GPCET
Pioneering Innovative Education

G. PULLAIAH COLLEGE OF ENGINEERING AND TECHNOLOGY

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Department of Electronics and Communication Engineering

Bridge Course
On
Basic Electrical and Electronics Engineering

(15A99301)

1. ELECTRONIC DEVICES

1.1 Define Electronics & its application.

The world's reliance on electronics is so great that commentators claim people live in an "electronic age." People are surrounded by electronics—televisions, radios, computers, mobiles, Laptop and DVD players, along with products with major electric components, such as microwave ovens, refrigerators, and other kitchen appliances, automatic vehicles, Robotics, as well as hearing aids and medical instruments and numerous applications in industry.

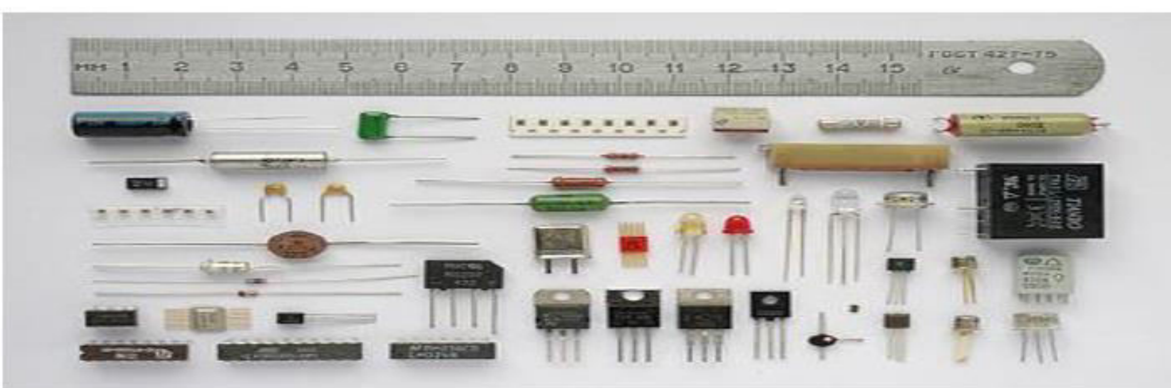
Definition*: The branch of engineering which deals with current conduction through a Vacuum or Gas or Semiconductor is known as* **Electronics.** An *electronic device* is that in which current flows through a vacuum or gas or semiconductor. This control of electrons is accomplished by devices that resist, carry, select, steer, switch, store, manipulate, and exploit the electron. Or Electronics deals with electrical circuits that involve active electrical components such as vacuum tubes, transistors, diodes and integrated circuits**,** and associated passive interconnection technologies. Commonly, electronic devices contain circuitry consisting primarily or exclusively of active semiconductors supplemented with passive elements; such a circuit is described as an electronic circuit**.**

Pre Knowledge (Some of the basic definitions): Passive Components: Capable of operating without an external power source. Typical passive components are resistors, capacitors, inductors.

Active components: Requiring a source of power to operate. Includes transistors (all types), integrated circuits (all types), TRIACs, SCRs, LEDs, etc.

APPLICATIONS of Electronics:

E*lectronic components*: capacitor (C), cathode ray tube (CTR), diode (D), digital signal processor (DSP, field effect transistor (FET), integrated circuit (IC), junction gate field effect transistor (JFET), inductor (L), Liquid crystal display (LCD), light dependent resistor (LDR, light emitting diode (LED), Metal oxide semiconductor field effect transistor (MOSFET), transistor (Q), ***resistor*** (R), relay (RLA, RY), switch (SW), transformer (T), thermistor (TH), transistor (Tr), integrated circuit (U, IC), variable capacitor (VC), variable resistor (VR) and more.



Consumer Electronics include products like – Audio Systems, Video Systems, TV (Television), Computer, Laptop, Digital Camera, DVD Players, Home and Kitchen Appliances, GPS, Mobiles Phones etc.

Communication. Electronic communication systems connect people around the world. Using telephones, Internet and computers, people in different countries communicate almost instantly. Radios transmit sounds and televisions transmit sounds and pictures great distances. Cellular telephones enable a person to call another person. Within seconds, fax machines send and receive copies of documents over telephone lines/Satellite.

Information processing. Scientists, artists, students, government and business workers, and hobbyists at home all rely on computers, Internet to handle huge amounts of information quickly and accurately. Computers solve difficult mathematical problems, maintain vast amounts of data, create complex simulations, and perform a multitude of other tasks that help people in their everyday lives.

Medicine and research. Include product like X-ray machines ECG (Electrocardiogram) use radiation to take images of bones and internal organs. Radiation therapy, or radiotherapy, uses X-rays and other forms of radiation to fight cancer. Many hearing-impaired people depend on hearing aids to electrically amplify sound waves.

Computers and other electronic instruments provide scientists and other researchers with powerful tools to better understand their area of study. Computers, for example, help scientists design new drug molecules, track weather systems, and test theories about how galaxies and stars develop. Electron microscopes use electrons rather than visible light to magnify specimens 1 million times or more.

Automation. Electronic components enable many common home appliances, such as refrigerators, washing machines, and toasters, to function smoothly and efficiently. People can electronically program coffeemakers, lawn sprinklers, and many other products to turn on and off automatically. Microwave ovens heat food quickly by penetrating it with short radio waves produced by a vacuum tube.

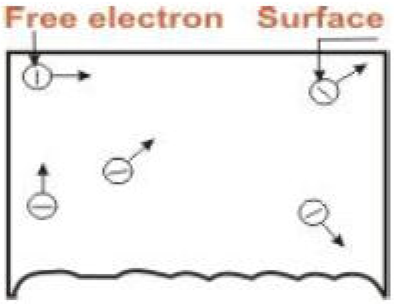
Instrumentation. Measuring Instruments like CRO, Multimeter, ph-meter, strain gauge, VTVM, Frequency Counter are used in different Laboratory/organisations.

Many automobiles have electronic controls in their engines and fuel systems. Electronic devices also control air bags, which inflate to protect a driver and passengers in a collision.

1.2 Define Electronic Emission & different types of Emission.

The Electronics devices depends the movements of free Electrons in an evacuated space. *The liberation of electrons from the surface of a metal is known as* ***Electron Emission.***

- For electron emission, metals are used because they have many free electrons.
- The electrons are free only to transfer from one atom to another within the metal but they cannot leave the metal surface to provide electron emission.
- Thus at the surface of the metal, a free electron encounters forces that prevent it to leave the metal.
- In other words, the metallic surface offer a barrier to free electrons, their kinetic energy increases and is known as surface barrier.
- However, if sufficient energy is given to the free electrons, their kinetic energy increases and thus the electrons will cross over the surface barrier to leave the metal.
- This additional energy required by an electron to overcome the surface barrier of the metal is called *work function* of the metal.



The metallic surface offers a barrier to free electrons and is known as *surface barrier*.

Work function (W0): *The amount of additional energy*(such as heat energy, energy stored in electric field, light energy or kinetic energy of the electric charges bombarding the metal surface) *required to emit an electron from a metallic surface is known as* **work function** *of that metal*. The minimum energy required by an electron to just escape (i.e. with zero velocity) from metal's surface is called **Work function (W0)** of the metal. The work function of pure metals varies (roughly) from 2eV to 6eV. Its value depends upon the nature of the metal, its purity and the conditions of the surface.

