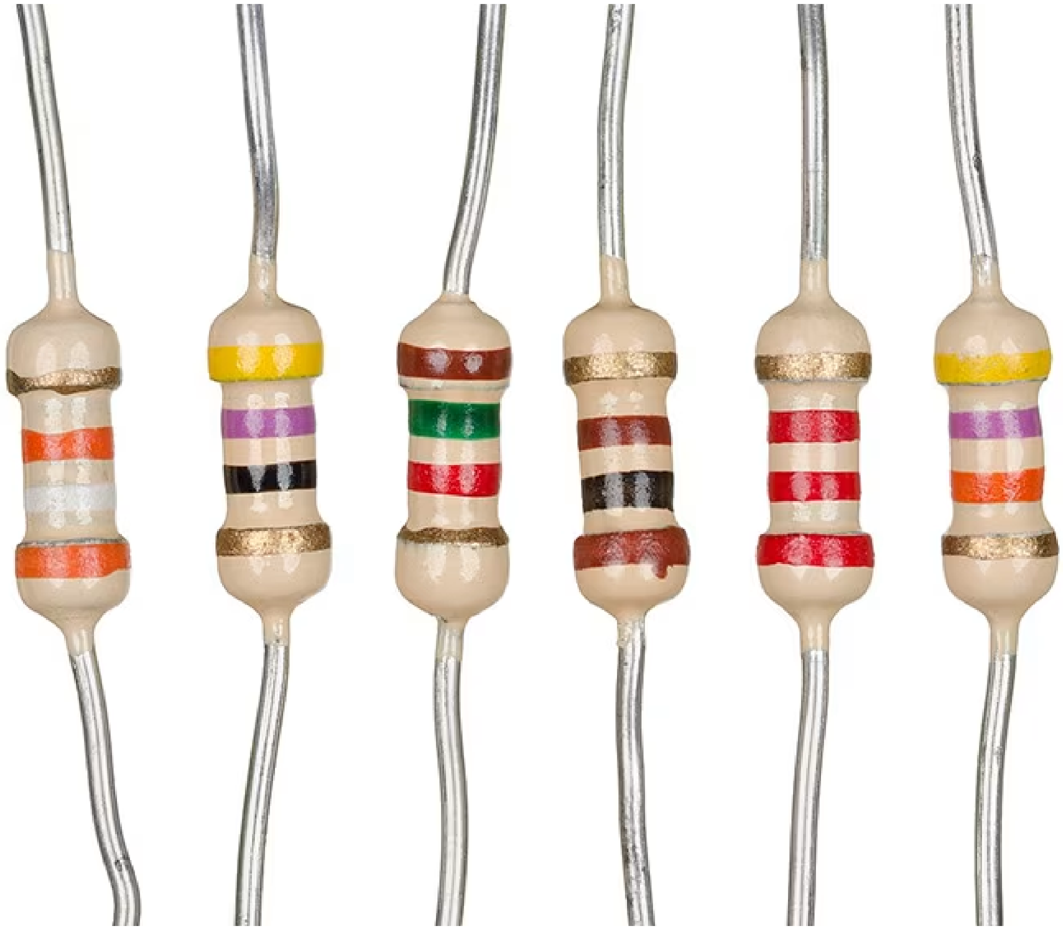
# Basic electronic components: Simple yet In-Depth Guide

madhusudan.live/blog/basic-electronic-components-simple-yet-detailed-guide

## Resistors:



resistors

These tiny devices are called as resistors, their function is to limit the speed of electron flow i.e. current. Think of them as speed breakers, similar to how speed breakers encourage us to limit the speed while driving, the resistors function the same for controlling the flow of electric current.

**Types of resistors:**

there are two main types of resistors

**fixed resistors**:

The resistance value is fixed on these resistors and can't be changed, examples of these resistors are:

- Carbon Film Resistor
- Metal Film Resistor
- Wire wound Resistor
- Thick Film Resistor

**variable resistors:**

The resistors whose value i.e. resistance can be changed or varied are called as variable resistors. e.g. potentiometers, presets, etc.

## Resistor colour code

For fixed resistors, their value can be calculated by looking at their colours, the stripes that you can see in the above image have special meanings, refer to the following table to see their values.

