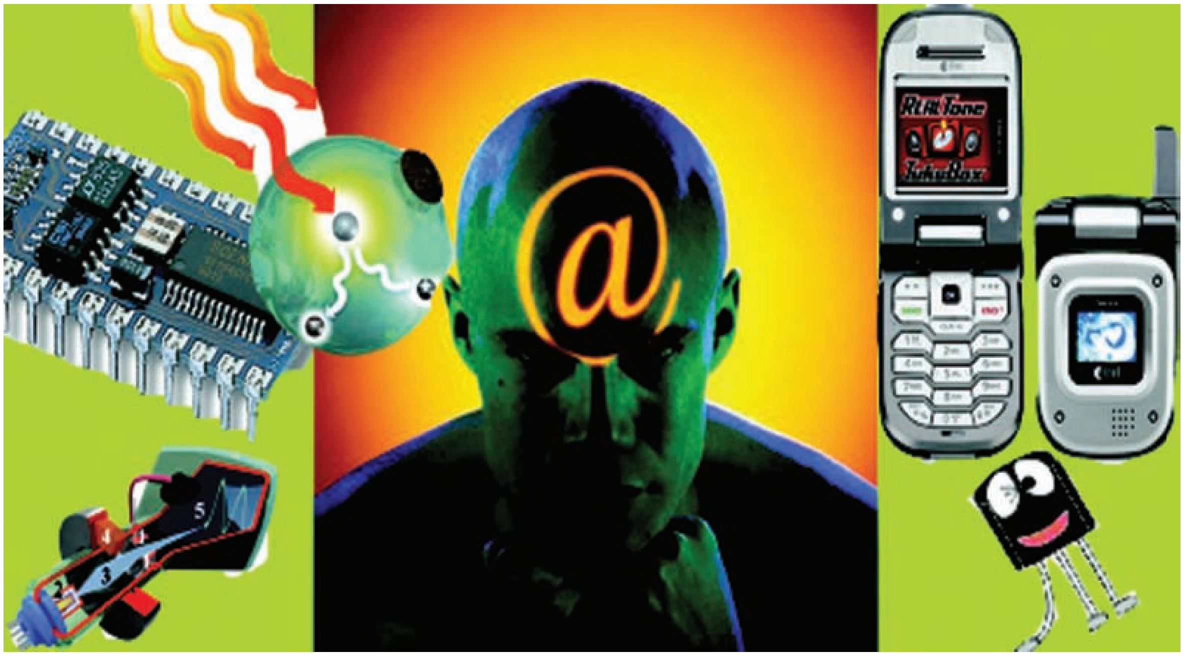
04. Electronic accessories for human activities



At the end of this chapter, you will be competent to

- Identify and use various electronic accessories according to their properties.
- Use diodes, transistors, capacitors and resistors to fulfil the day to day needs.
- Identify the integrated circuits as modern electronic appliances and use them in amplifying and digital circuits.
- Use appropriate appliances and methods to rectify and smooth alternating current.
- Identify and improve various electronic circuits and appliances related to new trends in communication.

4.1 Identification of electronic accessories for human activities

Man in the 21st Century use various equipment to fulfil his needs. Many of the equipments used by us in the modern times are electronic equipment. Many of the appliances and tools are made of electronic accessories. They help to ease our workload. Some such appliances are loudspeakers, radio sets, calculators telephones and electronic watches etc.

Fig 4.1 Radio set

Electrical conductors and Insulators

In electric appliances used in day to day activities, materials which carry the current are the **conductors.** Special feature of the metallic elements used as electric conductors is the possibility of free movement of the electrons in the last energy level of the atoms. The metal wires have a lot of loosely bonded elecrtons which can move freely.

