

Introduction to digital electronics II

Electronic components and their uses.

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Introduction

In this topic we are going to discuss the following:

- Definition of an electronic device and electronic components.
- Electric circuit symbols for electronic components.
- Describe uses of electronics components.
- Rectification

Electronic Devices & Components

- An electronic device can be defined as a device that utilizes electrical circuits and components to perform its functions.
- Examples of electronic devices include:
 - Computers, smart phones
 - Televisions, decoders
 - Radios, printers
 - Digital Cameras
- Electronic components are basic elements used in electronic circuits to control the flow of electricity and perform functions like amplification.

• Examples of electronic components include:

- Resistors
- Capacitors
- Inductors
- Diodes
- Transistor
- Light Emitting Diodes
- Photodiodes

Circuit symbols for electronic components

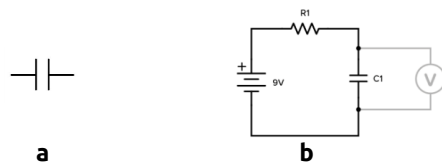
Capacitors

- This is an electric component that **stores** and **releases** electrical energy.
- It is made up of **two parallel conductive plates** separated by an insulating material called a **dielectric**.
- When voltage is applied across the plates, an **electric field** forms in the dielectric, storing energy.
- We have **different types** of capacitors depending on the dielectric used.

• Types of capacitors include:

- Metal foil capacitors
- Electrolytic capacitors
- Ceramic capacitor
- Film capacitors
- Mica capacitors

• Below is a **circuit symbol** for a capacitor:



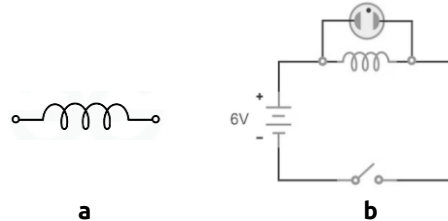
a: capacitor symbol, **b:** capacitor in a circuit

Circuit symbols for electronic components

Inductors

- This is an electric component that **stores** energy in a magnetic field when electrical current flows through it.
- It is made up of a **coil of a wire** or a **wire loop**.
- Its ability to store energy is measured by its **inductance** and its expressed in **henrys (H)**
- Inductance is the behavior of a coil to **resist** changes in electric current.

Below is a **circuit symbol** for an inductor:



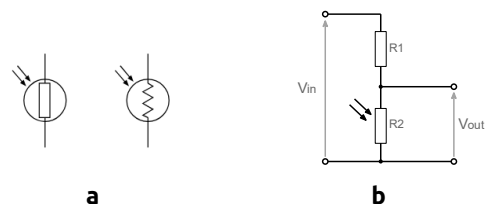
a: Inductor symbol, b: Inductor in a circuit

Circuit symbols for electronic components

Light Dependent Resistor - LDR

- This is a type of resistor whose **resistance varies** significantly with the **intensity of light** falling on it.
- It is also called **photoresistor** or **photoconductor**.
- The resistance of an LDR **decreases** as the light intensity increases.
- Mostly used in various light sensing applications

Below is a **circuit symbol** for a LDR:



a: LDR symbols, b: LDR in a circuit

Circuit symbols for electronic components

Diode

- This is a two terminal electronic component that allows electric current to flow in **one** direction only.
- It acts as a one way valve for electrical current.
- When current is applied in correct direction (**Forward bias**), the diode **conducts** electric current.
- In **reverse bias**, the diode **blocks** electric current.

• We have different types of diodes, such as:

- **Zener Diode** – allow current to follow in Reverse bias
- Light Emitting Diode
- Photodiode
- **Standard Rectifier Diode** – used in power rectification.
- Schottky Diode

• Below is a **circuit symbol** for a diode:



Circuit symbols for electronic components

Light Emitting Diode (LED)

- This is a type of a diode, (semiconductor) that **emits light** when an electric current passes through it.
- In this diode, electrons **recombine** with holes within the semiconductor material, releasing energy in the form of **photons** (light).
- LED are used in **indicator lights, displays, lighting** and backlighting.
- Below is a **circuit symbol** of a LED.

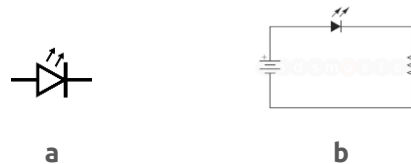
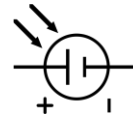


Figure **a** shows an LED circuit symbol, while **b** shows an LED in a simple circuit.

Circuit symbols for electronic components

Photovoltaic cells

- This is an electrical component that **converts light** energy directly **into electrical** energy through the photovoltaic effect.
- It is also known as a **solar cell**.
- Photovoltaic effect is a process by which light energy is converted into electrical energy by a solar cell.
- On the right is a **circuit symbol** for a photovoltaic cell.



Uses of photovoltaic cells

- Photovoltaic cells are used in the manufacturing of solar panels.
- Power solar powered cars, satellites, and boats.
- Manufacturing of portable solar chargers.

