A **diode** is a two-terminal electronic component that conducts current primarily in one direction (asymmetric conductance). It has low (ideally zero) resistance in one direction and high (ideally infinite) resistance in the other. A semiconductor diode, the most commonly used type today, is a crystalline piece of semiconductor material with a p–n junction connected to two electrical terminals. It has an exponential current–voltage characteristic. Semiconductor diodes were the first semiconductor electronic devices. The discovery of asymmetric electrical conduction across the contact between a crystalline mineral and a metal was made by German physicist Ferdinand Braun in 1874. Today, most diodes are made of silicon, but other semiconducting materials such as gallium arsenide and germanium are also used. The obsolete thermionic diode is a vacuum tube with two electrodes, a heated cathode and a plate, in which electrons can flow in only one direction, from cathode to plate. Among many uses, diodes are found in rectifiers to convert alternating current (AC) power to direct current (DC), demodulation in radio receivers, and can even be used for logic or as temperature sensors. A common variant of a diode is a light-emitting diode, which is used as electric lighting and status indicators on electronic devices.

The most common function of a diode is to allow an electric current to pass in one direction (called the diode’s forward direction), while blocking it in the opposite direction (the reverse direction). Therefore, the diode can be viewed as an electronic version of a check valve. This unidirectional behavior is called rectification and is used to convert alternating current (AC) to direct current (DC). As rectifiers, diodes can be used for such tasks as extracting modulation from radio signals in radio receivers. However, diodes can have more complicated behavior than this simple on–off action, because of their nonlinear current–voltage characteristics. For instance, a diode’s forward-direction voltage drop varies only a little with the current, and is more so a function of temperature; this effect can be used as a temperature sensor or as a voltage reference. And its high resistance to current flowing in the reverse direction suddenly drops to a low resistance when the reverse voltage across the diode reaches a value called the breakdown voltage.

A **Zener diode** is a type of heavily doped P-N junction diode that operates in the reverse breakdown region. [It is mostly used as a voltage regulator](https://byjus.com/physics/zener-diode/) [1](https://byjus.com/physics/zener-diode/)[2](https://en.wikipedia.org/wiki/Zener_diode). When a Zener diode is connected to a voltage source, it allows current to flow through it until a certain voltage threshold is reached, at which point it starts conducting heavily, maintaining a constant voltage across its terminals. [Zener diodes are available in a wide range of voltages and some are even adjustable](https://byjus.com/physics/zener-diode/) [1](https://byjus.com/physics/zener-diode/).

The device is named after American physicist Clarence Zener who first described the Zener effect in 1934 in his primarily theoretical studies of breakdown of electrical insulator properties. [Later, his work led to the Bell Labs implementation of the effect in form of an electronic device, the Zener diode](https://byjus.com/physics/zener-diode/) [2](https://en.wikipedia.org/wiki/Zener_diode).

Zener diodes are used to generate low-power stabilized supply rails from a higher voltage and to provide reference voltages for circuits, especially stabilized power supplies. [They are also used to protect circuits from overvoltage, especially electrostatic discharge](https://byjus.com/physics/zener-diode/) [2](https://en.wikipedia.org/wiki/Zener_diode).

A \*\*Light Emitting Diode (LED)\*\* is a semiconductor device that emits light when current flows through it. It is a type of diode that is used in a wide range of applications, including lighting, displays, and indicators ¹. LEDs are available in different colors such as red, green, blue, yellow, etc. ¹.

The LED is made up of a semiconductor material that is doped with impurities to create a p-n junction. When a voltage is applied across the p-n junction, electrons and holes combine to produce light. The color of the light produced depends on the type of semiconductor material used ¹.

LEDs are more energy-efficient than traditional incandescent bulbs and have a longer lifespan ¹. They are also more durable and can withstand shock and vibration ¹. LEDs are used in various applications such as traffic signals, automotive lighting, backlighting for LCD televisions and computer monitors, and general lighting ¹.

A \*\*constant-current diode\*\* is an electronic device that limits current to a maximal specified value for the device. It is known as a current-limiting diode (CLD) or current-regulating diode (CRD) ¹. The device consists of an n-channel JFET with the gate shorted to the source, which functions like a two-terminal current limiter (analogous to a voltage-limiting Zener diode). It allows a current through it to rise to a certain value, but not higher ¹.

Note that some devices are unidirectional and voltage across the device must have only one polarity for it to operate as a CLD, whereas other devices are bidirectional and can operate properly with either polarity ¹. Wide-bandgap materials such as silicon carbide have been used in production devices to enable high-voltage applications in the kilovolt range ¹.

Constant-current diodes are used to generate low-power stabilized supply rails from a higher voltage and to provide reference voltages for circuits, especially stabilized power supplies. They are also used to protect circuits from overvoltage, especially electrostatic discharge ¹.

A \*\*Shockley diode\*\* is a four-layer semiconductor diode, which was one of the first semiconductor devices invented ¹. It is a PNPN diode with alternating layers of P-type and N-type material. It is equivalent to a thyristor with a disconnected gate ¹. The Shockley diode has a negative resistance characteristic ¹. It was largely superseded by the diac ¹.

Unlike other semiconductor diodes, the Shockley diode has more than one PN junction. The construction includes four sections of semiconductors placed alternately between the anode and cathode in the pattern of PNPN. Though it has multiple junctions, it is termed a diode for being a two-terminal device ¹. The Shockley diode remains in an OFF state, with a very high resistance, until a voltage greater than the trigger voltage is applied across its terminals. When the voltage exceeds the trigger value, the resistance drops to an extremely low value and the device switches ON. The constituent transistors help in maintaining the ON and OFF states. Since the construction resembles a pair of interconnected bipolar transistors, one PNP and other NPN, neither transistor can turn ON until the other is turned ON due to the absence of any current through the base-emitter junction. Once sufficient voltage is applied and one of the transistors breaks down, it starts conducting and allows base current to flow through the other transistor, resulting in saturation of both the transistors, keeping both in ON state. On reducing the voltage to a sufficiently low level, the current flowing becomes insufficient to maintain the transistor bias. Due to insufficient current, one of the transistors will cut off, interrupting the base current to the other transistor, hence sealing both transistors in the OFF state ¹.