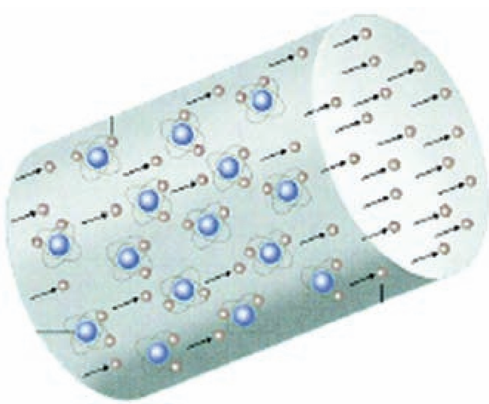


Fig 4.2 Motion of free electrons in a conductor

Due to this reason these electrons act as charge carriers under an electric potential. In rubber, plastic, polythene the atoms or molecules are joined tightly to each other by covalent bonds. Therefore there are no loosely bonded electrons in such substances. So, electric current does not flow through them. Such substances are known as **electrical insulators.**

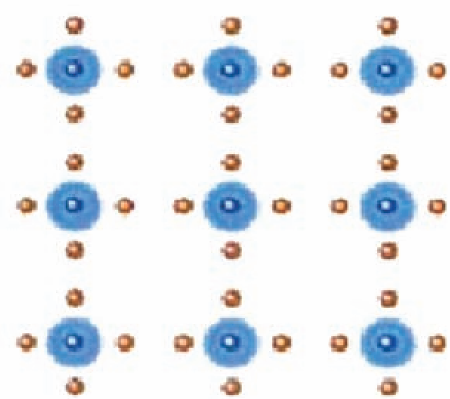


Fig 4.3 electron arrangement of a co-valent silicon lattice

Semi - Conductors

Semi - Conductors show intermediate properties between metals and non-metals. Most of the elements known as metaloids show the properties of semi conductors.

Semi-conductors are used mostly in making electronic accessories. Elements like silicon, germanium take a special place among them. The compounds like lead sulphide, gallium arsenide, indium phosphide also come under this category.

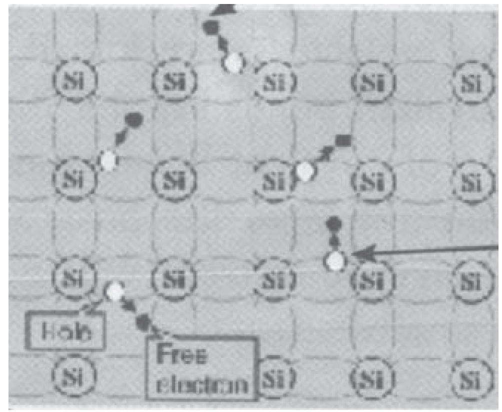


Fig 4.4 Silicon with free electrons

Now let us consider the bonding of the atoms of silicon, which is a semi-conductor.

The atomic number of silicon is 14. Since its valency will be 4, the number of electrons in the outer most shell is 4. A Silicon atom would make a crystalline lattice by sharing electrons with 4 atoms in tetrahedral manner. This is shown in Fig 4.3.

Under low temperature, semi conductors conduct electricity only faintly. But as the temperature rises considerable amount of electrons present in the co-valent bonds reach the free state. Then the heated non-metallic elements start conducting electricity.

Elements like silicon and Germanium (without mixing up with impurities) are called **intrinsic semi-conductors** which remain as lattice shown in the Fig 4.3 . Each electron got free from the silicon lattice on heating makes a hole each in the lattice, therefore the silicon made to this position contains a large number of free electrons and holes (Fig. 4.4)

The conductivity of intrinsic semi-conductors can also be increased by mixing small amounts of other elements. The method of adding impurities to semi-conductors in this manner is called **doping.** Arsenic or boron can be used to dope silicon or germanium. In making semi-conductor there are two ways of doping (Fig 4.5, Fig 4.6).

- By doping small amount of phosporus or arsenic (which are in the fifth group of the periodic table and rich in valency electrons) with silicon or germanium, a semi-conductor of n type or negative type can be made.