Different types of Emission:

There are following four principal method of obtaining electron emission from the surface of a metal:

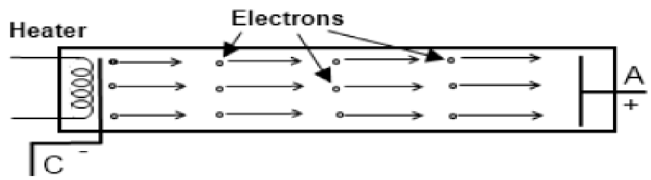
1. Thermionic Emission - (Due to Thermal energy)
2. Field Emission - (*Due to application of strong electric field)*
3. Secondary Emission – (***due to bombardment of high-speed electrons)***
4. Photo Electric Emission – (*by the application of light)*

1. Thermionic Emission

The process of electron emission from a metal surface by supplying thermal energy to it is known as **Thermionic emission**.

In this type of emission the electron emission is achieved by heating the electrode to a sufficient temperature (about 2500oC) to enable the free electrons to leave the metal surface. Due to heating the electrons get enough energy that they emit from the surface of that material heat energy is converted into kinetic energy, causing accelerated motion of free electrons and electrons acquire additional energy equal to the work function of the metal. An electron emitted from a hot cathode comes out with a velocity that presents different between the kinetic energy possessed by electron just before emission usually used in cathode of diode, triode, pentode, CRT and many other. The higher the temperature, the greater is the emission of electrons. The commonly used materials for electron emission are *tungsten, thoriated tungsten* and *metallic oxides of barium and strontium*.

S.No.	Emitter	Work Function	Operating Temperature
1	*Tungsten*	4.52 eV	2327°C
2	*Thoriated tungsten*	2.63 eV	1700°C
3	*Oxide-coated*	1.1 eV	750°C



2. Field Emission

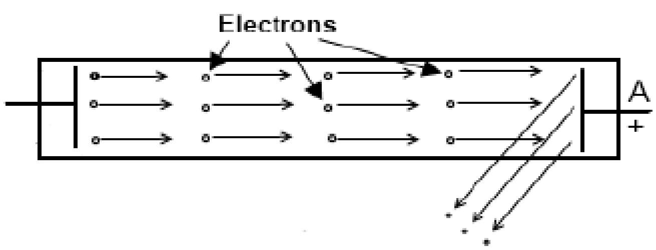
The process of electron emission by the application of strong electric field at the surface of a metal is known as **field emission.**

When metal surface is placed in an electric field, the electron rotating in their orbits experience a force due to electrostatic field. Hence the process of electron emission by application of strong electric field at the surface of a metal is called field emission. It is also called *cold cathode emission* or *auto- electronic emission*.

3. Secondary Emission

Electron emission from a metallic surface by the bombardment of high-speed electrons or other particles is known as secondary emission.

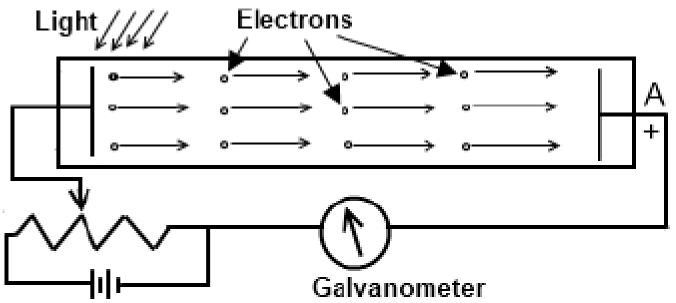
When high-speed electrons suddenly strike a metallic surface, they may give some or all of their kinetic energy to the free electrons in the metal. If the energy of the striking electrons is sufficient, it may cause free electrons to escape from the metal surface. This phenomenon is called secondary emission. The electrons that strike the metal are called primary electrons while the emitted electrons are known as secondary electrons. The intensity of secondary emission depends upon the emitter material, mass and energy of the bombarding particles.



4. Photo Electric Emission

Electron emission from a metallic surface by the application of light is known as photo electric emission.

When a beam of light strikes the surface of cathode normally made of potassium, Sodium the energy of photons of light is transfer to the free electrons of cathode. In this method, the energy of light falling upon the metal surface is transferred to the free electrons within the metal to enable them to leave the surface. The greater the intensity of light beam falling on the metal surface, the greater is the photoelectric emission. The emitted electrons are known as *photo electrons* and the phenomenon is known as *photoelectric emission*. Photo-electric emission is utilised in photo tubes which form the basis of television and sound films.



- **Classification of solid according to electrical conductivity (Conductor, Semiconductor & Insulator) with respect to energy band diagram only.**

Pre-Knowledge:

(*i*) Valence band. *The range of energies* (*i.e. band*) *possessed by valence electrons is known as* **valence band.** The electrons in the outermost orbit of an atom are known as valence electrons. This band may be completely or partially filled.

(*ii*) Conduction band.

The range of energies (*i.e. band*) *possessed by conduction band electrons is known as* **conduction band.** Generally, insulators have empty conduction band. On the other hand, it is partially filled for conductors. The free electrons which are responsible for the conduction of current in a conductor are called *conduction electrons*.

(*iii*) Forbidden energy gap. *The separation between conduction band and valence band on the energy level diagram is known as* **forbidden energy gap.**

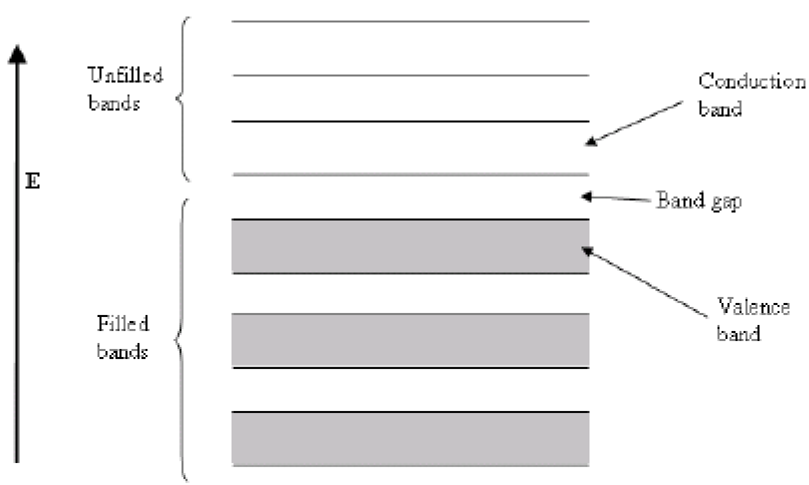


Fig 1. Energy band diagram

Classification:

Solid-state materials According to electrical conductivity can be classified into three groups. Such as:

1. Insulators - Insulators are materials having an electrical conductivity (like diamond: 10-14S/cm);

2. Semiconductors - semiconductors have a conductivity (for silicon it can range from 10-5S/cm to 103S/cm)

3. Conductors - at last conductors are materials with high conductivities: (like silver: 106S/cm.)

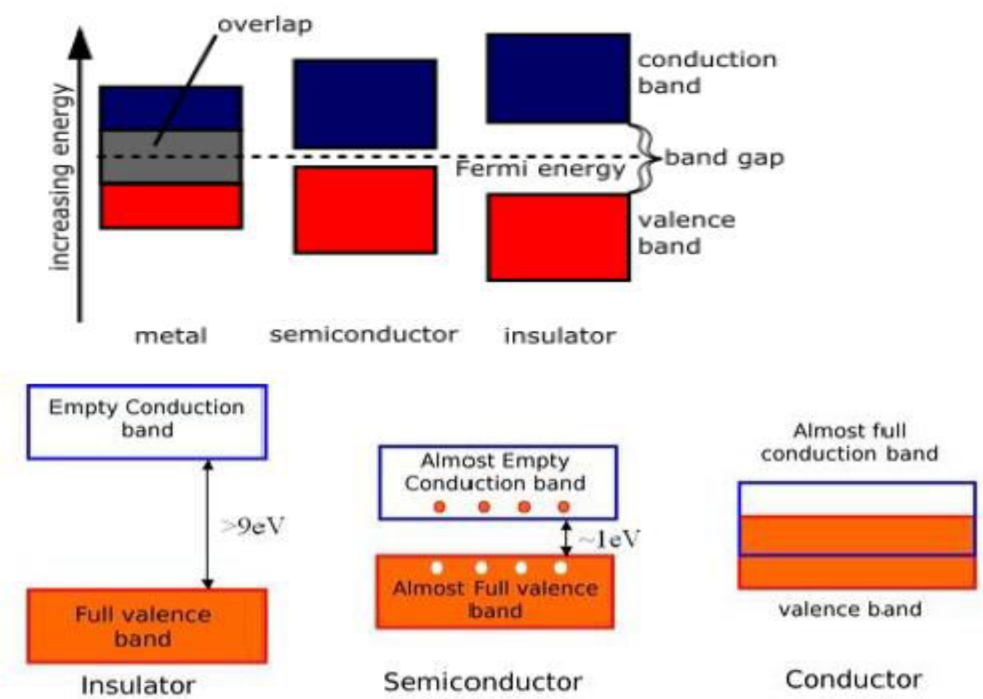


Figure 2 : Representation of energy bands

(i)* Insulators.** Insulators (*e.g.* wood, glass, plastics,rubber etc.) are those substances which do not allow the passage of electric current through them. In terms of energy band, the valence band is full while the conduction band is empty as shown in Fig 2. Further, the energy gap between valence and conduction bands is very large (15 eV***). Therefore, a very high electric field is required to push the valence electrons to the conduction band. For this reason, the electrical conductivity of such materials is extremely small. At room temperature, the valence electrons of the insulators do not have enough energy to cross over to the conduction band. However, when the temperature is raised, some of the valence electrons may acquire enough energy to cross over to the conduction band. Hence, the resistance of an insulator decreases with the increase in temperature *i.e.* an insulator has negative temperature coefficient of resistance.

***(ii)* Conductors.** Conductors (*e.g.* copper, aluminum) are those substances which easily allow the passage of electric current through them. It is because there are a large number of free electrons available in a conductor. In terms of energy band as in Fig 2, the valence and conduction bands overlap each other due to this overlapping; a slight potential difference across a conductor causes the free electrons to constitute electric current.

***(iii)* Semicondutors.** Semiconductors (*e.g. germanium, silicon etc*.) are those substances whose electrical conductivity lies in between conductors and insulators. In terms of energy band, the valence band is almost filled and conduction band is almost empty in fig 2. Further, the energy gap between valence and conduction bands is very small. The semiconductor has :

(*a*) Filled valence band

(*b*) Empty conduction band

(*c*) Small energy gap or forbidden gap (1 eV) between valence and conduction bands.

(d) Semiconductor virtually behaves as an insulator at low temperatures. However, even at room temperature, some electrons cross over to the conduction band, imparting little conductivity (i.e. conductor).

- **Discuss Intrinsic & Extrinsic Semiconductor.**

Intrinsic Semiconductor

A semiconductor in an extremely pure form is known as an **intrinsic semiconductor**.

In this case the holes in the valence band are vacancies created by electrons that have been thermally excited to the conduction band and hole-electron pairs are created. When electric field is applied across an intrinsic semiconductor, the current conduction takes place by two processes, namely; by *free electrons* and *holes* as shown in Fig 3. The free electrons are produced due to the breaking up of some covalent bonds by thermal energy. At the same time, holes are created in the covalent bonds. Under the influence of electric field, conduction through the semiconductor is by both free electrons and holes. Therefore, the total current inside the semiconductor is the sum of currents due to free electrons and holes. This creates new holes near the positive terminal which again drift towards the negative terminal.

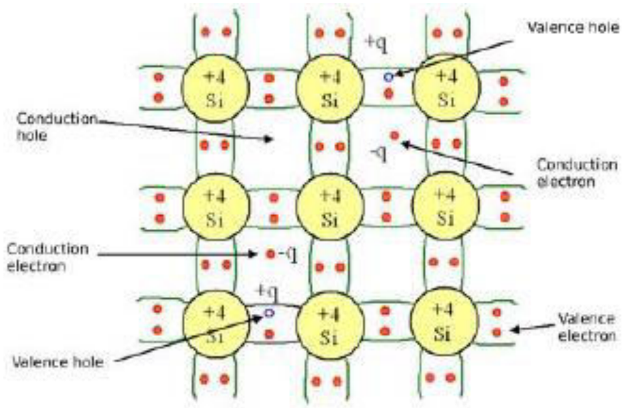


Figure 3 : Diagram showing the electronic bonds in an intrinsic semiconductor (Si)

Extrinsic Semiconductor

An extrinsic semiconductor is a semiconductor doped by addition of small amount impurity which is able to change its electrical properties (conduction), making it suitable for electronic applications (diodes, transistors, etc.) or optoelectronic applications (light emitters and detectors). This is achieved by adding a small amount of suitable impurity (having 3 or 5 valence electron) to a semiconductor (having 4 valence electron). It is then called impurity or extrinsic semiconductor.

- The process of adding impurities to a semiconductor is known as *doping*. The purpose of adding impurity is to increase either the number of free electrons or holes in the semiconductor crystal.

- If a penta valent impurity (having 5 valence electrons) is added to the semiconductor, a large number of free electrons are produced in the semiconductor.
- If a trivalent impurity (having 3 valence electrons) is added to the semiconductor, large number of holes are produced in the semiconductor crystal.

Depending upon the type of impurity added, extrinsic semiconductors are classified into:

(i) *n*-type semiconductor

(ii) *p*-type semiconductor

(i) n-type Semiconductor

When a small amount of pentavalent impurity is added to a pure semiconductor, it is known as **n-type semiconductor.**

The addition of pentavalent impurity pro-vides a large number of free electrons in the semiconductor crystal. Typical examples of pentavalent impurities are *arsenic* , *antimony,Bismuth and Phosphorous etc*. Such impurities which produce *n*-type semiconductor are known as *donor impurities* because they donate or provide free electrons to the semiconductor crystal.

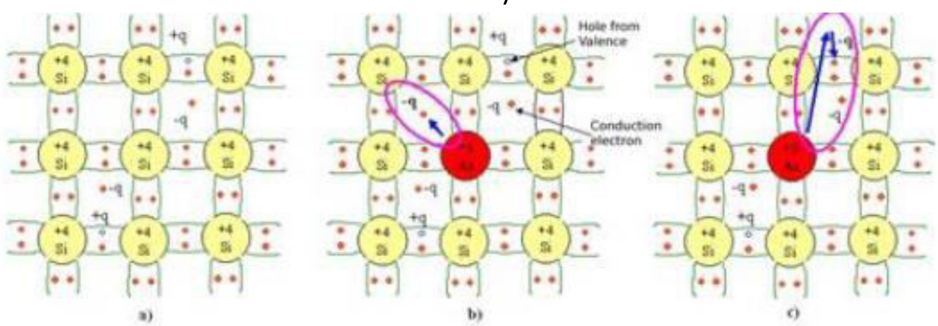


Figure 4 : Schematic representation of electronic bonds in a Silicon crystal doped with Arsenic As (n doping)

Electrons are said to be the majority carriers whereas holes are the minority carriers.

(ii) p-type Semiconductor

When a small amount of trivalent impurity is added to a pure semiconductor, it is called **p-type Semiconductor.**

The addition of trivalent impurity provides a large number of holes in the semiconductor. Typical examples of trivalent impurities are *gallium* , *indium, boron etc*. Such impurities which produce *p*-type semiconductor are known as *acceptor impurities* because the holes created can accept the electrons

fig 5.