The Shockley diode has niche applications such as trigger switch for silicon-controlled rectifier and relaxation oscillator/sawtooth oscillator ¹. It was also used as an audio amplifier ¹.

A \*\*Schottky diode\*\* is a type of metal-semiconductor junction diode that has a low forward voltage drop and fast switching speed ¹. It is named after the German physicist Walter H. Schottky who first described the Schottky effect in 1938 ¹. The Schottky diode is formed by the junction of a metal and a semiconductor, creating a Schottky barrier ¹. The metal side acts as the anode, and the semiconductor acts as the cathode of the diode; meaning conventional current can flow from the metal side to the semiconductor side, but not in the opposite direction ¹.

Schottky diodes are often used in high-frequency applications because they have a low forward voltage drop and fast switching speed ¹. They are also used in power rectification applications because they have a low reverse recovery time ¹. The Schottky diode is widely used in power electronics, such as in power supplies, voltage regulators, and DC-DC converters ¹.

A \*\*Tunnel diode\*\* or \*\*Esaki diode\*\* is a type of semiconductor diode that has effectively "negative resistance" due to the quantum mechanical effect called tunneling ¹. It was invented in August 1957 by Leo Esaki, Yuriko Kurose, and Takashi Suzuki when they were working at Tokyo Tsushin Kogyo, now known as Sony ¹. Tunnel diodes have a heavily doped positive-to-negative (P-N) junction that is about 10 nm (100 Å) wide ¹. The heavy doping results in a broken band gap, where conduction band electron states on the N-side are more or less aligned with valence band hole states on the P-side ¹. They are usually made from germanium, but can also be made from gallium arsenide and silicon materials ¹.

The "negative" differential resistance in part of their operating range allows them to function as oscillators and amplifiers, and in switching circuits using hysteresis. They are also used as frequency converters and detectors ¹. Their low capacitance allows them to function at microwave frequencies, far above the range of ordinary diodes and transistors ¹. Due to their low output power, tunnel

diodes are not widely used: Their radio frequency output is limited to a few hundred milliwatts due to their small voltage swing. In recent years, however, new devices that use the tunneling mechanism have been developed. The resonant-tunneling diode (RTD) has achieved some of the highest frequencies of any solid-state oscillator ². Another type of tunnel diode is a metal-insulator-insulator-metal (MIIM) diode, where an additional insulator layer allows "step tunneling" for more precise control of the diode ³.

A \*\*varactor diode\*\* is a type of diode designed to exploit the voltage-dependent capacitance of a reverse-biased p–n junction ¹. It is also known as a varicap diode, variable capacitance diode, variable reactance diode, or tuning diode ¹. Varactor diodes are used as voltage-controlled capacitors and are commonly used in voltage-controlled oscillators, parametric amplifiers, and frequency multipliers ¹. Voltage-controlled oscillators have many applications such as frequency modulation for FM transmitters and phase-locked loops. Phase-locked loops are used for the frequency synthesizers that tune many radios, television sets, and cellular telephones ¹.

The varactor was developed by the Pacific Semiconductor subsidiary of the Ramo Wooldridge Corporation who received a patent for the device in June 1961 ¹. The device name was also trademarked as the "Varicap" by TRW Semiconductors, the successor to Pacific Semiconductors, in October 1967. This helps explain the different names for the device as it came into use ¹.

The amount of reverse bias applied across the varactor diode controls its capacitance. The capacitance change characteristic depends on doping profile. Generally, for abrupt junction profile, the depletion region thickness is proportional to the square root of the applied voltage, and capacitance is inversely proportional to the depletion region thickness. Thus, the capacitance is inversely proportional to the square root of applied voltage. For hyperabrupt junction profile capacitance change is more non-linear, but hyperabrupt varicaps have larger capacitance variation and can work with lower voltages ¹.

A \*\*Transient Voltage Suppression (TVS) diode\*\* is an electronic component used to protect electronics from voltage spikes induced on connected wires ¹. It is also known as a varicap diode, variable capacitance diode, variable reactance diode, or tuning diode ¹. The device operates by shunting excess current when the induced voltage exceeds the avalanche breakdown potential. It is a clamping device, suppressing all overvoltages above its breakdown voltage. It automatically resets when the overvoltage goes away, but absorbs much more of the transient energy internally than a similarly rated crowbar device ¹.

TVS diodes are used to protect sensitive electronics from voltage spikes caused by lightning strikes, electrostatic discharge, and other transient voltage events ¹. They are also used in voltage-controlled oscillators, parametric amplifiers, and frequency multipliers ¹. Voltage-controlled oscillators have many applications such as frequency modulation for FM transmitters and phase-locked loops. Phase-locked loops are used for the frequency synthesizers that tune many radios, television sets, and cellular telephones ¹.

A \*\*gold-doped diode\*\* is a type of diode that employs gold as a dopant. Doping is the process of adding impurities to a semiconductor material to modify its electrical properties ¹. In the case of gold-doped diodes, gold atoms are introduced into the semiconductor material, typically silicon, to create a more efficient and faster device ². As a dopant, gold (or platinum) acts as recombination centers, which helps the fast recombination of minority carriers. This allows the diode to operate at signal frequencies, at the expense of a higher forward voltage drop ¹. Gold-doped diodes are faster than other p–n diodes (but not as fast as Schottky diodes) ¹.