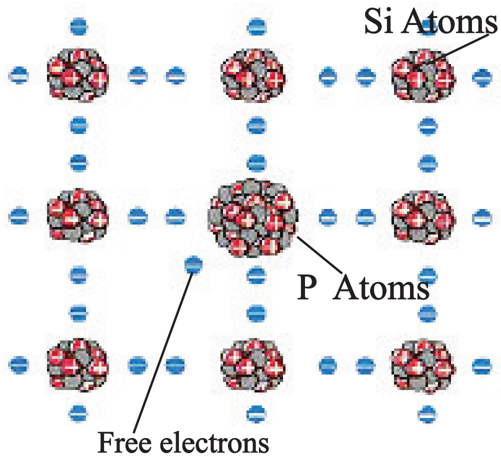


Fig 4.5 n-type semi conductors

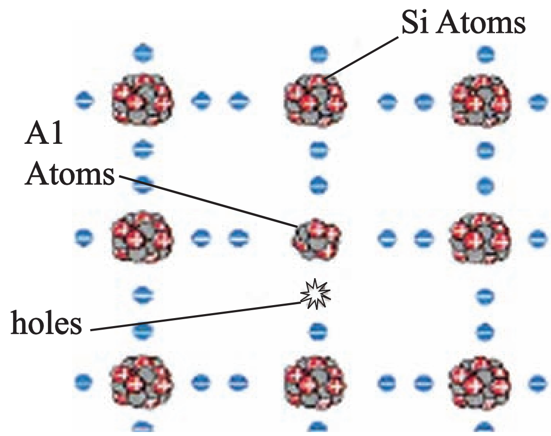


Fig 4.6 p-type semi-conductor

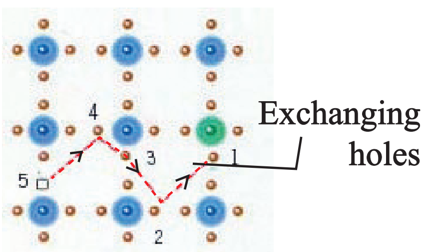


Fig 4.7 Free electrons substitute the holes in a p-type semi conductor

• Similarly, by doping a small amount of aluminum or boron (which are in the third group of the periodic table with less valency electrons) to silicon, a semi-conductors of p type or positive type can be made. In n-type semi-conductors, more free electron and in p-type semi-conductors more holes can be seen. (Fig 4.5 and 4.6)

p-n Junction

p-n junction can be made by joining a p-type semi-conductor and a n-type semi-conductor in a special way.

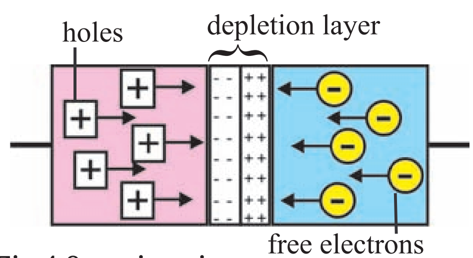


Fig 4.8 p-n junction

Here, p-type semi-conductor will be rich in holes and n-type semi-conductor will be rich in free electrons. As soon as p-n- Junction is made, some amount of holes present in p-side diffuse to n side and some amount of free electrons in n-side diffuse towards p-side. Then p-side closer to the junction becomes negatively charged and n side becomes positively charged. In addition on either side of the junction, an area of voltage block is seen. p-n junction of Silicon has 0.7 V and germanium has 0.3 V with positive and negative charges on either side of this p-n junction in a thin layer called the depletion layer.

Junction diodes

A junction diode is made by connecting two terminals to the semi-conductors used in making the p-n Junction (Fig 4.9)

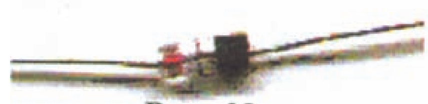


Fig 4.9 Junction diode

Action of diode

A p-n junction diode can be biased in two ways. Fig 4.11(b) shows a p-n junction diode where its p side is connected to positive terminal of a battery and n side to negative terminal. An electric current flows through the p-n junction.