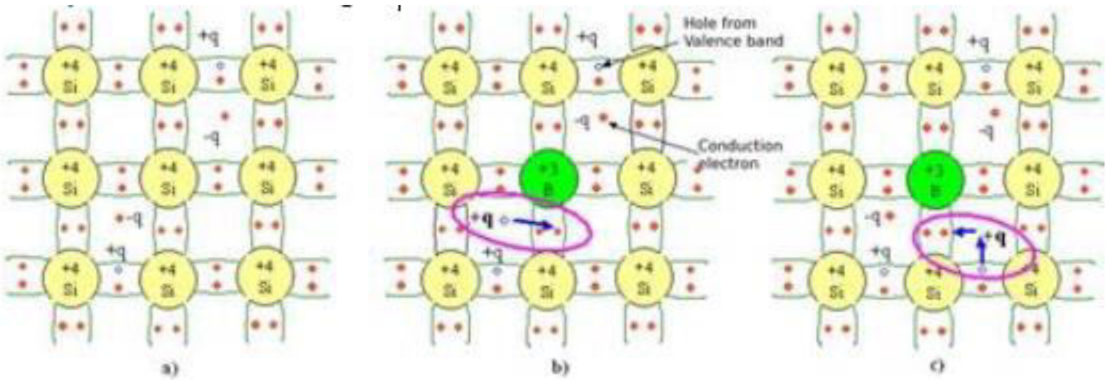


Figure 5 : schematic representation of a Si crystal doped with boron (B)

Electrons are said to be the minority carriers whereas holes are the majority carriers.

1.4 Explain the difference between vacuum tube & semiconductor.

Figure 6: Vacuum tubes

Vacuum Tubes:

Advantages

1. Superior sound quality.
2. Can handle large currents
3. Tolerant of large overloads and voltage spikes.
4. Characteristics highly independent of temperature, greatly simplifying biasing.
5. Wider dynamic range than transistors circuits, due to higher operating voltages and overload tolerance.
6. Capacitive coupling can be done with small, high-quality film capacitors, due to inherently high-impedances of tube circuits.
7. Operation is usually in Class A or Class AB, minimizing crossover notch distortion.
8. Tubes can be relatively easily replaced by user.

Disadvantages

1. Bulky(Larger in Size), hence not suitable for portable products
2. Higher operating voltages required.
3. High power consumption; needs heater supply that generates waste heat and yields lower efficiency, notably for small-signal circuits.
4. Glass tubes are fragile, compared to metal transistors.

5. Cathode electron-emitting materials are used up in operation.

6. High-impedance devices that need impedance matching transformer for low-impedance loads, like speakers; however, the magnetic cushion provided by an output transformer prevents the output tubes from blowing up.

7. Sometimes higher cost than equivalently powered transistors.

8. Complicated in manufacturing process.

Transistors:

Advantages

1. Usually smaller size, lower cost and longer life.

2. Can handle small current

3. Can be combined in the millions on one cheap die to make an integrated circuit, whereas tubes are limited to at most three functional units per glass bulb.

4. Lower power consumption, less waste heat, and high efficiency than equivalent tubes, especially in small-signal circuits.

5. Can operate on lower-voltage supplies for greater safety, lower costs, tighter clearances.

6. Usually more physical ruggedness than tubes (depends upon construction).

Disadvantages

1. Tendency toward higher distortion

2. Complex circuits and considerable negative feedback required for low distortion.

3. Large unit-to-unit manufacturing tolerances and unreliable variations in key parameters, such as gain and threshold voltage.

4. Device parameters vary considerably with temperature, complicating biasing and increasing likelihood of thermal runaway.

5. Cooling is less efficient than with tubes, because lower operating temperature is required for reliability. Tubes prefer hot; transistors do not. Massive, expensive and unwieldy heat sinks are always required for power transistors, yet they are not always effective (power output transistors still blow up; whereas, tubes fade down gracefully over time with warning.)

6. Less tolerant of overloads and voltage spikes than tubes.

7. Capacitive coupling usually requires high-value electrolytic capacitors, which give audibly and measurably inferior performance at audio frequency extremes.

8. Greater tendency to pick up radio frequency interference and self-oscillate to the point of self-destruction, due to rectification by low-voltage diode junctions or slew-rate effects.

9. Maintenance more difficult; devices are not easily replaced by user.

1.5 State basic concept of Integrated Circuits (I.C) & its use.

Figure 7:| Integrated Circuits

An integrated circuit (IC), sometimes called a *chip* or microchip, is a semiconductor wafer on which thousands or millions of tiny resistors, capacitors, and transistors are fabricated. An IC can function as an amplifier**,** oscillator, timer, counter, computer memory**,** or microprocessor. A particular IC is categorized as either linear analog or digital, depending on its intended application. IC's are are of Linear , digital and mixed types

Linear ICs have continuously variable output (theoretically capable of attaining an infinite number of states) that depends on the input signal level. As the term implies, the output signal level is a linear function of the input signal level. Linear ICs are used as audio-frequency **(**AF**)** and radio-frequency **(**RF**)** amplifiers. The *operational amplifier* (op amp) is a common device in these applications.

Digital ICs operate at only a few defined levels or states, rather than over a continuous range of signal amplitudes. These devices are used in computers, computer networks, modems, and frequency counters. The fundamental building blocks of digital ICs are logic gates, which work with binary data, that is, signals that have only two different states, called low (logic 0) and high (logic 1).

Applications and Uses of Integrated Circuits

The advantages of Integrated Circuits are:

1. Very small size: Hundred times smaller than the discrete circuits.
2. Lesser weight: As large number of components can be packed into a single chip, weight is reduced
3. Reduced cost: The mass production technique has helped to reduce the price,
4. High reliability: Due to absence of soldered connection, few interconnections and small temperature rise failure rate is low.
5. Low power requirement: As the size is small power consumption is less.
6. Easy replacement: In case of failure chip can easily be replaced.

Linear IC's also known as analog Integrated circuits are:

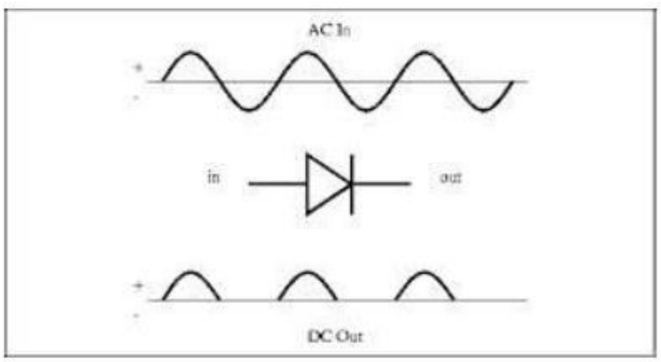
1. Power amplifiers
2. Small-signal amplifiers
3. Operational amplifiers
4. Microwave amplifiers
5. RF and IF amplifiers
6. Voltage comparators
7. Multipliers
8. Radio receivers
9. Voltage regulators

Digital IC's are mostly used in computers. They are also referred as switching circuits because their input and output voltages are limited to two levels - high and low i.e. binary. They include:

1. Flip-flops
2. Logic gates
3. Timers
4. Counters
5. Multiplexers
6. Calculator chips

7. Memory chips
8. Clock chips
9. Microprocessors
10. Microcontrollers
11. Temperature sensors

Mixed type applications - cars (automotive controls), televisions, computers, microwaves, portable devices like laptops, MP3, play stations, cameras, cellular phones to ship equipments, aero planes, space craft's. These are also used in switching telephone circuits and data processing. They also found applications in military equipments. The most common application of IC is digital watch which tells hour, second, minute, day and month. Another common but important application is scientific calculator which can perform basic functions like addition, subtraction, multiplication and division as well as complex functions like square root, cube, permutations, combinations , trigonometric functions, etc
The conversion of bidirectional alternating current (a.c.) into unidirectional direct current (d.c.) is called rectification. Electronic devices can convert a.c. power into d.c. power with very high efficiency.