A \*\*Super Barrier Diode (SBD)\*\* is a type of rectifier diode that incorporates the low forward voltage drop of the Schottky diode with the surge-handling capability and low reverse leakage current of a normal p–n junction diode ¹. It is also known as a super barrier rectifier ³. The SBD is designed for high power, low loss, and fast switching applications ².

The SBD utilizes a MOSFET-like structure to deal with the loss. The MOS channel forms a low potential barrier for majority carriers, resulting in forward-bias performance similar to that of the Schottky diode at low voltages ³. The presence of the MOS channel also results in a lower reverse leakage current than that of a Schottky diode ³.

SBDs are used in high-frequency applications because they have a low forward voltage drop and fast switching speed ¹. They are also used in power rectification applications because they have a low reverse recovery time ¹. The SBD is widely used in power electronics, such as in power supplies, voltage regulators, and DC-DC converters ¹.

A **thermal diode** is a device that allows heat to flow preferentially in one direction. [It can refer to a device that allows heat to flow preferentially in one direction, or an electrical (semiconductor) diode in reference to a thermal effect or function 1](https://en.wikipedia.org/wiki/Thermal_diode).

[Thermal diodes are used in thermoelectric cooling applications, where they are used to monitor the temperature of the processor’s die](https://en.wikipedia.org/wiki/Thermal_diode) [1](https://en.wikipedia.org/wiki/Thermal_diode). [They are also used in voltage-controlled oscillators, parametric amplifiers, and frequency multipliers 1](https://en.wikipedia.org/wiki/Thermal_diode). Voltage-controlled oscillators have many applications such as frequency modulation for FM transmitters and phase-locked loops. [Phase-locked loops are used for the frequency synthesizers that tune many radios, television sets, and cellular telephones 1](https://en.wikipedia.org/wiki/Thermal_diode).

[A **crystal diode** is a type of semiconductor diode that is made up of a crystalline piece of semiconductor material with a p–n junction connected to two electrical terminals 1](https://en.wikipedia.org/wiki/Diode). [It has an exponential current–voltage characteristic 1](https://en.wikipedia.org/wiki/Diode). [Semiconductor diodes were the first semiconductor electronic devices](https://en.wikipedia.org/wiki/Diode) [1](https://en.wikipedia.org/wiki/Diode).

[Crystal diodes are also known as point-contact diodes, cat’s-whisker diodes, or crystals 2](https://www.watelectronics.com/crystal-diode/). [They were used in early radio receivers as detectors of amplitude modulated radio signals 3](https://en.wikipedia.org/wiki/Crystal_detector). [The contact between two dissimilar materials at the surface of the detector’s semiconducting crystal forms a crude semiconductor diode, which acts as a rectifier, conducting electric current well in only one direction and resisting current flowing in the other direction 3](https://en.wikipedia.org/wiki/Crystal_detector).

[Crystal diodes are not commonly used today, but they have niche applications such as in thermoelectric cooling applications, where they are used to monitor the temperature of the processor’s die 1](https://en.wikipedia.org/wiki/Diode).

[An **avalanche diode** is a type of diode that is designed to experience avalanche breakdown at a specified reverse bias voltage 1](https://en.wikipedia.org/wiki/Avalanche_diode). [The junction of an avalanche diode is designed to prevent current concentration and resulting hot spots, so that the diode is undamaged by the breakdown 1](https://en.wikipedia.org/wiki/Avalanche_diode). [The avalanche breakdown is due to minority carriers accelerated enough to create ionization in the crystal lattice, producing more carriers, which in turn create more ionization 1](https://en.wikipedia.org/wiki/Avalanche_diode). [Because the avalanche breakdown is uniform across the whole junction, the breakdown voltage is nearly constant with changing current when compared to a non-avalanche diode](https://en.wikipedia.org/wiki/Avalanche_diode) [1](https://en.wikipedia.org/wiki/Avalanche_diode).

[Avalanche diodes are optimized for avalanche effect, so they exhibit small but significant voltage drop under breakdown conditions, unlike Zener diodes that always maintain a voltage higher than breakdown 1](https://en.wikipedia.org/wiki/Avalanche_diode). [This feature provides better surge protection than a simple Zener diode and acts more like a gas-discharge tube replacement](https://en.wikipedia.org/wiki/Avalanche_diode) [1](https://en.wikipedia.org/wiki/Avalanche_diode). [Avalanche diodes have a small positive temperature coefficient of voltage, whereas diodes relying on the Zener effect have a negative temperature coefficient 1](https://en.wikipedia.org/wiki/Avalanche_diode).

Avalanche diodes are used as clamping devices to suppress overvoltage spikes in electronic circuits. [They are also used as noise sources in radio equipment and hardware random number generators 1](https://en.wikipedia.org/wiki/Avalanche_diode).

[A **PIN diode** is a type of diode with a wide, undoped intrinsic semiconductor region between a p-type semiconductor and an n-type semiconductor region 1](https://en.wikipedia.org/wiki/PIN_diode). The p-type and n-type regions are typically heavily doped because they are used for ohmic contacts. [The wide intrinsic region makes the PIN diode an inferior rectifier (one typical function of a diode), but it makes it suitable for attenuators, fast switches, photodetectors, and high-voltage power electronics applications](https://en.wikipedia.org/wiki/PIN_diode) [1](https://en.wikipedia.org/wiki/PIN_diode).

[The PIN photodiode was invented by Jun-Ichi Nishizawa and his colleagues in 1950](https://en.wikipedia.org/wiki/PIN_diode) [1](https://en.wikipedia.org/wiki/PIN_diode). A PIN diode operates under what is known as high-level injection. In other words, the intrinsic “i” region is flooded with charge carriers from the “p” and “n” regions. Its function can be likened to filling up a water bucket with a hole on the side. Once the water reaches the hole’s level it will begin to pour out. [Similarly, the diode will conduct current once the flooded electrons and holes reach an equilibrium point, where the number of electrons is equal to the number of holes in the intrinsic region 1](https://en.wikipedia.org/wiki/PIN_diode).