Fig 4.10-Different types of junction diodes

The battery should be able to overcome the barrier potential of the depletion layer. Biasing the p-n junction in this way is called 'forward biased' condition. In this instance, the bulb does glow as the electric current flows. (Fig 4.12(a))

voltage block. Fig (b) the holes are replaced by the positive terminal of the battery those holes move from P terminal to n terminal. Similarly due to the electron supplied by the negative terminal of the battery, electrons are moving from n to p.

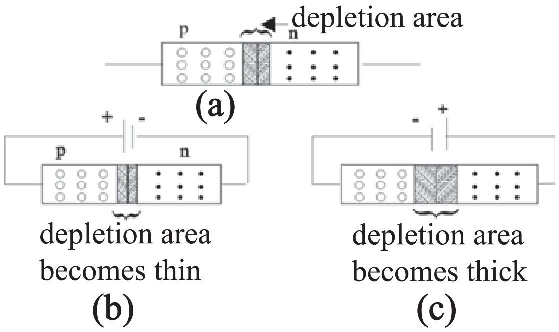


Fig 4.11-Action of a junction diode

Fig. 4.12 (b) and 4.11(c) show a p-n junction diode connected to a battery with its terminals inter-changed. Then the depletion layer becomes thick and charge carriers (holes and electrons) are unable to move. Thus the electric current does not flow and the bulb does not glow. Biasing the p-n junction diode in this way is called 'reverse biased' condition.

A diode can also, used as a switch. In addition be it is regarded as a valve. Electric current flows in a diode only in one direction.

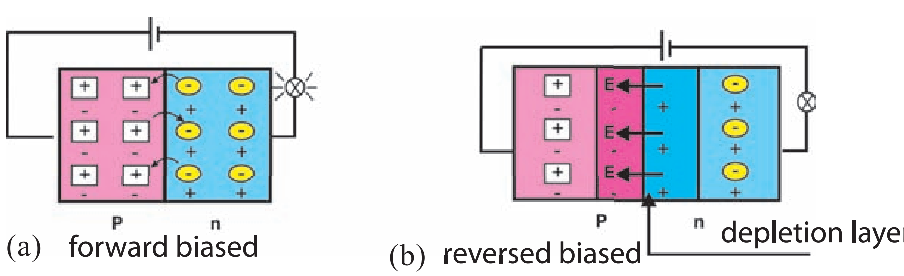


Fig 4.12 A simple circuit using diodes

As diodes allow the flow of electricity along one direction its symbol can be shown as:fig 4.13

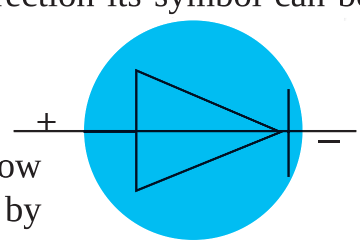
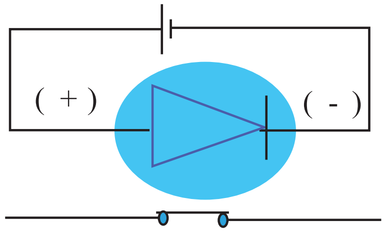
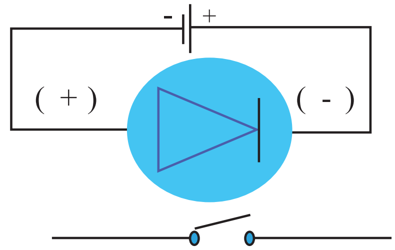


Fig 4.13 symbol of diode

The direction of the flow of current is shown by the arrow head and prevention of flow of current is shown by simple line.



