202: Principles of electrical science  
**Handout 17: Electronics components**

**Learning outcome**

The learner will:

1. Understand the types, applications and limitations of electronic components in electrical systems and equipment.

**Assessment criteria**

The learner can:

6.2 state the basic operating principles of **electronic components and devices**.

**Range**

**Electronic components and devices**: Capacitors, Resistors, Rectifiers, Diodes, Zener, LED, photo, Thermistors, Diacs, Triacs, Transistors, Thyristors, Invertors.

## Electronic components

### Capacitors

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| A capacitor is a passive two-terminal electrical component used to store energy in an electric field. The forms of practical capacitors vary widely, but all contain at least two electrical conductors separated by a dielectric (insulator); for example, one common construction consists of metal foils separated by a thin layer of insulating film. Capacitors are widely used as parts of electrical circuits in many common electrical devices.  When there is a potential difference (voltage) across the conductors, a static electric field develops across the dielectric, causing positive charge to collect on one plate and negative charge on the other plate. Energy is stored in the electrostatic field. |  |
| Capacitors are widely used in electronic circuits for blocking direct current while allowing alternating current to pass, in filter networks, for smoothing the output of power supplies, in the resonant circuits that tune radios to particular frequencies and in electric power systems for power factor correction. |  |

Various types of capacitors are available usually referred to by their dielectric material. The following lists some of these:

* paper
* plastic
* glass
* mica
* ceramic
* aluminium (electrolytic)
* tantalum (electrolytic).

Apart from their capacitance in farads, capacitors are also graded according to their operating voltage which should not be exceeded in use otherwise the dielectric will breakdown causing permanent damage.

### Resistors

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| A resistor is a passive two-terminal electronic component that implements electrical resistance as a circuit element.  Practical resistors can be made of various compounds and films, as well as resistance wire (wire made of a high-resistivity alloy, such as nickel-chrome). Resistors are also implemented within integrated circuits, particularly analogue devices, and can also be integrated into hybrid and printed circuits. |  |

Various types of resistors are available usually referred to by their composition. The following lists some of these:

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| * Carbon composition * Carbon pile * Carbon film * Thick film | * Wirewound resistors * Variable resistors * Potentiometers |

Apart from their resistance in ohms, resistors are also graded according to their power rating in watts and their tolerance expressed as a percentage.

To identify smaller resistors coloured bands are used; the following is the resistor colour code chart.

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### Diodes

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| In electronics, a diode is a two-terminal electronic component with an asymmetric transfer characteristic, with low (ideally zero) resistance to current flow in one direction and high (ideally infinite) resistance in the other. A semiconductor diode, the most common type today, is a crystalline piece of semiconductor material with a p–n junction connected to two electrical terminals.  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 current in the opposite direction (the reverse direction). This unidirectional behaviour is called **rectification**, and is used to convert alternating current to direct current, including extraction of modulation from radio signals in radio receivers. |  |

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| In the diagram right, when the positive is applied to the left‑hand end, current will flow (see the direction of the arrow). If the positive is applied to the right‑hand end, current will not flow (current hits the solid bar).  A light-emitting diode (LED) is a semiconductor light source. LEDs are used as indicator lamps in many devices and are increasingly used for other lighting including area lighting.  Appearing as practical electronic components in 1962, early LEDs emitted low-intensity red light, but modern versions are available across the visible, ultraviolet, and infrared wavelengths, with very high brightness. |  |
| A photodiode is a semiconductor device that consumes light energy to generate electric current. It is also sometimes referred as photo-detector, photo-sensor, or light detector. Photodiode is very sensitive to light so when light or photons falls on the photodiode it easily converts light into electric current. |  |
| Zener diodes are a special type of semiconductor diode. Unlike standard diodes that only allow current to flow in one direction, a Zener diode will allow current to flow in the opposite direction, but only when exposed to enough voltage. It has many applications including simple reference voltages, clamping signals to specific voltage ranges, and easing the load on a voltage regulator. |  |

### Rectifiers

A rectifier is an electrical device that converts alternating current (a.c.), which periodically reverses direction, to direct current (d.c.), which flows in only one direction. The process is known as rectification.

Most rectifiers contain one or more diodes to produce unidirectional current flow that by definition is direct current. However, the d.c. produced will not be ‘smooth’ as derived from a battery but will be ‘pulsating’ as shown in the following diagrams.

In **half wave rectification** of a single-phase supply, either the positive or negative half of the a.c. wave is passed, while the other half is blocked. Because only one half of the input waveform reaches the output, mean voltage is lower. Half-wave rectification requires a single diode in a single-phase supply, or three in a three-phase supply.

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A **full-wave rectifier** converts the whole of the input waveform to one of constant polarity (positive or negative) at its output. Full-wave rectification converts both polarities of the input waveform to pulsating d.c. and yields a higher average output voltage. Four diodes in a bridge configuration and any a.c. source are needed.