[PIN diodes are used in many applications such as attenuators, fast switches, photodetectors, and high-voltage power electronics applications](https://en.wikipedia.org/wiki/PIN_diode) [1](https://en.wikipedia.org/wiki/PIN_diode). [They are also used in voltage-controlled oscillators, parametric amplifiers, and frequency multipliers](https://en.wikipedia.org/wiki/PIN_diode) [1](https://en.wikipedia.org/wiki/PIN_diode). Voltage-controlled oscillators have many applications such as frequency modulation for FM transmitters and phase-locked loops. [Phase-locked loops are used for the frequency synthesizers that tune many radios, television sets, and cellular telephones](https://en.wikipedia.org/wiki/PIN_diode) [1](https://en.wikipedia.org/wiki/PIN_diode).

[A **point-contact diode** is a type of semiconductor diode that is formed by touching a metallic wire with an N-type semiconductor to form a small area of contact 1](https://en.wikipedia.org/wiki/Diode). This creates a small point junction. It is widely used because such a small point junction possesses a small value of junction capacitance. [Thus, the charge storage at the junction is low 2](https://electronicscoach.com/point-contact-diode.html). [Point-contact diodes are also known as cat’s-whisker diodes or crystals 1](https://en.wikipedia.org/wiki/Diode).

[Point-contact diodes were used in early radio receivers as detectors of amplitude modulated radio signals](https://en.wikipedia.org/wiki/Diode) [1](https://en.wikipedia.org/wiki/Diode). [The contact between two dissimilar materials at the surface of the detector’s semiconducting crystal forms a crude semiconductor diode, which acts as a rectifier, conducting electric current well in only one direction and resisting current flowing in the other direction](https://en.wikipedia.org/wiki/Diode) [1](https://en.wikipedia.org/wiki/Diode).

[Point-contact diodes are not commonly used today, but they have niche applications such as in thermoelectric cooling applications, where they are used to monitor the temperature of the processor’s die](https://en.wikipedia.org/wiki/Diode) [1](https://en.wikipedia.org/wiki/Diode).

A **Gunn diode** is a type of diode that is used in high-frequency electronics. It is based on the “Gunn effect” discovered in 1962 by physicist J. B. [Gunn](https://en.wikipedia.org/wiki/Gunn_diode) [1](https://en.wikipedia.org/wiki/Gunn_diode). [Its largest use is in electronic oscillators to generate microwaves, in applications such as radar speed guns, microwave relay data link transmitters, and automatic door openers](https://en.wikipedia.org/wiki/Gunn_diode) [1](https://en.wikipedia.org/wiki/Gunn_diode). Its internal construction is unlike other diodes in that it consists only of N-doped semiconductor material, whereas most diodes consist of both P and N-doped regions. [It, therefore, conducts in both directions and cannot rectify alternating current like other diodes, which is why some sources do not use the term diode but prefer TED 1](https://en.wikipedia.org/wiki/Gunn_diode).

In the Gunn diode, three regions exist: two are heavily N-doped on each terminal, with a thin layer of lightly n-doped material between them. When a voltage is applied to the device, the electrical gradient will be largest across the thin middle layer. If the voltage increases, the layer’s current will first increase. [Still, eventually, at higher field values, the conductive properties of the middle layer are altered, increasing its resistivity and causing the current to fall](https://en.wikipedia.org/wiki/Gunn_diode) [1](https://en.wikipedia.org/wiki/Gunn_diode). This means a Gunn diode has a region of negative differential resistance in its current–voltage characteristic curve, in which an increase of applied voltage causes a decrease in current. [This property allows it to amplify, functioning as a radio frequency amplifier or to become unstable and oscillate when it is biased with a DC voltage](https://en.wikipedia.org/wiki/Gunn_diode) [1](https://en.wikipedia.org/wiki/Gunn_diode).

[The negative differential resistance, combined with the timing properties of the intermediate layer, is responsible for the diode’s largest use: in electronic oscillators at microwave frequencies and above](https://en.wikipedia.org/wiki/Gunn_diode) [1](https://en.wikipedia.org/wiki/Gunn_diode). A microwave oscillator can be created simply by applying a DC voltage to bias the device into its negative resistance region. [In effect, the diode’s negative differential resistance cancels the load circuit’s positive resistance, thus creating a circuit with zero differential resistance, which will produce spontaneous oscillations](https://en.wikipedia.org/wiki/Gunn_diode) [1](https://en.wikipedia.org/wiki/Gunn_diode). The oscillation frequency is determined partly by the properties of the middle diode layer but can be tuned by external factors. In practical oscillators, an electronic resonator is usually added to control frequency in the form of a waveguide, microwave cavity, or YIG sphere. The diode is usually mounted inside the cavity. The diode cancels the resonator’s loss resistance, producing oscillations at its resonant frequency. [The frequency can be tuned mechanically by adjusting the size of the cavity or changing the magnetic field in the case of YIG spheres](https://en.wikipedia.org/wiki/Gunn_diode) [1](https://en.wikipedia.org/wiki/Gunn_diode).

Gunn diodes are used to build oscillators in the 10 GHz to THz frequency range. [Gallium arsenide Gunn diodes are made for frequencies up to 200 GHz; gallium nitride materials can reach up to 3 terahertz](https://en.wikipedia.org/wiki/Gunn_diode) [1](https://en.wikipedia.org/wiki/Gunn_diode).