Stage 'ON'-current flows
(forward bias.)



stage OFF-current does not flow
(Reverse/ Backward bias)

Fig 4.14

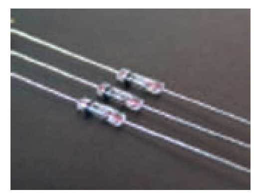
When the current is supplied on forward bias sense, the switch will be 'On' stage and when the current is supplied on backward or reverse bias sense, the switch will be 'OFF' stage of the diode. This feature of the diodes is useful in setting electronic circuits.

Special type of diodes

There are lot of uses of diodes. Diodes are used to stress various qualities to do various functions. They are point contact diodes, rectifier diodes, zener diodes, photodiodes, light emitting diodes (LED) etc.

1) Point contact diodes

These diodes are used to convert high frequency radio waves to audio frequency waves. These are not good for high currents. The outer cover of this is made up of transparent glass. This is also known as crystal diodes.



External appearance

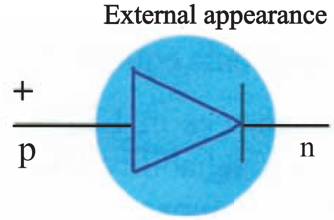


Fig 4.15 External appearance and symbol of point contact diodes

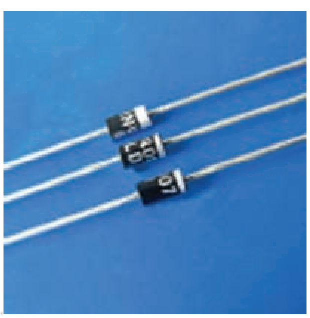


Fig 4.16 Rectifier diode

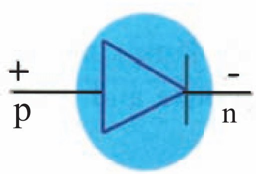


Fig 4.16-a

2) Rectifier diodes

These diodes are used to convert alternating current (AC)-into direct current (DC)-Fig4.16)

3) Zener diodes

A Zener diode is shown in fig 4.17

These are used to obtain a fixed voltage eventhough the input voltage varies in a certain range. It behaves like a normal silicon diode but when reverse biased, breaks down at a particular voltage, called its breakdown or Zener voltage. It helps to protect the electronic appliances.

Zener voltage. This ranges from about 2 to 200V. It protects the electronic appliances.

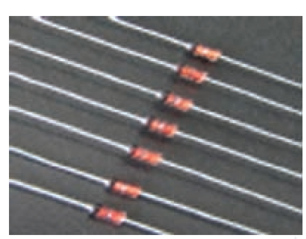
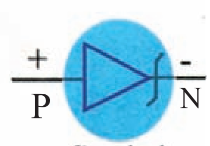


Fig 4.17 Zenerdiode



Symbol

4) Photo diodes

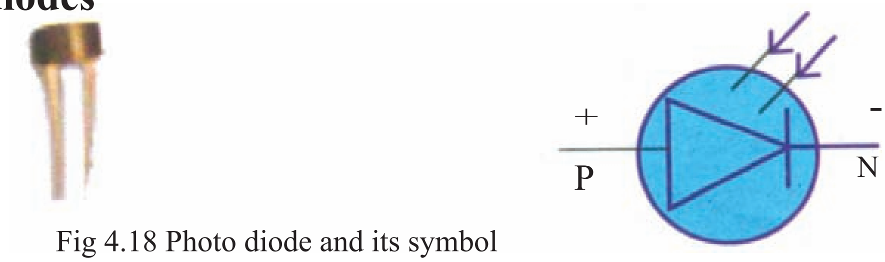


Fig 4.18 Photo diode and its symbol

A special characterstic of these diodes is when light falls on the p-n junction of the diode, the reverse bias resistance is decreased and a current starts flowing (Fig. 4.18). As the semi-conductor junction is made of cadmium compounds, light sensitive property is high in this type of diodes. These act as electric switch. In these diodes, there is a convex lens to focus light on to the p-n junction. These diodes are used in cameras, appliances used for alarm signals, light sensitive appliances and optic fibres.