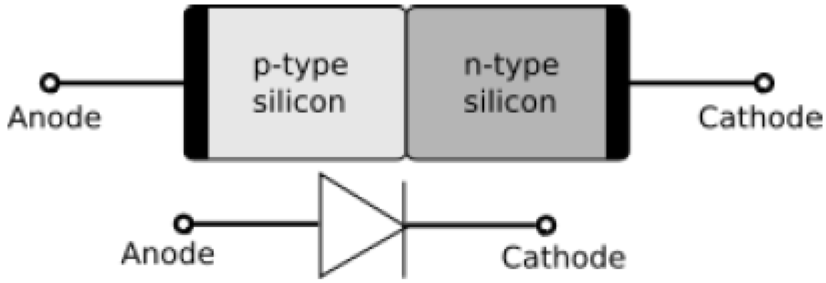
Example-Diodes : Diodes are useful electrical components for rectification purposes. Diodes are used in many applications like the following.

- Converting AC power from the 60Hz line into DC power for radios, televisions, telephone answering machines, computers, and many other electronic devices.
- Converting radio frequency signals into audible signals in radios.
- used as rectifier in DC Power Supplies**.**
- In Demodulation or Detector Circuits**.**
- In clamping networks used as DC Restorers
- In clipping circuits used for waveform generation.
- As switches in digital logic circuit

- **Rectifying diode**

Review of P-type and N-type semiconductor junction of P-type & N-type i.e. PN junction Barrier voltage, depletion region, Junction Capacitance.
A p–n junction is a boundary or interface between two types of semiconductor material, **p-type** and **n-type**, inside a single crystal of **semiconductor**. p–n junctions are elementary "building blocks" of most **semiconductor electronic devices** such as **diodes**, **transistors**, **solar cells**, **LEDs**, and **integrated circuits**.

After joining p-type and n-type semiconductors, electrons from the n region near the p–n interface tend to diffuse into the p region. The regions nearby the p–n interfaces lose their neutrality and become charged, forming the **space charge region** or **depletion layer**



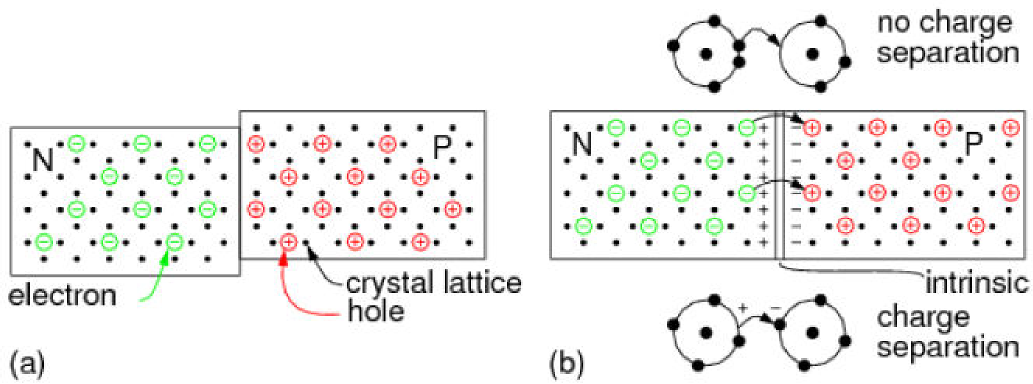
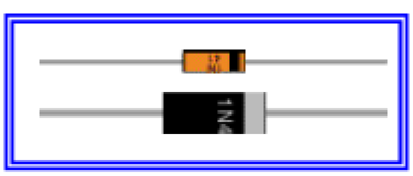


Fig 8 (a) Blocks of P and N semiconductor in contact have no exploitable properties. (b) Single crystal doped with P and N type impurities develops a potential barrier.

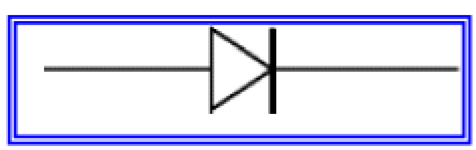
This separation of charges at the PN junction constitutes a potential barrier. This potential barrier must be overcome by an external voltage source to make the junction conduct.

PN Junction Diodes

Example:



Circuit symbol:

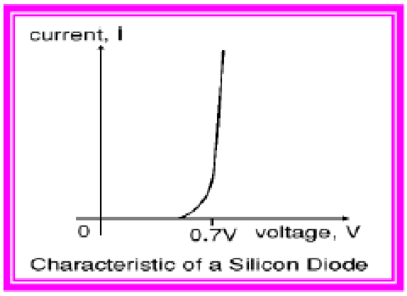


Function

Diodes allow electricity to flow in only one direction. The arrow of the circuit symbol shows the direction in which the current can flow.

Forward Voltage Drop

When a forward voltage is applied to diode, a small voltage experiences across a conducting diode, it is called the **forward voltage drop** and is about 0.7V for all normal diodes which are made from silicon. The forward voltage drop of a diode is almost constant whatever the current passing through the diode so they have a very steep characteristic (current-voltage graph).



Reverse Voltage

When a reverse voltage is applied a perfect diode does not conduct, but all real diodes leak a very tiny current of a few µA or less. This can be ignored in most circuits because it will be very much smaller than the current flowing in the forward direction. However, all diodes have a **maximum reverse voltage** (usually 50V or more) and if this is exceeded the diode will fail and pass a large current in the reverse direction, this is called **breakdown**.

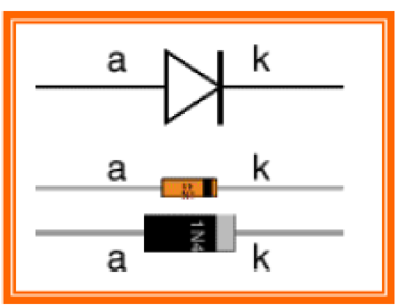
Ordinary diodes can be split into two types: Signal diodes which pass small currents of 100mA or less and Rectifier diodes which can pass large currents. In addition there are other types of diodes as such : LEDs, Zener diodes ,Tunnel diode,PIN diode,Photo diode and Varicap diode etc.

Practical Knowledge:

Connecting and soldering

Diodes must be connected the correct way round, the diagram may be labeled **a** or **+** for anode and **k** or **-** for cathode (yes, it really is k, not c, for cathode!). The cathode is marked by a line painted on the body. Diodes are labeled with their code in small print, you may need a magnifying glass to read this on small signal diodes!

Small **signal diodes** can be damaged by heat when soldering, but the risk is small unless you are using a **germanium diode** (codes beginning OA...) in which case you should use a heat sink clipped to the lead between the joint and the diode body. A standard crocodile clip can be used as a heat sink.



Signal diodes (small current)

Signal diodes are used to process information (electrical signals) in circuits, so they are only required to pass small currents of up to 100mA.

General purpose signal diodes such as the 1N4148 are made from silicon and have a forward voltage drop of 0.7V.

Germanium diodes such as the OA90 have a lower forward voltage drop of 0.2V and this makes them suitable to use in radio circuits as detectors which extract the audio signal from the weak radio signal.

For general use, where the size of the forward voltage drop is less important, silicon diodes are better because they are less easily damaged by heat when soldering, they have a lower resistance when conducting, and they have very low leakage currents when a reverse voltage is applied.