A capacitor is a passive electronic component that stores electrical energy in an electric field. It consists of two conductive plates separated by a dielectric material. Capacitors are classified based on various aspects such as structure, polarization, and material used. Here are some common types of capacitors:

1. **Ceramic Capacitors**: These capacitors are made of ceramic and are non-polar devices. [They are commonly used in high-frequency applications and are available in different types such as disc, multilayer, and chip capacitors](https://byjus.com/physics/capacitor-types/) [1](https://byjus.com/physics/capacitor-types/)[2](https://www.linquip.com/blog/types-of-capacitors/).
2. **Film Capacitors**: These capacitors are made of thin plastic films and are available in different types such as polyester, polypropylene, and polycarbonate capacitors. [They have low leakage current and are commonly used in audio applications](https://byjus.com/physics/capacitor-types/) [1](https://byjus.com/physics/capacitor-types/)[2](https://www.linquip.com/blog/types-of-capacitors/).
3. **Electrolytic Capacitors**: These capacitors use an electrolyte as the dielectric material and are polarized devices. [They have high capacitance values and are commonly used in power supply circuits](https://byjus.com/physics/capacitor-types/) [1](https://byjus.com/physics/capacitor-types/)[2](https://www.linquip.com/blog/types-of-capacitors/).
4. **Tantalum Capacitors**: These capacitors use tantalum metal as the anode material and are polarized devices. [They have high capacitance values and are commonly used in portable electronic devices](https://byjus.com/physics/capacitor-types/) [1](https://byjus.com/physics/capacitor-types/)[2](https://www.linquip.com/blog/types-of-capacitors/).
5. **Aluminum Capacitors**: These capacitors use aluminum metal as the anode material and are polarized devices. [They have high capacitance values and are commonly used in power supply circuits](https://byjus.com/physics/capacitor-types/) [1](https://byjus.com/physics/capacitor-types/)[2](https://www.linquip.com/blog/types-of-capacitors/).

A resistor is a passive electronic component that restricts the flow of electrical current. Resistors are classified based on various aspects such as structure, power rating, and material used. Here are some common types of resistors:

1. **Fixed Resistors**: These resistors have a fixed resistance value and cannot be adjusted. [They are available in different types such as carbon composition, carbon film, metal film, thick and thin film, foil resistor, and wirewound](https://www.theengineerspost.com/types-of-resistor/) [1](https://www.theengineerspost.com/types-of-resistor/)[2](https://www.electrical4u.com/types-of-resistor/)[3](https://www.build-electronic-circuits.com/types-of-resistors/).
2. **Variable Resistors**: These resistors have a resistance value that can be adjusted manually or electronically. [They are available in different types such as potentiometers, rheostats, and trimmers](https://www.theengineerspost.com/types-of-resistor/) [1](https://www.theengineerspost.com/types-of-resistor/)[2](https://www.electrical4u.com/types-of-resistor/)[3](https://www.build-electronic-circuits.com/types-of-resistors/).
3. **Thermistors**: These resistors have a resistance value that varies with temperature. [They are commonly used in temperature sensing applications and are available in two types: positive temperature coefficient (PTC) and negative temperature coefficient (NTC)](https://www.theengineerspost.com/types-of-resistor/) [1](https://www.theengineerspost.com/types-of-resistor/)[2](https://www.electrical4u.com/types-of-resistor/)[3](https://www.build-electronic-circuits.com/types-of-resistors/).
4. **Light-Dependent Resistors (LDR)**: These resistors have a resistance value that varies with the intensity of light falling on them. [They are commonly used in light sensing applications](https://www.theengineerspost.com/types-of-resistor/) [1](https://www.theengineerspost.com/types-of-resistor/)[2](https://www.electrical4u.com/types-of-resistor/)[3](https://www.build-electronic-circuits.com/types-of-resistors/).

Delay lines are electronic circuits that delay a signal by a certain amount of time. They are used in many pulse circuit applications and can be classified into two main groups: electronic circuits and electromagnetic delay lines. Electronic circuits operate on the principle of being in a stable state until triggered by a pulse. Then they shift to a quasi-stable state for a period of time determined usually by the time constant or RC circuit. After this period of time, the circuit returns against to its stable state until triggered again by another pulse. If some means is provided to have a pulse generated at a time the circuit returns to its stable state, a time delay circuit results. Electromagnetic delay lines may be further classified as distributed parameter or lumped parameter delay lines. The distributed parameter line more closely approaches a transmission line, whereas the lumped parameter line resembles a filter. Delay ranging from a few nanoseconds to hundreds of microseconds are obtainable with electromagnetic lines. [For longer delays acoustic delay lines and storage devices are used](https://www.daenotes.com/electronics/digital-electronics/delay-lines-types-uses) [1](https://www.daenotes.com/electronics/digital-electronics/delay-lines-types-uses).