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**Thermistors**

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| A thermistor is a type of resistor whose resistance varies significantly with temperature, more so than in standard resistors. The word is a combination of thermal and resistor. Thermistors are widely used as inrush current limiters, temperature sensors, self-resetting overcurrent protectors, and self-regulating heating elements.  The material used in a thermistor is generally a ceramic or polymer. Thermistors typically achieve a higher precision within a limited temperature range, typically −90°C to 130°C. |  |
| There are two types of thermistor available:   * positive temperature coefficient (ptc) * negative temperature coefficient (ntc).   With PTC devices the resistance increases as the temperature increases whereas with NTC devices the resistance decreases as the temperature increases. |  |

### Diac

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| The diac, or "diode for alternating current", is a diode that conducts current only after its break‑over voltage, VBO, has been reached momentarily.  When this occurs, the diode enters the region of negative dynamic resistance, leading to a decrease in the voltage drop across the diode and, usually, a sharp increase in current through the diode. |  |

The diode remains ‘in conduction’ until the current through it drops below a value characteristic for the device, called the holding current, IH. Below this value, the diode switches back to its high-resistance (non-conducting) state. This behaviour is bidirectional, meaning typically the same for both directions of current. Most diacs have a break‑over voltage around 30V.

Diacs have no gate electrode, unlike some other thyristors that they are commonly used to trigger, such as TRIACs.

Diacs are commonly found in dimmer switches where they are used to ‘fire’ the triac, which is the device that actually controls the light output of the light source

### TRIAC

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| TRIAC, from TRIode for Alternating Current, is an electronic component that can conduct current in either direction when it is triggered (turned on).  TRIACs belong to the thyristor family and are closely related to Silicon-controlled rectifiers (SCR). However, unlike SCRs, which are unidirectional devices (ie can conduct current only in one direction), TRIACs are bidirectional and so current can flow through them in either direction. Another difference from SCRs is that TRIACs can be triggered by either a positive or a negative current applied to its gate electrode, whereas SCRs can be triggered only by currents going into the gate.  Once triggered, the device continues to conduct until the current drops below a certain threshold, called the holding current.  The bidirectionality makes TRIACs very convenient switches for a.c. circuits, also allowing them to control very large power flows with |  |

milliampere-scale gate currents. In addition, applying a trigger pulse at a controlled phase angle in an a.c. cycle allows one to control the percentage of current that flows through the TRIAC to the load, which is commonly used, for example, in controlling the speed of low-power induction motors, in dimming lamps and in controlling a.c. heating resistors.

### Transistors

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| A transistor is a semiconductor device used to amplify and switch electronic signals and electrical power. It is composed of semiconductor material with at least three terminals for connection to an external circuit. A voltage or current applied to one pair of the transistor's terminals changes the current through another pair of terminals.  Because the controlled (output) power can be higher than the controlling (input) power, a transistor can amplify a signal. Today, some transistors are packaged individually, but many more are found embedded in integrated circuits. |  |
| *Transistor as a switch:* Transistors are commonly used as electronic switches, both for high-power applications such as switched-mode power supplies and for low-power applications such as logic gates.  *Transistor as an amplifier:* The common-emitter amplifier is designed so that a small change in voltage (Vin) changes the small current through the base of the transistor; the transistor's current amplification combined with the properties of the circuit mean that small swings in Vin produce large changes in Vout. |  |

### Thyristor

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| A thyristor is a solid-state semiconductor device which conducts when their gate receives a current trigger and continue to conduct while they are forward biased (that is, while the voltage across the device is not reversed).  Some sources define silicon controlled rectifiers and thyristors as the same. Other sources define thyristors as a larger set of devices. | |  |
| Because thyristors can control a relatively large amount of power and voltage with a small device, they find wide application in control of electric power, ranging from light dimmers and electric motor speed control to high-voltage direct current power transmission.  Originally thyristors relied only on current reversal to turn them off, making them difficult to apply for direct current; newer device types can be turned on and off through the control gate signal.  A thyristor is not a proportional control like a transistor but is only ever fully on or fully off.  Thyristors have three states: |  | | |

* Reverse blocking mode ­– voltage is applied in the direction that would be blocked by a standard diode.
* Forward blocking mode – voltage is applied in the direction that would cause a standard diode to conduct, but the thyristor has not yet been triggered into conduction.
* Forward conducting mode – the thyristor has been triggered into conduction and will remain conducting until the forward current drops below a threshold value known as the *‘holding current’*.

### Invertors

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| A power inverter, or inverter, is an electrical power converter that changes direct current (d.c.) to alternating current (a.c.); the converted a.c. can be at any required voltage and frequency with the use of appropriate transformers, switching, and control circuits.  Solid-state inverters have no moving parts and are used in a wide range of applications, and from small switching power supplies in computers, to large electric utility high-voltage direct current applications that transport bulk power. Inverters are commonly used to supply a.c. power from d.c. microgeneration sources such as solar panels or batteries. |  |

The inverter performs the opposite function of a rectifier. The electrical inverter is a high-power electronic oscillator. It is so named because early mechanical a.c. to d.c. converters were made to work in reverse, and thus were ‘inverted’, to convert d.c. to a.c.