

A diode is a semiconductor device that allows current to flow in one direction only. This property makes diodes essential for converting alternating current (AC) to direct current (DC). Diodes are used in power supplies, **signal processing**, and even in the creation of **light-emitting diodes** (LEDs) for **displays** and lighting applications.

## Transistors

The transistor is perhaps the most crucial component in modern electronics. A transistor is a semiconductor device used to **amplify** or **switch** electronic signals. The three connection points of a transistor are called **pins (or leads)**. By controlling the flow of current between two pin using a small current or voltage applied to a third pin, transistors can switch on or off. Transistors are the building blocks of digital logic circuits, amplifiers, and microprocessors.

## Integrated Circuits (ICs)

Integrated circuits are a collection of multiple electronic components (transistors, diodes, resistors, etc.) embedded together on a small chip of semiconductor material, typically silicon. ICs can **range** from simple **logic gates** to complex microprocessors that contain billions of transistors. As with transistors, the connection points of an integrated circuit are called **pins (or leads)**.



Figure 1. Transistor and Integrated Circuit (IC)

## Analog and Digital Circuits

One of the most significant **distinctions** in electronics is the difference between analog and digital circuits.

### Analog Circuits

Analog circuits deal with **continuous** signals. Analog signals can represent real-world data like sound, light, or temperature. For example, an analog **amplifier** increases the **amplitude** of an analog signal, such as a microphone picking up sound and sending it to a speaker. Analog electronics are typically used in audio equipment, radio frequency circuits, and some sensor applications. However, analog signals can easily be affected by **noise**, which refers to unwanted signals.

### Digital Circuits

Digital circuits, on the other hand, deal with **discrete** signals, often represented as binary 0s and 1s. These circuits process information in binary form and are the **backbone** of modern computing.