5) Light emitting diodes (LED)

These are made from semi conductor gallium arsenide or Indium phosphide. When these are forward biased they conduct electricity and emit red, green or yellow light depending on its composition. There is a minimum voltage for LED to be active. It is 1.6 V for red LEDs. LEDs consume a small current about 20 mA. If it exceeds 5V, it may damage the LED. (Fig. 4.19)

LEDs are used as indicator lamps in radio receivers, traffic signal lights and other electronic equipment.

The advantages of LEDs over odinary lamps are their small size, reliability long life, fast response and modest current requirements.

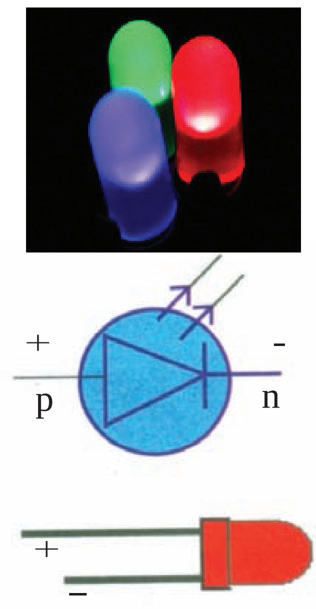


Fig 4.19 Light Emitting diodes and its symbol

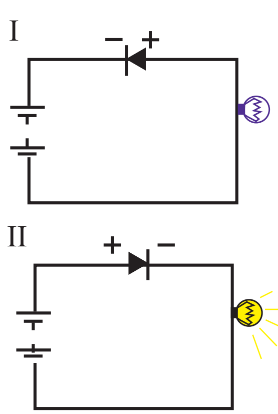


Fig 4.20 Circuits with diodes

Circuits where doides are used

Different types of circuits are made using the switch action of the diode.

Make two circuits as shown in the figure 4.20 and see how bulbs are lit. You will see that the bulb in (i) does not light up and the bulb in (ii) lights.

Testing the diodes using a multimeter

Do the activities shown in the figure 4.21

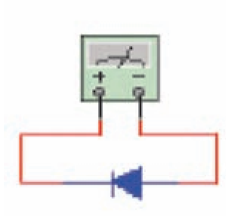


Fig 4.21- a

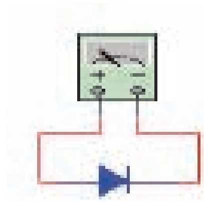


Fig 4.21- b

Activities 4.1

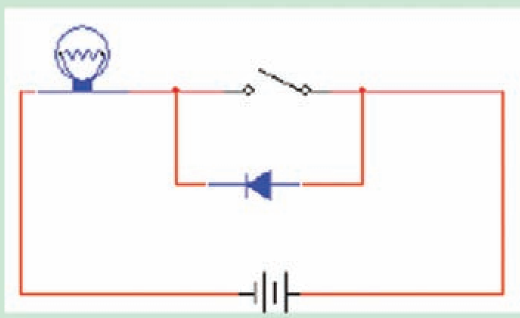


Fig 4.22

Could you see any difference in the bulb when it is switched on? Change the anode (+) and cathode (-) and see what happens.