Generally, these resistors have 3 or 4 bands, but they can also be up to 6 bands, but the logic to calculate their values is similar.

| colour | band | multiplier | tolerance |
|---|---|---|---|
| Black | 0 | 1Ω | - |
| Brown | 1 | 10 Ω | ±1% |
| Red | 2 | 100 Ω | ±2% |
| Orange | 3 | 1 KΩ | |
| Yellow | 4 | 10 KΩ | |
| Green | 5 | 100 Ω | |
| Blue | 6 | 1 MΩ | |
| Violet | 7 | | |
| Grey | 8 | | |
| White | 9 | | |
| Gold | | 0.1 Ω | ±5% |
| Silver | | 0.01 Ω | ±10% |

**For calculating 3 band resistor value:**

1st band: it signifies 1st digit

2nd band: it signifies the 2nd digit

3rd band: this band signifies a multiplier

**For calculating 4 band resistor value:**

1st band: it signifies 1st digit

2nd band: it signifies the 2nd digit

3rd band: this band signifies a multiplier

4th band: this band signifies tolerance

**For 5, 6 band resistors:**

The last 2 bands have the same meaning but the first 3 or 4 bands are the significant digits in the case of 5 and 6-band resistors respectively

**Example:**

resistor with colour code

Here in this example

1st three bands refer to the 1st three significant digits the 4th band is the multiplier, the last one is the tolerance

let's calculate:

put the 1st 3 digits as it is: i.e. 426, next is a multiplier i.e. 10^3, last one is tolerance i.e. ±10%

putting it all together: 426KΩ ± 10%

Some important formulae about resistors:

Ohm's law:

It states that the current flowing through a conductor is directly proportional to the voltage across its two ends. Read more on Ohm's law

## Capacitors

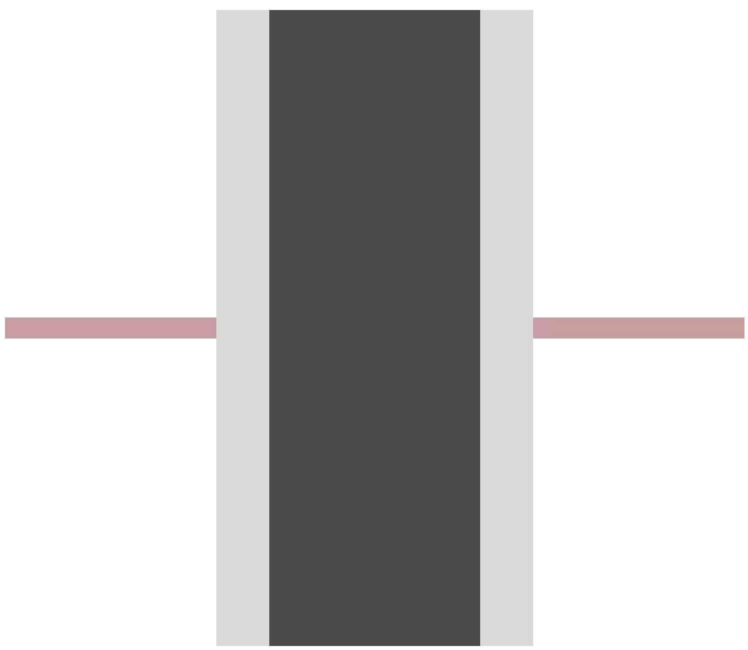
A capacitor is an electronic device that stores electric energy in the form of electrical charge accumulated on their plates. When a capacitor is connected to a power source, it gets charged as the charges accumulate on its plates. Soon the power source is disconnected, the charges on the plate are released, and hence the capacitor acts like a mini battery.

But hey, did you see, I said a capacitor stores the charges in its plates, so let me show you the internals of a capacitor.

See these grey parts below, these are called as the plates and the blackish material inside is called a dielectric. The plates of the capacitor are conducting, but the dielectric material is an insulating or non-conducting material. The dielectric material prevents the flow of electrons, but it allows the electric field to exist.

The capacitor has a property called capacitance, capacitance is defined as the ratio of electric charge (Q) stored in the capacitor to the voltage (V) applied to it and its unit is farads(F).

**C = Q / V**



Construction of capacitor

**Types of capacitors**

Following are the types of capacitors along with their dielectric material, capacitance, voltage ratings and important characteristics.

1. **Ceramic Capacitor:**

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   **Dielectric Material**: Ceramic
   **Capacitance**: Typically ranges from picofarads (pF) to microfarads (uF).
   **Voltage Rating**: Can range from a few volts to hundreds of volts.
   **Characteristics**: Commonly used for high-frequency applications, compact size, and low cost.