Circuit symbols for electronic components

Logic gates

- These are **building blocks** of **digital circuits** that perform basic **logical functions** on one or more binary inputs to produce a single binary output.
- They are used to implement **Boolean algebra** in electronic devices such as computers.
- We have different types of logic gates such as **OR**, **AND**, **NOT**, **NOR**, and **NAND**.
- On the right is a circuit symbol for an **AND** gate and an **Or** gate.



AND gate

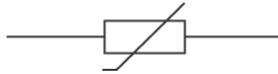


OR gate

Circuit symbols for electronic components

Thermistor

- This is a type of resistor whose resistance varies significantly with temperature.
- The name thermistor is derived from 'thermal' and 'resistor'.
- This electronic component is widely used as temperature sensor.
- Below is a circuit symbols for a thermistor



Uses of a thermistor

Use to make resistance thermometers which are used to measure very small temperatures.

Used to monitor temperatures in incubators.

Used in overcurrent protection by limiting current flow.

Used in battery packs to monitor temperature to avoid overheating.

Used in thermostats and climate control systems to measure and regulate temperature.

Circuit symbols for electronic components

Transistor

- This is a **three terminal** semiconductor electrical component **formed by merging three pieces of doped** pure semiconductors.

OR

- It is a semiconductor device that is used to amplify or switch electronic signals and electrical power.

- The **three terminals** of a transistor are:
 - The **base** (b)
 - The **collector** (c)
 - The **emitter** (e)

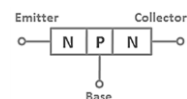
Types of transistors

- The P-type and N-type semiconductor material forms **two types** of transistors based on arrangement of the materials.

- The **two types** are:

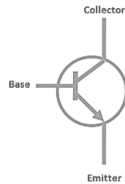
NPN transistor: Has **two** N-type materials separated by a thin layer of the P-type material.

Below is a **block** diagram of an NPN transistor.



Circuit symbols for electronic components

- Below is a **circuit symbol** of an **NPN** transistor:

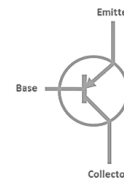


- The **arrow** in the circuit symbol indicates the direction of **conventional current** flow when the transistor is in operation.
- Conventional current is the flow of **positive charge** from the positive terminal to the negative terminal of the cell.

PNP transistor: Has **two** P-type materials separated by a thin layer of the N-type material.

- Below is a **block diagram** of an NPN transistor.

- Below is a **circuit symbol** for a **PNP** transistor.

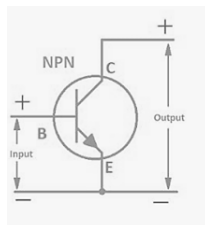


Circuit symbols for electronic components

- Note:** NPN transistors are commonly used that the PNP transistors because current moves faster in NPN transistors than in PNP transistors.

Operation of a transistor – NPN

- Consider the circuit below:



- When **no voltage** is applied to the base, **no current flows** from the **collector** to the **emitter** because the **P-N junction** between the **base** and the **emitter** is **not forward biased**.

- When **small positive voltage** is applied to the **base**, it allows a **small current** to flow **from** the base to the **emitter**. This **small current** opens the **gate** and allows a much larger current to flow **from** the **collector** to the **emitter**.

- Thus:** a small current entering the base controls a much larger current to flow from the collector to the emitter. (Amplification)

Uses of electronic components

Capacitor

- To maintain power to memory devices like calculators.
- Used in rectification process
- Used to reduce noise in sound systems.
- Used in UPS (uninterrupted power supply) systems to store and supply power to computers.
-

Inductors

- Used in making traffic light sensors that use coil.
- Used in red light cameras that are used to curb traffic violations – to reduce road accidents.
- Used in transformers to transfer energy between circuits.
- Used with capacitors to create filters for frequencies.

Uses of electronic components

Light Dependent Resistor

- Used in automatic lighting systems where lights are turned on and off based on ambient light levels.
- Used in security systems to detect changes in light levels when a beam of light is interrupted.
- Used in cameras to measure the amount of light.
- Used in street lamps to turn them on and off.
- used in display systems to adjust screen brightness.

Light Emitting Diode

- Used in indicator lights.
- Used in LED screens for TV, computer monitors and mobile devices.
- Used for lighting in homes and offices.
- Used for backlighting in LCD displays.

Uses of electronic components

Transistors

- Used in amplification of signals.
- Used for switching in digital circuits.
- Used in signal modulation.
- Used in voltage regulation and stabilization.
- Used in current control.

Logic Gates

- Used in digital computing especially in processors, memory devices and digital signal processing.
- Used to control logic for various automated systems.
- Used in encoding, decoding and data transmission processes.

Uses of electronic components

Diode

- Used in protecting electrical devices in circuits.
- Used in regulating the voltage applied to devices hence protecting the **d.c** devices – Zener diode.
- Used in **rectification process**: A process in which an AC signal is converted into a DC.

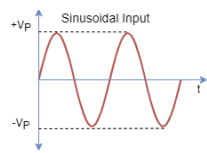
Rectification

- This is a process of converting an Alternating Current (AC) into Direct Current (DC).
- We have **two** types of rectification
 - Half-wave Rectification
 - Full-wave Rectification

Half-wave Rectification

• This is the process of converting an AC input signal into a DC output signal by using a single diode.