An oscillator is an electronic circuit that produces a continuous, repeated, alternating waveform without any input. [Oscillators convert unidirectional current flow from a DC source into an alternating waveform which is of the desired frequency, as decided by its circuit components](https://www.bing.com/aclk?ld=e8v7cvM2-JhJqWd9wgeUJRSTVUCUwZUnek448o03ekJeh4F3AmqLkili2UghL0IjG3bg74HAFyXGQJC3pcL71OEU5z_hVmqtlLdTVjfwrxKOzDctO310wTslUr9JU4ep5rWz5uKL17W_xDXrsXhpbVMFicCV2tE6B1qk66-3yy03mNka3h&u=aHR0cHMlM2ElMmYlMmZ3d3cuYW1hem9uLmluJTJmcyUyZiUzZmllJTNkVVRGOCUyNmtleXdvcmRzJTNkMTYlMmJtaHolMmJvc2NpbGxhdG9yJTI2aW5kZXglM2RhcHMlMjZ0YWclM2Rtc25kZXNrc3RkaW4tMjElMjZyZWYlM2RwZF9zbF83ZWs3a2ttYWR3X2IlMjZhZGdycGlkJTNkMTMxNTAxNzUxNzgwNTUwNiUyNmh2YWRpZCUzZDgyMTg4ODU0MDI2NzQwJTI2aHZuZXR3JTNkbyUyNmh2cW10JTNkYiUyNmh2Ym10JTNkYmIlMjZodmRldiUzZGMlMjZodmxvY2ludCUzZCUyNmh2bG9jcGh5JTNkMTQ4NjIxJTI2aHZ0YXJnaWQlM2Rrd2QtODIxODk0ODg3NzUwMjklM2Fsb2MtOTAlMjZoeWRhZGNyJTNkODA3MF8xOTI4NjY2&rlid=5e353527b29d10d8fbbc50172f6d18a6) [1](https://www.electrical4u.com/what-is-an-oscillator/). Oscillators can be classified into two main groups: electronic circuits and electromagnetic delay lines. Electronic circuits operate on the principle of being in a stable state until triggered by a pulse. Then they shift to a quasi-stable state for a period of time determined usually by the time constant or RC circuit. After this period of time, the circuit returns against to its stable state until triggered again by another pulse. If some means is provided to have a pulse generated at a time the circuit returns to its stable state, a time delay circuit results. Electromagnetic delay lines may be further classified as distributed parameter or lumped parameter delay lines. The distributed parameter line more closely approaches a transmission line, whereas the lumped parameter line resembles a filter. Delay ranging from a few nanoseconds to hundreds of microseconds are obtainable with electromagnetic lines. [For longer delays acoustic delay lines and storage devices are used](https://www.electrical4u.com/what-is-an-oscillator/) [1](https://www.electrical4u.com/what-is-an-oscillator/)

[A transmission line is a specialized cable or other structure designed to conduct electromagnetic waves in a contained manner 1](https://en.wikipedia.org/wiki/Transmission_line). It is used to transport electrical energy from one location to another, such as from a power plant to a substation or from a substation to a distribution network. Transmission lines are classified into different types based on their length and voltage level. Here are some common types of transmission lines:

1. [**Short Transmission Line**: A transmission line with a length less than 80 km (50 miles) and voltage level less than 69 kV 2](https://www.electrical4u.com/transmission-line-in-power-system/).
2. [**Medium Transmission Line**: A transmission line with a length more than 80 km (50 miles) but less than 250 km (150 miles) and operational voltage level from 69 kV to approximately 133 kV 2](https://www.electrical4u.com/transmission-line-in-power-system/).
3. [**Long Transmission Line**: A transmission line with a length more than 250 km (150 miles) and voltage level above 133 kV](https://en.wikipedia.org/wiki/Transmission_line) [2](https://www.electrical4u.com/transmission-line-in-power-system/).

[Transmission lines are also characterized by their parameters, such as resistance, inductance, capacitance, and conductance, which affect the efficiency of power transmission](https://en.wikipedia.org/wiki/Transmission_line) [2](https://www.electrical4u.com/transmission-line-in-power-system/).

A waveguide is a structure that guides waves by restricting the transmission of energy to one direction. [Common types of waveguides include acoustic waveguides which direct sound, optical waveguides which direct light, and radio-frequency waveguides which direct electromagnetic waves other than light like radio waves](https://en.wikipedia.org/wiki/Waveguide) [1](https://en.wikipedia.org/wiki/Waveguide). [Without the physical constraint of a waveguide, waves would expand into three-dimensional space and their intensities would decrease according to the inverse square law](https://en.wikipedia.org/wiki/Waveguide) [1](https://en.wikipedia.org/wiki/Waveguide). There are different types of waveguides for different types of waves. [The original and most common meaning is a hollow conductive metal pipe used to carry high frequency radio waves, particularly microwaves](https://en.wikipedia.org/wiki/Waveguide) [1](https://en.wikipedia.org/wiki/Waveguide). [Dielectric waveguides are used at higher radio frequencies, and transparent dielectric waveguides and optical fibers serve as waveguides for light](https://en.wikipedia.org/wiki/Waveguide) [1](https://en.wikipedia.org/wiki/Waveguide). [In acoustics, air ducts and horns are used as waveguides for sound in musical instruments and loudspeakers, and specially-shaped metal rods conduct ultrasonic waves in ultrasonic machining 1](https://en.wikipedia.org/wiki/Waveguide). The geometry of a waveguide reflects its function; in addition to more common types that channel the wave in one dimension, there are two-dimensional slab waveguides which confine waves to two dimensions. The frequency of the transmitted wave also dictates the size of a waveguide: each waveguide has a cutoff wavelength determined by its size and will not conduct waves of greater wavelength; an optical fiber that guides light will not transmit microwaves which have a much larger wavelength. Some naturally occurring structures can also act as waveguides. [The SOFAR channel layer in the ocean can guide the sound of whale song across enormous distances 1](https://en.wikipedia.org/wiki/Waveguide). Any shape of cross section of waveguide can support EM waves. Irregular shapes are difficult to analyze. [Commonly used waveguides are rectangular and circular in shape](https://en.wikipedia.org/wiki/Waveguide) [1](https://en.wikipedia.org/wiki/Waveguide).