2. **Electrolytic Capacitor:**

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   **Dielectric Material**: Oxide layer
   **Capacitance**: Higher values, often in microfarads (uF) to farads (F).
   **Voltage Rating**: Usually for higher voltage applications.
   **Characteristics**: Polarized (must be connected with the correct polarity), higher capacitance values, used for power supply filtering.

3. **Tantalum Capacitor:**

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   **Dielectric Material**: Tantalum Oxide
   **Capacitance**: Typically in the range of microfarads (uF) to farads (F).
   **Voltage Rating**: Suitable for higher voltage applications.
   **Characteristics**: Polarized, high stability, used in applications where reliability is critical.

4. **Film Capacitor:**

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   **Dielectric Material**: Various types, including polyester (Mylar), polypropylene, and polyethylene.
   **Capacitance**: Ranges from picofarads (pF) to microfarads (uF).
   **Voltage Rating**: Varies, but can handle moderate voltage levels.
   **Characteristics**: Non-polarized, good for precision applications, and available in various materials like polyester, polypropylene, and more.

5. **Variable Capacitor:**

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   **Dielectric Material**: Conductive polymer
   **Capacitance**: Adjustable, often used in tuning circuits.
   **Voltage Rating**: Varies, typically low.
   **Characteristics**: Designed to vary capacitance for tuning purposes in radios and other devices.

6. **Supercapacitor:**

   **Dielectric Material**: Electrochemical double layer.
   **Capacitance**: Typically in the range of farads (F) or even hundreds of farads.
   **Voltage Rating**: Can handle moderate voltages.
   **Characteristics**: Known for high capacitance, rapid charge/discharge, and used in applications requiring quick energy storage and release.

### Applications of capacitors:

**Capacitors are like tiny energy storage tanks in electronics.** They have three main jobs:

1. **Filter Noise:** They clean up electrical signals, like removing static from music.
2. **Store Energy:** They save and release electrical energy when needed, like a battery.
3. **Start Motors:** In things like fans or toy cars, capacitors give the initial push to make them start spinning. You might have seen your fans, those big cylinders-like guys.
4. **Block Static:** They keep your computer chips safe from sudden electricity spikes, like a shield.
5. **Signal Boost:** In radios and antennas, capacitors help to make weak signals stronger, like using a magnifying glass to see things better.

## Diodes

Here comes the semiconductor devices, diodes are basically semiconductor devices that allow the flow of electric current in only one direction and block the other.

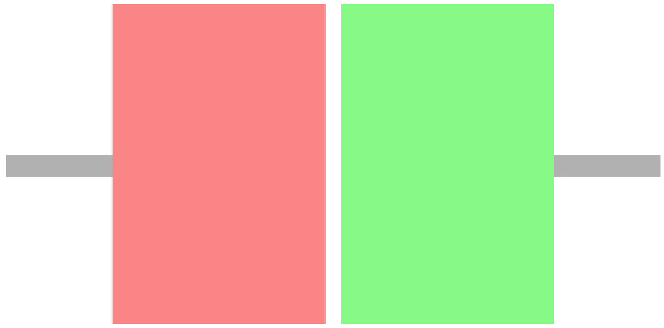
A diode is a two-terminal device, and it is made by joining P-Type and N-Type semiconductors.

Now, you may ask what are these semiconductors? What are P-type and N-type semiconductors? A semiconductor, as its name suggests, is neither a conductor nor an insulator, its conductivity lies between them, meaning that, a semiconductor device acts as a conductor when it meets certain conditions otherwise it acts as an insulator.

Let me break it down even further, a semiconductor, when it meets certain conditions, allows the electric current to flow and blocks it otherwise.

The electrons in the outermost orbit of the semiconductor are responsible for this behaviour, the valence electrons or the valency of these semiconductor atoms, the construction is out of scope, read more about diodes

Now P-type and N-type semiconductors are nothing but when p-type impurities are added to these semiconductors they form a p-type semiconductor, similarly, when an n-type impurity is added to it, they form an n-type semiconductor



Construction of diode

## Types and applications of diodes

There are various types of diodes, each designed for specific applications. Here's an overview of some common types of diodes:

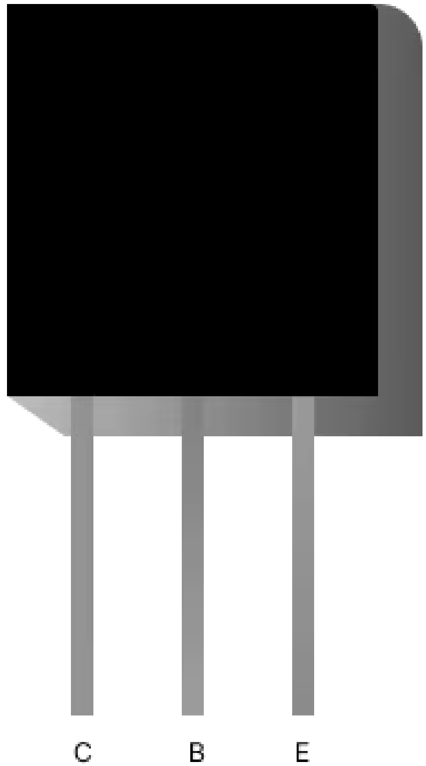
1. **PN Junction Diode:** The standard diode is composed of P-N semiconductor materials. Allows current to flow in one direction while blocking it in the other.
2. **Light Emitting Diode (LED):** Emits light when current flows through it. Widely used in displays, indicators, and lighting applications.
3. **Zener Diode:** Designed for voltage regulation and voltage reference applications. Provides a constant voltage across its terminals when operated in the reverse breakdown region.
4. **Schottky Diode:** Known for its fast switching capabilities. Used in high-frequency and high-speed applications. Has a lower forward voltage drop compared to standard diodes.
5. **Varactor Diode (Varicap Diode):** Used in tuning circuits, such as in radio receivers, to change the capacitance and tune specific frequencies.
6. **Avalanche Diode:** Operates in the avalanche breakdown region. Used in avalanche photodiodes for detecting light.

## Transistors

Transistors are fundamental electronic components that play a crucial role in amplifying and controlling electrical signals in our electronic world of circuits. They are often described as the "building blocks" of modern electronics.

Without transistors, it would be challenging to build the complex electronic devices and systems that have become an integral part of our daily lives.

In other words, transistors act like electronic switches and signal boosters that allow us to create everything from simple on-off switches to powerful computers. yes, you saw it right, the computer CPUs that we use have millions of transistors in them.



transistor

Here's an overview of transistors:

1. **Bipolar Junction Transistor (BJT):** BJTs are three-layer semiconductor devices (N-P-N or P-N-P). They amplify current and can be used as switches. Commonly used in analog applications and amplifiers.
2. **Field-Effect Transistor (FET):** FETs control current flow using an electric field. They are classified into MOSFETs (Metal-Oxide-Semiconductor FET) and JFETs (Junction FET). MOSFETs are commonly used in digital and power applications, while JFETs are used in low-frequency applications.
3. **MOSFET (Metal-Oxide-Semiconductor FET):** MOSFETs are widely used in digital and power electronics. They have low power consumption, making them suitable for integrated circuits (ICs).