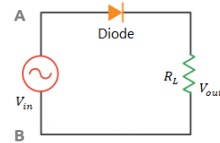
• An AC input signal is in form of a sinusoidal wave that alternates between the positive and the negative as shown below:



• The circuit symbol for an AC input signal is



• A simple halfwave rectifier circuit is:



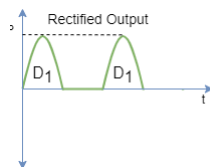
• During the positive half cycle of the AC input signal (A is positive and B negative), the diode is in forward bias, as such it allows current to flow.

• During the negative half cycle of the AC input signal (A negative and B positive), the diode is in reverse bias, as such it blocks current.

Half-wave Rectification

• The output of a halfwave rectifier is a pulsating DC signal, This is so because during the negative half cycles, there is zero output signal.

• The output wave of a halfwave rectifier is shown below:



Application of a halfwave rectification

• Used in electrical devices that do not require stable/ smooth DC output – very cost effective in electronic device construction.

• Used in signal demodulation in AM radio modulators.

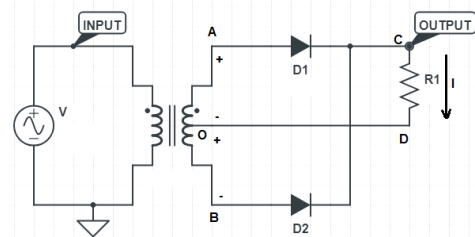
• Can also be used in indicator light circuits to make the flashing light signal.

Full-wave Rectification

- This is the process of converting the complete cycle of an AC into a smooth DC output signal.
- Full wave rectification makes use of both halves of the AC input signal resulting in a more stable and smooth DC output signal.
- Full wave rectification can be grouped into two, namely:
 - Centre Tapped rectifier
 - Bridge rectifier

Centre Tapped Rectifier

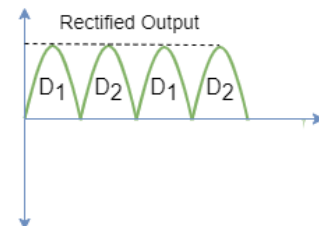
- This rectifier uses **two** diodes to convert an AC input signal into a smooth DC output signal.
- A simple center tapped rectifier circuit is shown below:



Full-wave Rectification

- In a center tapped, during the **positive** half cycle (A positive), **diode D1** will be in **forward bias** as such it allows current to pass through to the load R1. (in this cycle, **D2 is in reverse bias**).
- During the **negative** half cycle (B positive), **diode D2** will be in forward bias as such allowing current to pass through to the load R1. (in this cycle, **D1 is in reverse bias**).
- In this rectifier circuit the load R1 will continue to receive a DC current signal even though the AC is alternating.

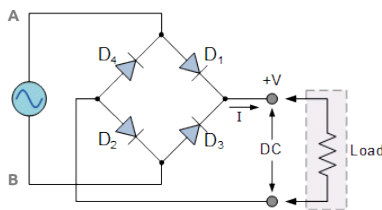
- The DC output signal for a full rectifier is in the form as shown below:



Full-wave Rectification

Bridge Rectifier

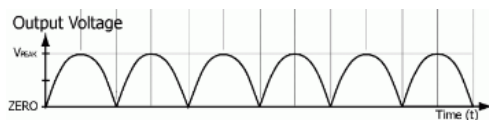
- This rectifier uses **four** diodes to convert an AC input signal into a smooth DC output signal.
- A simple bridge rectifier circuit is shown below:



- During the **positive half cycle (A positive)**, diodes **D1 and D2** will be in **forward bias** allowing current to pass through the load. (Diodes **D3 and D4** will be in **reverse bias** as such blocking current).
- During the **negative half cycle (B positive)**, diodes **D3 and D4** are in forward bias as such allows current to flow through the load, while **D1 and D2** will be in **reverse bias** hence blocking the flow of current.
- The output of this rectifier is a smooth DC signal as shown on the next slide.

Full-wave Rectification

- The output DC wave form for a bridge rectifier:



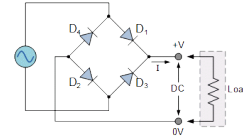
Application of Full wave rectification

- Used in electronic devices such as radios, TV and computers as DC power supplies to supply a stable DC output.
- Used in power adapters and chargers for stable DC output voltage supply.
- Used to minimize noise and distortion in audio signals.
- Full wave rectifiers are used in electroplating processes to supply a stable DC voltage to ensure uniform deposition of metal onto surfaces.

Quiz

1. State any **three** examples of electronic components.
2. What is a depletion layer?
3. Describe how a capacitor is constructed.
4. Using a well labelled diagram, describe how a light dependent resistor can be used in a circuit.
5. Describe how a diode functions in a half wave rectification.
6. Mention any **two** used of a thermistor.

6. **Figure 1** is a full wave rectifier circuit.



Explain its operation.

7. Describe how a P-type semiconductor material is formed.
8. Using a well labelled diagram, explain the operation of an NPN transistor.