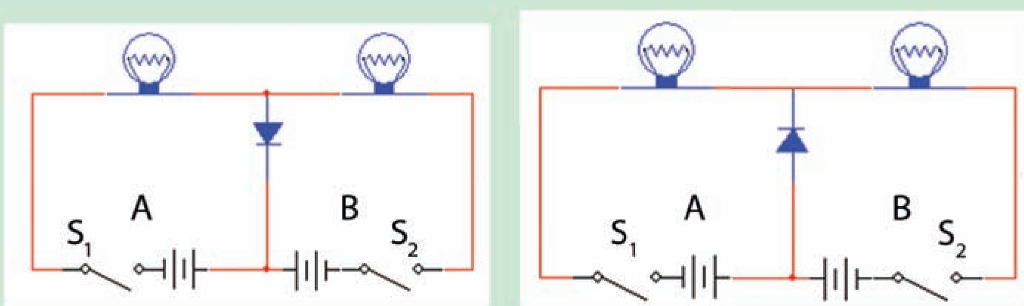


Fig 4.23

Switch on S_1 and S_2 separately in the circuits shown in 4.23.Then switch them on together and see what happens. Switch them off and see what happens. Then change the terminals of the battery A in circuit 1 and see what happens. Then change the terminals of Battery B and observe what happens. Repeat this sequence changing the terminals of the diodes too and observe what happens.

4.2 using transistors to fulfil day-to-day needs

At the dawn of electronic age, thermionic valve was used as the main electronic device in amplification circuits and computers. But after 1950 it was replaced by the junction transistor.

Transistor

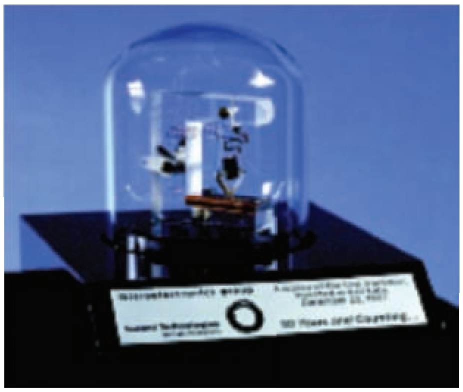
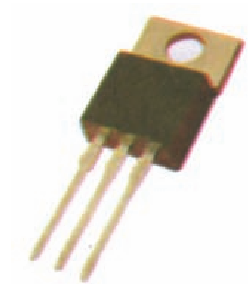


Fig 2.24

In 1947 American scientists William Shockely, Walten Bratain and John Bardene made the first transistor in the world. They were awarded the Nobel Prize for Physics in 1956 for the invention of the transistor. Intergrated circuit (IC) used in modern electronic circuits are based on the tarnsistors.



Type of transistors and their structure.

Mainly transistors are of two types. They are;

1. n p n type
2. p n p type

n p n type was made by keeping a very thin p portion in between two n type semi conductors, p n p type was made by keeping a very thin n portion in between two p type semi-conductors. The terminal connected to the high doping area is called the emitter,

The terminal of the transistor connected to the less doping area is called the collector. The terminal connected to the middle part is called the base.

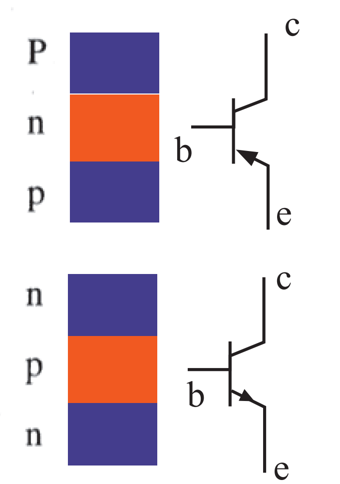


Fig 4.25

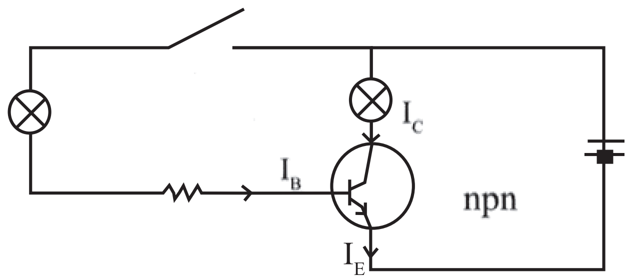
Types of transistors

Structure, symbol and the external appearance is given in the fig 4.25. When examining the structure of a transistor it is clear that it consists of two p-n junctions.

Biasing of a transistor

You know that there is a potential barrier across the p-n junction. The value of this potential barrier for silicon is 0.7 V where as for germanium it is about 0.3 V. The current is controlled by considering the use that we get from it. Sometimes we use it as an amplifier, sometimes as a switch.