## Key Functions and Significance:

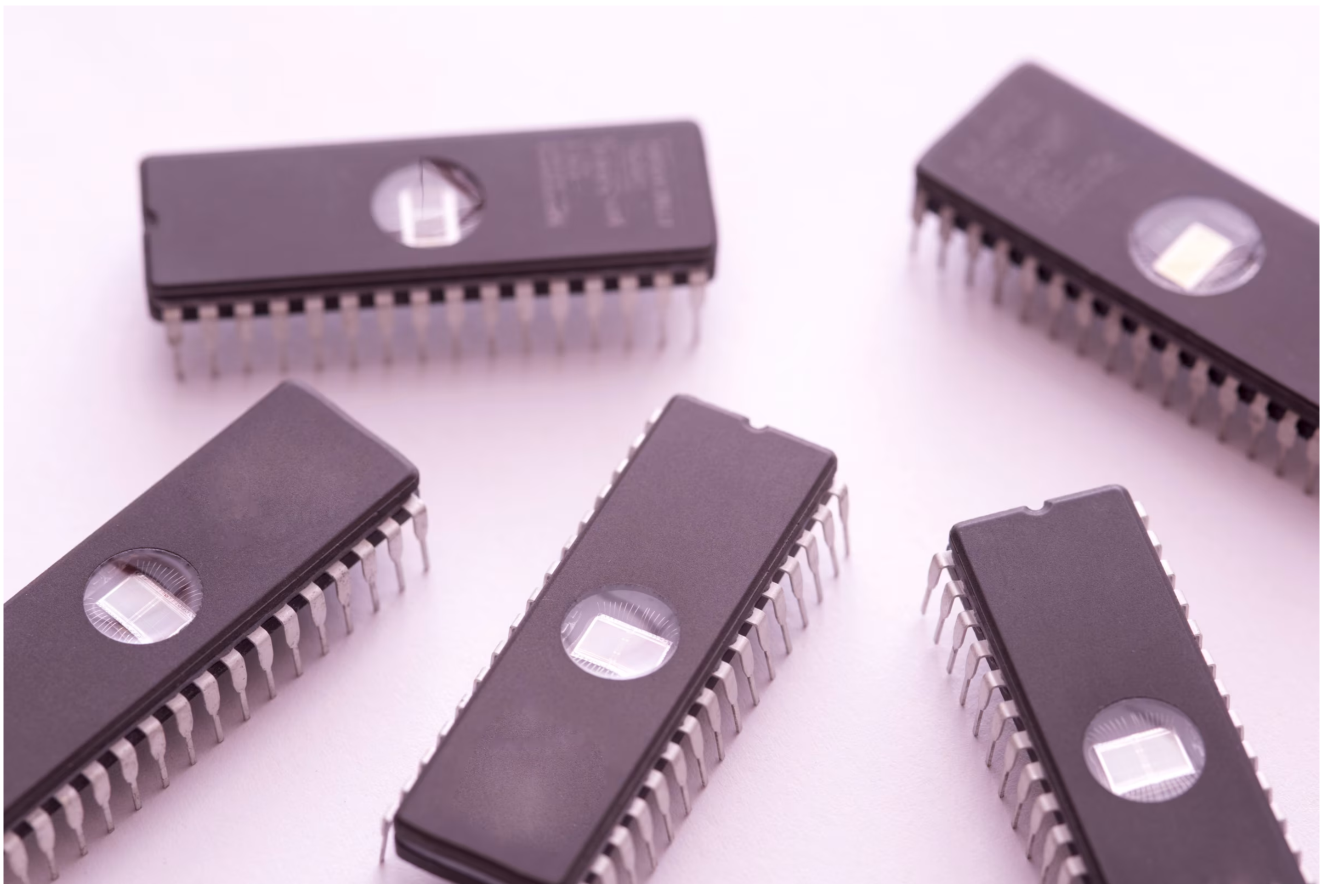
1. **Amplification:** Transistors amplify weak electrical signals, making them stronger. This is essential in audio amplifiers, radios, and other signal-processing applications.
2. **Switching:** Transistors can act as electronic switches, controlling the flow of electrical current. In digital circuits, they enable us the representation of binary logic i.e. 0s and 1s.
3. **Signal Modulation:** Transistors also play a vital role in amplitude modulation (AM) and frequency modulation (FM) in communication systems.
4. **Voltage Regulation:** They help regulate voltage levels in power supplies, ensuring stable and precise output voltages.

## Integrated Circuits (ICs)

Integrated Circuits often called ICs are miniature electronic circuits made up of semiconductor materials, mostly silicon. you might have seen those black squares/rectangles with legs.

These circuits house thousands, millions, or even billions of electronic components, including transistors, resistors, capacitors, and more, all on a single chip.

The components are interconnected to perform various functions, from processing data to controlling electrical signals.



Integrated Circuits

## Types of Integrated Circuits

1. **Analog ICs:** Handle continuous signals for tasks like amplification and voltage regulation.
2. **Digital ICs:** Process discrete binary signals (0s and 1s) for computing and memory functions.
3. **Mixed-Signal ICs:** Combine analog and digital circuitry, used in devices like smartphones.

4. **RF ICs:** Specialized for radio-frequency applications, like amplifying and processing wireless signals.
5. **Memory ICs:** Store and retrieve data, from computer DRAM to flash memory in USB drives.
6. **Power Management ICs (PMICs):** Regulate voltage and manage power in electronic devices.
7. **Communication ICs:** Enable data transmission, including Ethernet controllers and wireless communication.

## Microcontrollers

These are small, embedded computers on a chip, used to control devices and processes in appliances, automobiles, and industrial systems. they are like the brains of the system.