I believe you meant to ask about **contactors** in electronics. [A contactor is an electromechanical control device that is used to make or break the connection between the load and power supply 1](https://www.electricaltechnology.org/2020/06/electrical-contactor.html). It is similar to a relay, but it is designed for higher current carrying applications. A contactor has several contacts as per the application and load. Generally, these contacts are normally open (NO) contact. And hence the load is shut off when the coil of the contactor is de-energized. [But the contactor can be designed for both normally open and normally close applications](https://www.electricaltechnology.org/2020/06/electrical-contactor.html) [1](https://www.electricaltechnology.org/2020/06/electrical-contactor.html). Contactors are commonly used in starters that are used to turn ON and OFF equipment like motors, transformers, etc. [There are different types of contactors such as knife blade switch, manual contactor (double break contactor), and magnetic contactor](https://www.electricaltechnology.org/2020/06/electrical-contactor.html) [1](https://www.electricaltechnology.org/2020/06/electrical-contactor.html).

A relay is an electronic switch that can turn on or off a much larger electric current. It consists of a set of input terminals for a single or multiple control signals, and a set of operating contact terminals. [The switch may have any number of contacts in multiple contact forms, such as make contacts, break contacts, or combinations thereof 1](https://en.wikipedia.org/wiki/Relay). [Relays are used where it is necessary to control a circuit by an independent low-power signal, or where several circuits must be controlled by one signal 1](https://en.wikipedia.org/wiki/Relay). [There are different types of relays such as electromechanical relay, solid-state relay, reed relay, and hybrid relay](https://en.wikipedia.org/wiki/Relay) [2](https://circuitdigest.com/article/relay-working-types-operation-applications)

A transformer is an electronic device that is used to transfer electrical energy from one circuit to another at the same frequency. It consists of two or more coils of insulated wire wound around a magnetic core. The primary coil is connected to the input voltage source, and the secondary coil is connected to the output load. [Transformers are used to increase or decrease the supply voltage without a change in the frequency of AC between circuits 1](https://byjus.com/jee/transformer/). Transformers can be classified into different types based on their structure, polarization, and material used. Here are some common types of transformers:

1. [**Step-up Transformer**: This transformer increases the output voltage and decreases the output current 1](https://byjus.com/jee/transformer/).
2. [**Step-down Transformer**: This transformer decreases the output voltage and increases the output current 1](https://byjus.com/jee/transformer/).
3. [**Isolation Transformer**: This transformer is used to isolate two circuits electrically while allowing them to communicate magnetically 1](https://byjus.com/jee/transformer/).
4. [**Autotransformer**: This transformer has a single winding that acts as both primary and secondary winding 1](https://byjus.com/jee/transformer/).

An inductor is a passive component that is used in most power electronic circuits to store energy in the form of magnetic energy when electricity is applied to it. [One of the key properties of an inductor is that it impedes or opposes any change in the amount of current flowing through it](https://www.bing.com/aclk?ld=e8Myvdpt4ilRhx6Q_C8GbaPDVUCUzHbryDyF3X-jO5Cy8OinJcisD-Uxc3ShhsHgLIEYXk20KdYi_BkKb4fzSkv349Q--f_MSPfUWK3p0HOgD5yYtMuyUfeT-TScT5LEgKJzgxkeV1JQjfjcZ7A05bNB_26RWQikfXXKmadnQawoNmLJRs&u=aHR0cHMlM2ElMmYlMmZ3d3cuYW1hem9uLmluJTJmcyUyZiUzZmllJTNkVVRGOCUyNmtleXdvcmRzJTNkMXVoJTJiaW5kdWN0b3IlMjZpbmRleCUzZGFwcyUyNnRhZyUzZG1zbmRlc2tzdGRpbi0yMSUyNnJlZiUzZHBkX3NsXzUwemphNGVvdHVfYiUyNmFkZ3JwaWQlM2QxMzE1MDE3NTE1MzI5OTg2JTI2aHZhZGlkJTNkODIxODg4NTM5OTU5ODclMjZodm5ldHclM2RvJTI2aHZxbXQlM2RiJTI2aHZibXQlM2RiYiUyNmh2ZGV2JTNkYyUyNmh2bG9jaW50JTNkJTI2aHZsb2NwaHklM2QxNDg2MjElMjZodnRhcmdpZCUzZGt3ZC04MjE4OTQ3MzI3MzQ2OSUzYWxvYy05MCUyNmh5ZGFkY3IlM2Q0ODk0XzE4OTQzMjI&rlid=c4b4300b667d1fc568d4553bc652de6e) [1](https://byjus.com/jee/inductor/). Inductors can be classified into different types based on their structure, polarization, and material used. Here are some common types of inductors:

1. [**Air-core Inductors**: These inductors have a core made of air and are used for high-frequency applications](https://www.bing.com/aclk?ld=e8Myvdpt4ilRhx6Q_C8GbaPDVUCUzHbryDyF3X-jO5Cy8OinJcisD-Uxc3ShhsHgLIEYXk20KdYi_BkKb4fzSkv349Q--f_MSPfUWK3p0HOgD5yYtMuyUfeT-TScT5LEgKJzgxkeV1JQjfjcZ7A05bNB_26RWQikfXXKmadnQawoNmLJRs&u=aHR0cHMlM2ElMmYlMmZ3d3cuYW1hem9uLmluJTJmcyUyZiUzZmllJTNkVVRGOCUyNmtleXdvcmRzJTNkMXVoJTJiaW5kdWN0b3IlMjZpbmRleCUzZGFwcyUyNnRhZyUzZG1zbmRlc2tzdGRpbi0yMSUyNnJlZiUzZHBkX3NsXzUwemphNGVvdHVfYiUyNmFkZ3JwaWQlM2QxMzE1MDE3NTE1MzI5OTg2JTI2aHZhZGlkJTNkODIxODg4NTM5OTU5ODclMjZodm5ldHclM2RvJTI2aHZxbXQlM2RiJTI2aHZibXQlM2RiYiUyNmh2ZGV2JTNkYyUyNmh2bG9jaW50JTNkJTI2aHZsb2NwaHklM2QxNDg2MjElMjZodnRhcmdpZCUzZGt3ZC04MjE4OTQ3MzI3MzQ2OSUzYWxvYy05MCUyNmh5ZGFkY3IlM2Q0ODk0XzE4OTQzMjI&rlid=c4b4300b667d1fc568d4553bc652de6e) [1](https://byjus.com/jee/inductor/).
2. [**Ferrite-core Inductors**: These inductors have a core made of ferrite and are used for high-frequency applications](https://www.bing.com/aclk?ld=e8Myvdpt4ilRhx6Q_C8GbaPDVUCUzHbryDyF3X-jO5Cy8OinJcisD-Uxc3ShhsHgLIEYXk20KdYi_BkKb4fzSkv349Q--f_MSPfUWK3p0HOgD5yYtMuyUfeT-TScT5LEgKJzgxkeV1JQjfjcZ7A05bNB_26RWQikfXXKmadnQawoNmLJRs&u=aHR0cHMlM2ElMmYlMmZ3d3cuYW1hem9uLmluJTJmcyUyZiUzZmllJTNkVVRGOCUyNmtleXdvcmRzJTNkMXVoJTJiaW5kdWN0b3IlMjZpbmRleCUzZGFwcyUyNnRhZyUzZG1zbmRlc2tzdGRpbi0yMSUyNnJlZiUzZHBkX3NsXzUwemphNGVvdHVfYiUyNmFkZ3JwaWQlM2QxMzE1MDE3NTE1MzI5OTg2JTI2aHZhZGlkJTNkODIxODg4NTM5OTU5ODclMjZodm5ldHclM2RvJTI2aHZxbXQlM2RiJTI2aHZibXQlM2RiYiUyNmh2ZGV2JTNkYyUyNmh2bG9jaW50JTNkJTI2aHZsb2NwaHklM2QxNDg2MjElMjZodnRhcmdpZCUzZGt3ZC04MjE4OTQ3MzI3MzQ2OSUzYWxvYy05MCUyNmh5ZGFkY3IlM2Q0ODk0XzE4OTQzMjI&rlid=c4b4300b667d1fc568d4553bc652de6e) [1](https://byjus.com/jee/inductor/).
3. [**Iron-core Inductors**: These inductors have a core made of iron and are used for low-frequency applications](https://www.bing.com/aclk?ld=e8Myvdpt4ilRhx6Q_C8GbaPDVUCUzHbryDyF3X-jO5Cy8OinJcisD-Uxc3ShhsHgLIEYXk20KdYi_BkKb4fzSkv349Q--f_MSPfUWK3p0HOgD5yYtMuyUfeT-TScT5LEgKJzgxkeV1JQjfjcZ7A05bNB_26RWQikfXXKmadnQawoNmLJRs&u=aHR0cHMlM2ElMmYlMmZ3d3cuYW1hem9uLmluJTJmcyUyZiUzZmllJTNkVVRGOCUyNmtleXdvcmRzJTNkMXVoJTJiaW5kdWN0b3IlMjZpbmRleCUzZGFwcyUyNnRhZyUzZG1zbmRlc2tzdGRpbi0yMSUyNnJlZiUzZHBkX3NsXzUwemphNGVvdHVfYiUyNmFkZ3JwaWQlM2QxMzE1MDE3NTE1MzI5OTg2JTI2aHZhZGlkJTNkODIxODg4NTM5OTU5ODclMjZodm5ldHclM2RvJTI2aHZxbXQlM2RiJTI2aHZibXQlM2RiYiUyNmh2ZGV2JTNkYyUyNmh2bG9jaW50JTNkJTI2aHZsb2NwaHklM2QxNDg2MjElMjZodnRhcmdpZCUzZGt3ZC04MjE4OTQ3MzI3MzQ2OSUzYWxvYy05MCUyNmh5ZGFkY3IlM2Q0ODk0XzE4OTQzMjI&rlid=c4b4300b667d1fc568d4553bc652de6e) [1](https://byjus.com/jee/inductor/).
4. [**Toroidal Inductors**: These inductors have a core shaped like a doughnut and are used for high-frequency applications](https://www.bing.com/aclk?ld=e8Myvdpt4ilRhx6Q_C8GbaPDVUCUzHbryDyF3X-jO5Cy8OinJcisD-Uxc3ShhsHgLIEYXk20KdYi_BkKb4fzSkv349Q--f_MSPfUWK3p0HOgD5yYtMuyUfeT-TScT5LEgKJzgxkeV1JQjfjcZ7A05bNB_26RWQikfXXKmadnQawoNmLJRs&u=aHR0cHMlM2ElMmYlMmZ3d3cuYW1hem9uLmluJTJmcyUyZiUzZmllJTNkVVRGOCUyNmtleXdvcmRzJTNkMXVoJTJiaW5kdWN0b3IlMjZpbmRleCUzZGFwcyUyNnRhZyUzZG1zbmRlc2tzdGRpbi0yMSUyNnJlZiUzZHBkX3NsXzUwemphNGVvdHVfYiUyNmFkZ3JwaWQlM2QxMzE1MDE3NTE1MzI5OTg2JTI2aHZhZGlkJTNkODIxODg4NTM5OTU5ODclMjZodm5ldHclM2RvJTI2aHZxbXQlM2RiJTI2aHZibXQlM2RiYiUyNmh2ZGV2JTNkYyUyNmh2bG9jaW50JTNkJTI2aHZsb2NwaHklM2QxNDg2MjElMjZodnRhcmdpZCUzZGt3ZC04MjE4OTQ3MzI3MzQ2OSUzYWxvYy05MCUyNmh5ZGFkY3IlM2Q0ODk0XzE4OTQzMjI&rlid=c4b4300b667d1fc568d4553bc652de6e) [1](https://byjus.com/jee/inductor/).

A table of electrical diagrams

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