The current through the transistor depends on the voltages supplied to the emitter, collector and the base. Biasing a transistor means keep the DC voltages constant according to the requirements. To forward bias the junction, DC current should be supplied with more voltage on p and less voltage on ‘n’.This overcomes the voltage barrier. By decreasing the voltage supplied to p and increasing the voltage applied to n, the junction can be reverse biased. This is mostly used in transistor circuits. Direct currrnt (DC) sourced are used to obtain these voltages and by using suitable resistors, the necessary voltageas are supplied to their relevant terminals.



I_E - emiter current

I_C - collector current

I_B - base current

Fig 4.26-A forward biased npn transistor.

The flow of current in a forward biased transistor is shown in the figure 4.26

A npn transistor is used here. Here the BE junction is forward biased and BC junction kept reverse biased. Therefore direct currents I_B, I_C and I_E flow in the circuite as shown in fig 4.26.

As the BE junction has been kept forward biased, free electrons which flow to the base continue to flow towards the collector. I_E and I_C currents are due to this movement of electrons.

I_C and I_E currents are in the milli ampere range and I_B current is in the micro ampere range. The important feature of a transistor is the ability to control I_C current by I_B current.

At the same time few electrons which flow to the base, combine with holes there. Electron flow is stopped as a result of that.

Negative charge at the base is neutralized by small I_B currents.

Do you Know?

I_E and I_C currents are of mili ampere range and I_B current is micro ampere range.Important feature of a transistor is the ability to control I_C current by I_B current .

Assignment 1

- Find out why the two ends of a transistor are named as emitter and collector.
- Find out the reason why the base part is made very thin.
- Find out why the emitter part has been doped more.

Activity 4.2 could be used to demonstrate the ability to control I_C by I_B

Activity 4.2

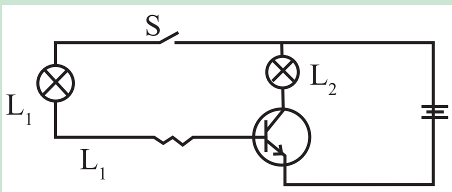


Fig 4.27-simple transistor circuit

Switch on S in this circuit and then switch off it. Observe what happens. When the switch S is opened L_1 and L_2 bulbs do not light up. When S is closed only L_2 is lit.

Conclusion

- Current through L_2 is more than the current across L_1
- Current through L_1 is not enough to light the bulb.
- Small I_B current controls the larger I_C

It is possible to control a large current in one circuit of the transistor by varying a small current in the other circuit of the transistor.

This shows that the transistor is used to amplify the current.

When the small current is stopped the large current in the other circuit also stops

Transistor is also used as a switch.

Transistor Amplifier

Amplification circuits are used to amplify signals produced by microphones. Radio and TV signals are also amplified using these.

A npn transistor amplifier circuit is shown in the fig 4.28

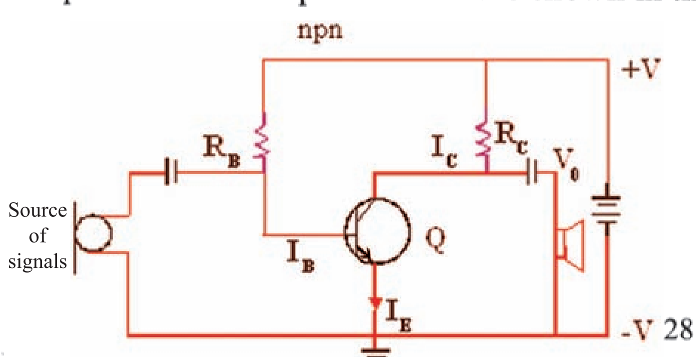


Fig 4.28-Trnasistor as an amplifier

Here the transistor is biased to amplify signals. Here the I_B current is of micro ampere range and I_C current is of milli ampere range.