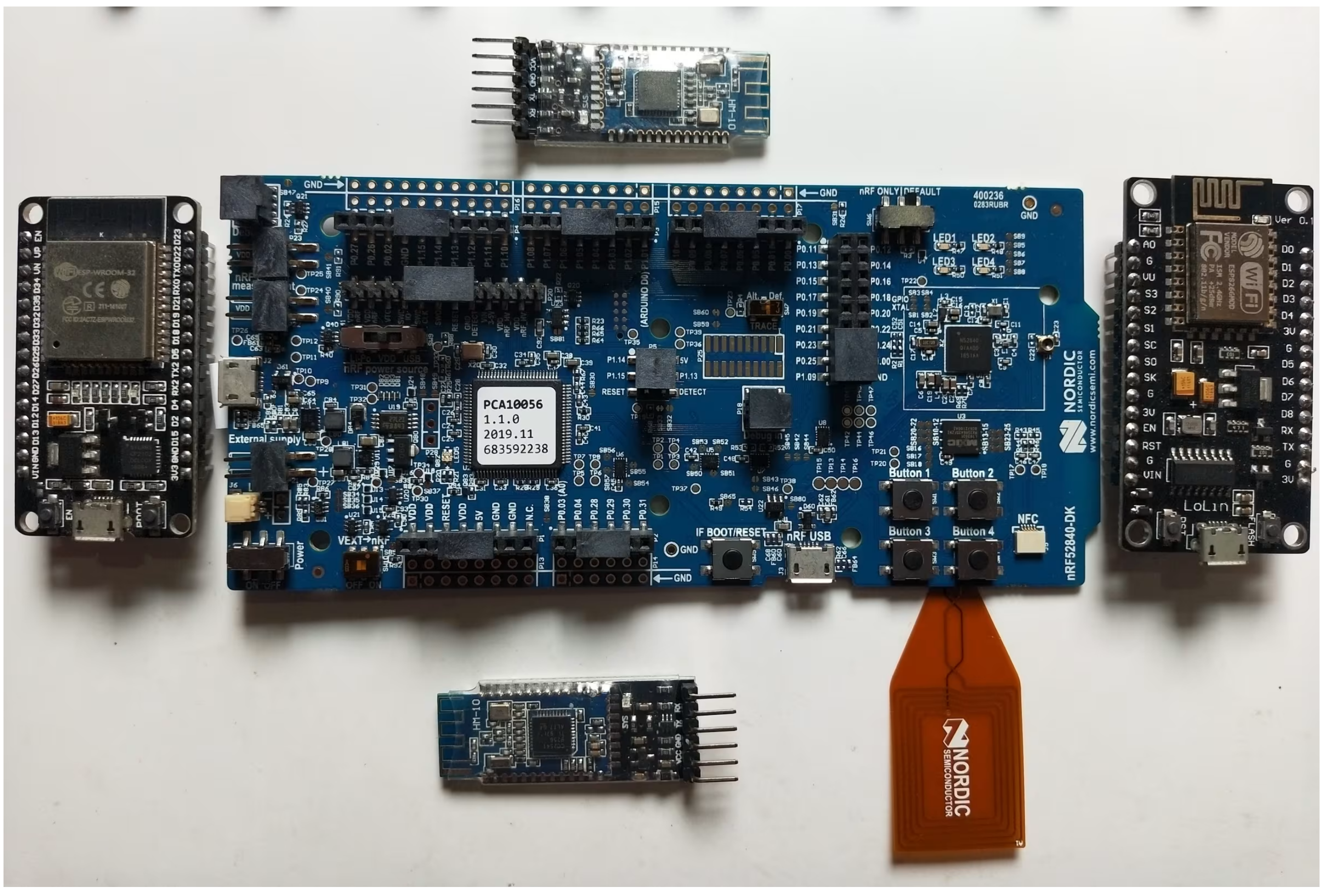



Photo of ESP8266, ESP32, HC05 and Nordic Semiconductors’ development board

**Examples:**

- **8051 microcontrollers**: This intel-developed family of microcontrollers is widely used. these are 8-bit microcontrollers suitable for small projects, robotics, and simple applications.

- **Arduino:** well Arduino is not a microcontroller but for its wide use and simplicity I'm adding here, that Arduino boards are basically development boards based on the ATMega328P microcontroller, they make the development and prototyping of embedded systems a lot easier, and they have Arduino IDE, framework and support for several libraries.
- **Wireless microcontrollers:** ESP32, ESP8266, and Nordic Semiconductor MCUs are a few to list, they provide wireless connectivity, and some offer Wi-Fi, Bluetooth or other networking protocols and hence are suitable for IoT-based applications.