Biasing of Diode: The process of applying an external voltage is called as “biasing”**.**

Pre Knowledge:

Zero Bias: When no external voltage potential is applied to the PN junction diode called Zero Biased Junction Diode. However if the diodes terminals are shorted together, a few holes (majority carriers) in the P-type material with enough energy to overcome the potential barrier will move across the junction against this barrier potential. This is known as the “Forward Current” and is referenced as IF.. Likewise, holes generated in the N-type material (minority carriers) and move across the junction in the opposite direction. This is known as the “Reverse Current” and is referenced as IR. This transfer of electrons and holes back and forth across the PN junction is known as diffusion, as shown Fig 9.

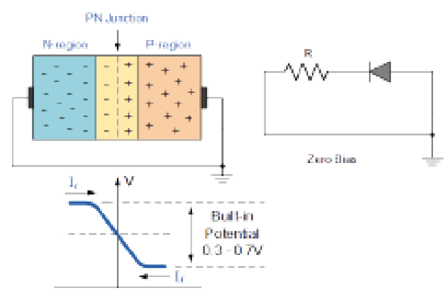


Fig 9: Zero Bias

But how ever there are two ways in which we can bias a pn junction diode.

1) Forward bias

2) Reverse bias

Forward Bias – The voltage potential is connected positive, (+ve) to the P-type material and negative, (-ve) to the N-type material across the diode which has the effect of **Decreasing** the PN junction diodes’s width.

Reverse Bias – The voltage potential is connected negative, (-ve) to the P-type material and positive, (+ve) to the N-type material across the diode which has the effect of **Increasing** the PN junction diode’s width.

The PN junction region of a **Junction Diode** has the following important characteristics:

- Semiconductors contain two types of mobile charge carriers, **Holes** and **Electrons**.
- The holes are positively charged while the electrons negatively charged.
- A semiconductor may be doped with donor impurities such as Antimony (N-type doping), so that it contains mobile charges which are primarily electrons.
- A semiconductor may be doped with acceptor impurities such as Boron (P-type doping), so that it contains mobile charges which are mainly holes.
- The junction region itself has no charge carriers and is known as the depletion region.
- The junction (depletion) region has a physical thickness that varies with the applied voltage.

- When a diode is **Zero Biased** no external energy source is applied and a natural **Potential Barrier** is developed across a depletion layer which is approximately 0.5 to 0.7v for silicon diodes and approximately 0.3 of a volt for germanium diodes.
- When a junction diode is **Forward Biased** the thickness of the depletion region reduces and the diode acts like a short circuit allowing full current to flow.
- When a junction diode is **Reverse Biased** the thickness of the depletion region increases and the

- Specifications:-(Definition)

Forward voltage drop, Reversed saturation current, maximum forward current ,power dissipation Package view of diodes of different power ratings(to be shown during practical hours)

The list below provides details of the various diode characteristics, and diode parameters found in the datasheets and specifications for diodes.

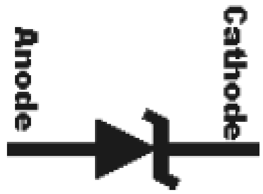
- ***Semiconductor material:*** Silicon is the most widely used material as if offers high levels of performance for most applications and it offers low manufacturing costs. The other material that is used is germanium. Germanium materials are generally reserved for more specialist diodes.
- ***Forward voltage drop (Vf):*** The voltage across a PN junction diode arise for two reasons. The first of the nature of the semiconductor PN junction and results from the turn-on voltage mentioned above. This voltage enables the depletion layer to be overcome and for current to flow. The second arises from the normal resistive losses in the device. It is the instantaneous forward voltage that a pn junction can conduct without damage the pn junction.
- ***Peak Inverse Voltage (PIV):*** It is the maximum voltage a diode can withstand in the reverse direction without damage to pn junction.
- ***Maximum forward current:*** It is the maximum instantaneous forward current that a pn junction can conduct without damage the pn junction When designing a circuit that passes any levels of current it is necessary to ensure that the maximum current levels for the diode are not exceeded. As the current levels rise, so additional heat is dissipated and this needs to be removed.
- ***Maximum power ratting:*** It is the maximum power that can be dissipated without damage the pn junction.

2.2 **Zener Diode :**Construction (reference to doping level)

2.2.2 Symbol ,circuit diagram for characteristics (forwarded & reversed)

Zener diodes

Circuit symbol:



Zener diodes or as they may sometimes be called, reference diodes operate like an ordinary diode in the forward bias direction. They have the normal turn on voltage of 0.6 volts for a silicon diode. However in the reverse direction their operation is rather different. Zener diodes are used to maintain a fixed voltage. They are designed to 'breakdown' in a reliable and non-destructive way so that they can be used **in reverse** to maintain a fixed voltage across their terminals. The diagram shows how they are connected, with a resistor in series to limit the current.

Zener diodes can be distinguished from ordinary diodes by their code and breakdown voltage which are printed on them. Zener diode codes begin BZX... or BZY... Their breakdown voltage is printed with V in place of a decimal point, so 4V7 means 4.7V for example. Some of Zener diodes are rated by their breakdown voltage and maximum power:

- The minimum voltage available is 2.7V.
- Power ratings of 400mW and 1.3W are common.

3.1 Rectifier: Definition- A semiconductor device which converts of an alternating current (AC) into direct current (DC **).**

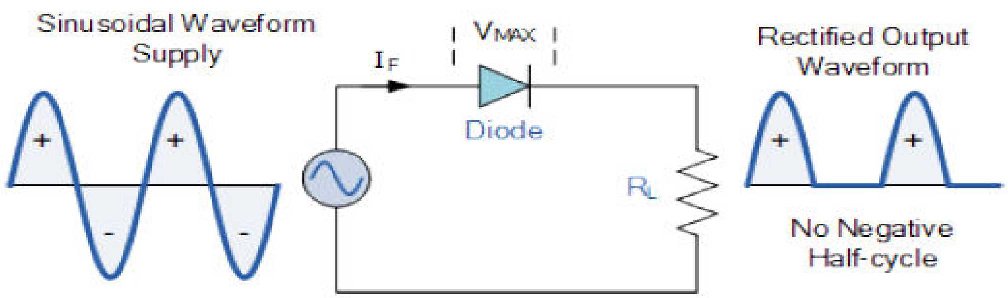
Example : Semiconductor Diode.

Need of Rectifier: To provide continuous voltage (DC Voltage) required to run almost all electronic devices & circuits.

3.1.1 Types of Rectifier : Half Wave Rectifier.

In this type the rectifier conducts current only during the + ve half cycles of the a.c. supply.

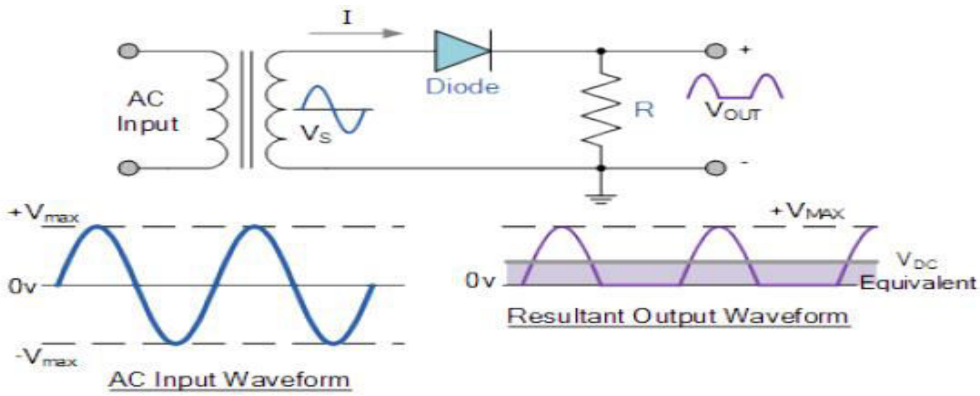
Simple Circuit:



Here – ve half cycles are suppressed i.e. during –ve half cycle no current passes through the diode hence no voltage appears across the load.

Max. rectifier Efficiency= Max. d.c.output power/ a.c. input power =40.6%

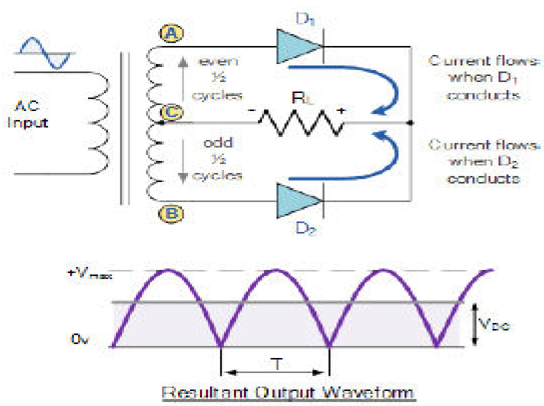
Schematic Diagram:



Full Wave Rectifier:

In this type , the rectifier utilises both half cycles of a.c. input voltage to produce the d.c output.

Full Wave Rectifier(Centre Tapped Type)



During the positive half cycle of the supply, diodeD1 conducts , while diodeD2 is reverse biased and the current flows through the load as shown .

Similarly ,during the negative half cycle of the supply, diodeD2 conducts , while diodeD1 is reverse biased and the current flows through the load as shown .

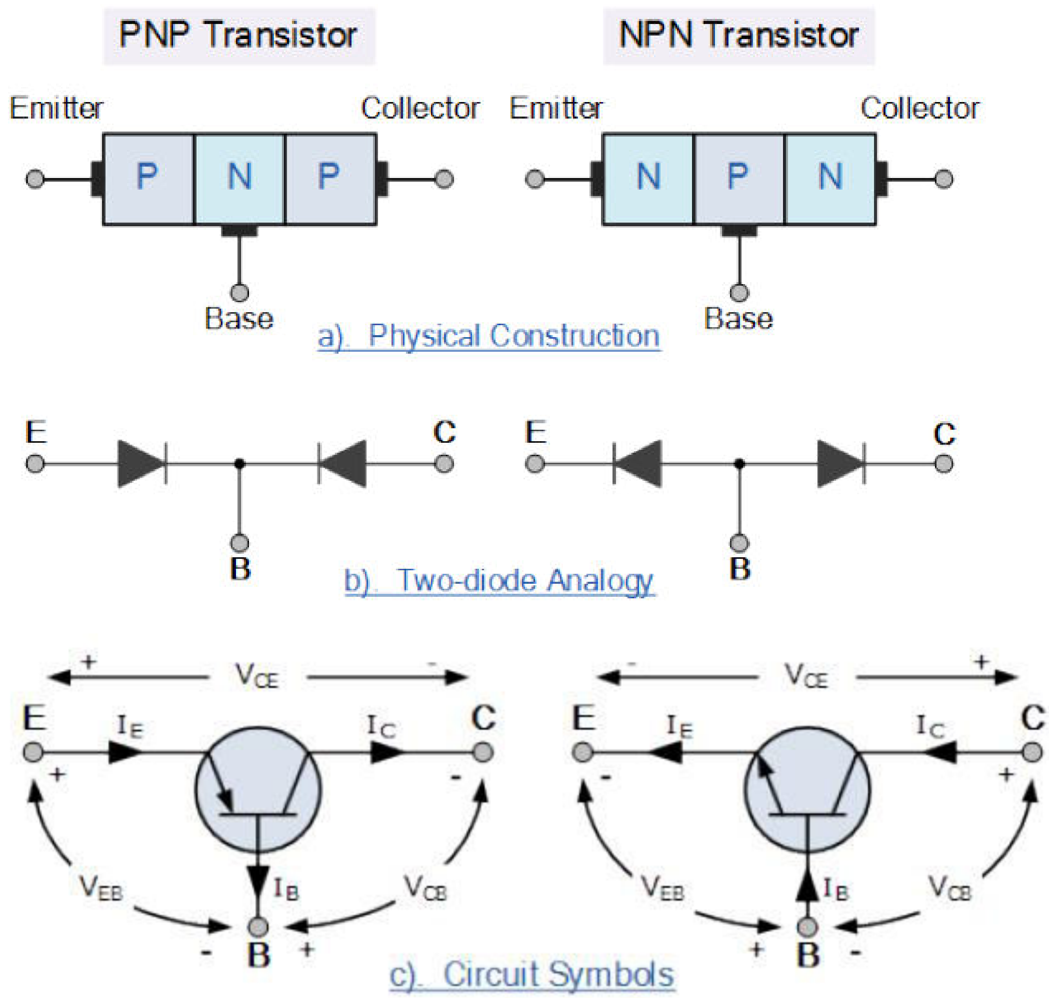
TRANSISTOR:

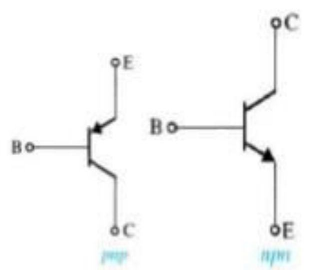
4.*1 Definition: A semiconductor device which transfers a signal from a low resistance to high resistance.*

Construction: A transistor consists of two pn junctions formed by sandwiching either p-type or n-type semiconductor between a pair of opposite types.

Accordingly there are two types of transistors namely ;

i) p-n-p transistor ii) n-p-n transistor





The direction of emitter arrow indicates direction of current flow.

Advantages: Small size ,Light weight ,Low supply voltage, No heating, High voltage gain ,Mechanically strong.

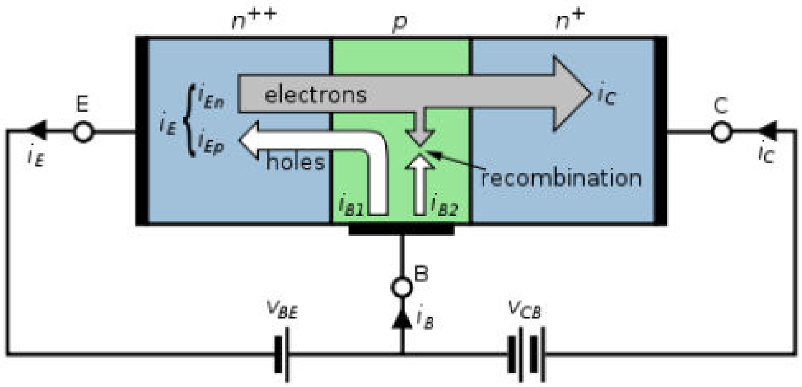
Bipolar Junction Transistor (BJT): A BJT consists of two pn junctions formed by sandwiching either p-type or n-type semiconductor between a pair of opposite types.

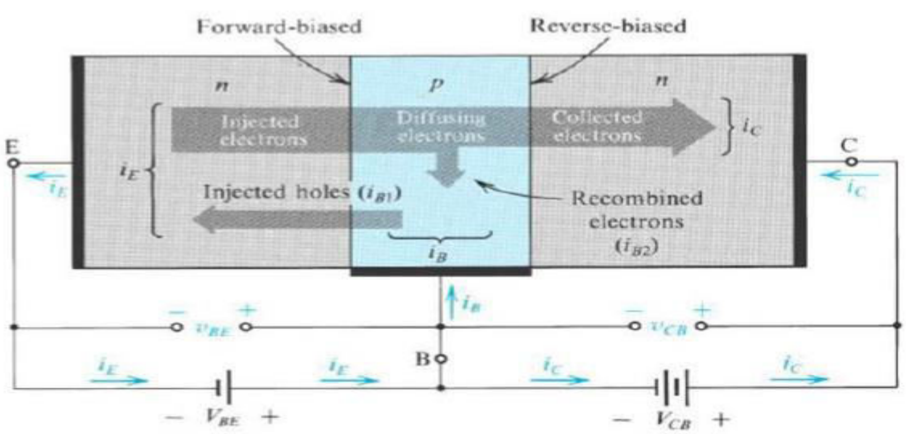
- **Types of Transistor (BJT) Basic concept**:

NPN transistor.

It has three sections of doped semiconductors.

- Emitter: The section on one side that supplies carriers(Electrons/Holes) is called Emitter. The emitter is always forward biased w.r.t. base so that it can supply large no of majority carriers(Electrons)
- Base: The middle section which forms two pn junctions between emitter & collector is called the Base.
- Collector: The section on one side that collects carriers(Electrons/Holes) is called Collector . The collector is always forward reverse bised w.r.t. base. Its function is to removes charges from its junction with the base.





- Conventional Current Flow in npn: The base emitter junction is forward biased . allowing low resistance in emitter (input) side & base-collector junction is reverse biased & provides high resistance in collector(Output) side .
- Accordingly the current flows from emitter towards base & collector

PNP transistor: Similarly the in pnp , the current conduction is due to majority carriers i.e. Holes as shown below.

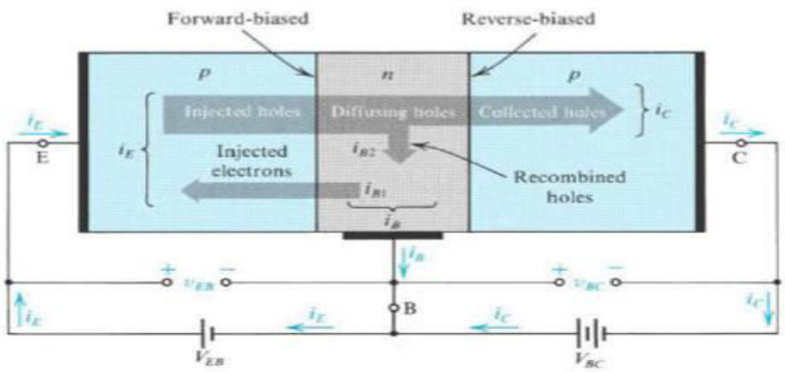


Fig 16 :Relation between different currents in transistor (I_E , I_B, I_C)

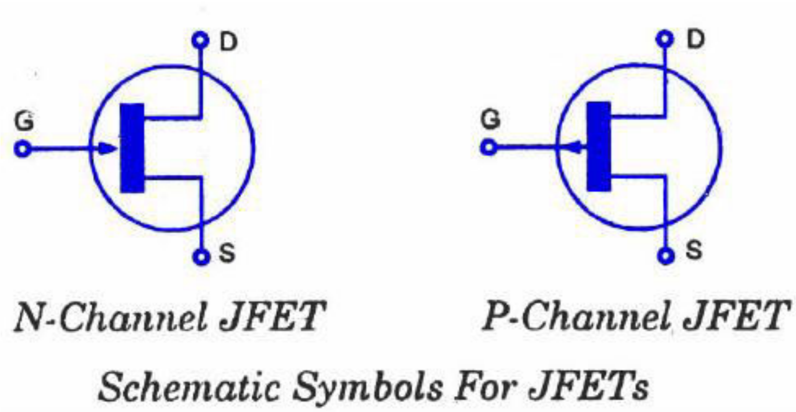
- **Transistor Configurations:CB ,CE& CC**

As the **Bipolar Transistor** is a three terminal device, there are basically three possible ways to connect it within an electronic circuit with one terminal being common to both the input and output. Each method of connection responding differently to its input signal within a circuit as the static characteristics of the transistor vary with each circuit arrangement.

- Common Base Configuration - has Voltage Gain but no Current Gain.
- Common Emitter Configuration - has both Current and Voltage Gain.
- Common Collector Configuration - has Current Gain but no Voltage Gain.

- **Unipolar Transistor (JFET)**

Junction Field Effect Transistor: A JFET is a three terminal semiconductor device in which current conduction is by one type of carrier i.e., electrons or holes.



Symbol:

Construction:

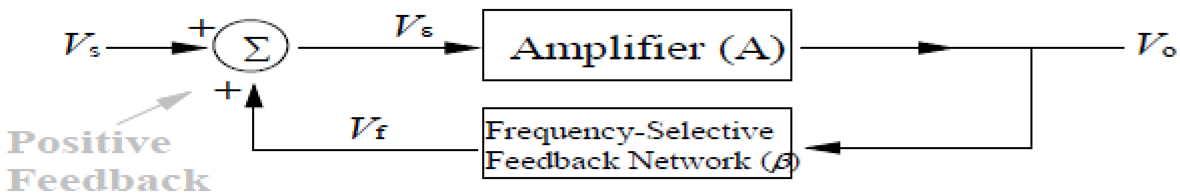
A JFET consists of a p-type or n-type silicon bar containing two pn junctions at the sides as in figure below.

JFET has three terminals viz., Gate (G) , Source(S) and Drain(D)

- **OSCILLATORS**

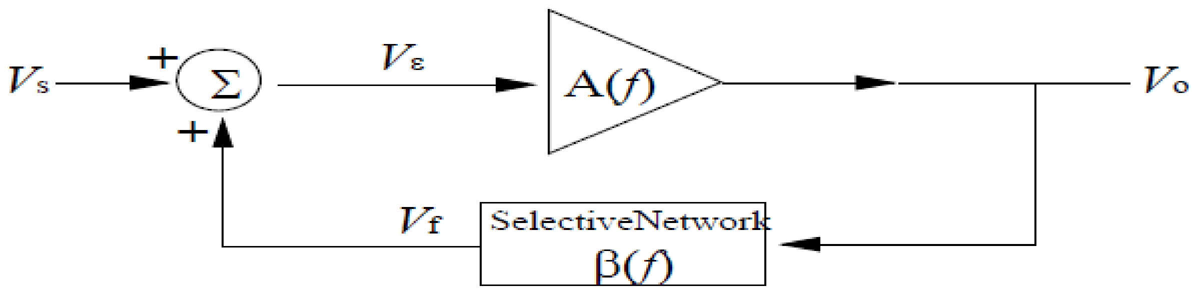
The use of positive feedback that results in a feedback amplifier having closed-loop gain |Af | greater than 1 and satisfies the phase conditions will result in operation as an oscillator circuit. An oscillator circuit then provides a varying output signal. If the output signal varies sinusoid ally, the circuit is referred to as a sinusoidal oscillator. If the output voltage rises quickly to one voltage level and later drops quickly to another voltage level, the circuit is generally referred to as a pulse or square-wave oscillator.

Essentials of Oscillators



For sinusoidal input is connected “Linear” because the output is approximately sinusoidal
A linear oscillator contains:

- a frequency selection feedback network
- an amplifier to maintain the loop gain at **unity**



APPLICATION OF OSCILLATORS

- Oscillators are used to generate signals, e.g.
- Used as a local oscillator to transform the RF signals to IF signals in a receiver;
- Used to generate RF carrier in a transmitter
- Used to generate clocks in digital systems;
- Used as sweep circuits in TV sets and CRO.

TYPES OF OSCILLATORS

1. Wien Bridge Oscillators
2. RC Phase-Shift Oscillators
3. LC Oscillators
4. Crystal Oscillator
5. Colpitt’s Oscillator
6. Tuned collector Oscillators
7. Hartley Oscillators