CHAPTER TEN

ELECTRONICS

Introduction:

- Electronics is the branch of science and engineering, which is closely related to the science of electricity.
- Electronics make possible wonders such as television, radio and the computer.
- Modern air, sea and space travel depend on navigation by radar, radio and computers.
- Electronics depends on certain highly specialized electron devices.
- Electron devices process various kinds of electric pulses, or signals, such as radio and TV signals.
- These signals then in turn operate the electronic equipment.
- Transistors are among the best known electronic devices, and operate millions of radios and television sets we use today.
- But new devices called integrated circuits have replaced individual transistors in modern electronic equipments.
- One integrated circuit can do the work of several thousand transistors, and yet the circuit may be as small as a pinhead. - Equipments that contain integrated circuits are smaller, cost less and use less power than transistor – operated equipments.
- Electronics and the science of electricity both deal with electric current, but they differ in how they use it.
- Electricity deals with electric current mainly in the form of energy, which is used to operate electric equipments such as electric lights and electric motors.
- Electronics on the other hand, deals with electric current mainly in the form of pulses, or signals. The current flows through electron devices, which change the current`s behavior to make it work as signal.
- The signals used in electronics may represent sounds, pictures, numbers, or other information.
- For example, in radio, they stand for sounds.-Almost every electronic equipment uses some non electronic devices to help process information.

- For example, radio and television equipments require electronic devices such as microphones and speakers.
- Microphone in a broadcasting studio change sound waves into weak electric

signals.
- Speakers in television and radio receivers change the signals back into sound waves.
- But the signal must first go through a number of changes, and electron devices in the broadcasting and the receiving equipment make most of these changes.
- Electron devices perform three main functions: (1) rectification (2) amplification (3) oscillation.
- By combing these functions in various ways, various electronic equipments can be designed.
- Rectification is the simplest and most basic electronic operation, which allows current to flow only in one direction.
- A device which performs this function is called a rectifier.
- But most electronic equipments made today use semiconductor diodes to provide rectification.
- Electronic equipments need electric current in the form of direct current (DC) to work, since this type of current flows in one direction.
- For this reason, electronic devices cannot work directly on the alternating current (AC), which most power plants produce.
- Alternating current continually reverses direction.
- Because rectifiers allows current to flow just in one direction, they can therefore change AC into DC.
- Electronic equipments which operate commercial power plants , have rectifiers for this purpose.
- Batteries provide DC, and so battery-powered electronic equipments do not need rectifiers.

Amplificatiion:

This strengthens a weak signal and is perhaps the most important electronic function. A device which does this job is called an amplifier, and most electronic equipments cannot operate without amplification. Modern electronic equipments depend on transistors and integrated circuits to provide amplification. Signals such as a radio signal loses strength as it travel through the air, and may become too weak by the time it is picked by a radio antenna. An amplifier in the radio therefore strengthens this signal.

Oscillation:

This converts direct current to a signal of a desired frequency, and devices which do this job are called oscillators. Most electronic equipments depend on transistors or integrated circuits to provide oscillation. Oscillators serve many purposes and an example is that, radio and television stations use them to produce the high frequency signals needed to carry sound and picture information.

The free electron theory:

The mode of electrical conduction in metal is due to the presence of free electrons within the metal. When no electrical field is present, the thermal energies of these free electrons enable them to move randomly and haphazardly through the metal. However, in the presence of an electric field, they are urged to move in the same direction opposite to the direction of the field, i.e. against the field. This movement of the free electrons in a particular direction, constitutes the conduction or the movement of current through the metal.

The band theory of solids:

Three types of bands are present within a solid and these are;

(i) The valence band.
(ii) The conduction band.
(iii) The forbidden band.

The valence band:

- Within this band, the electrons are covalently bounded to each other and to their individual atoms.
- They are not usually free to move, particularly at low temperatures.

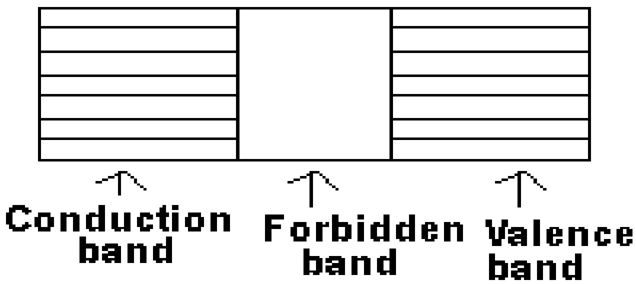
The conduction band:

- This corresponds to a higher energy level than the valence band.
- Here, the electrons are no longer bounded to their respective atoms, and as such they are free to move through the crystal (solid).
- Once an electron is in this band, the conduction of the solid improves.

The forbidden band:

-This is a band of unavailable energy, between the valence and the conduction band.

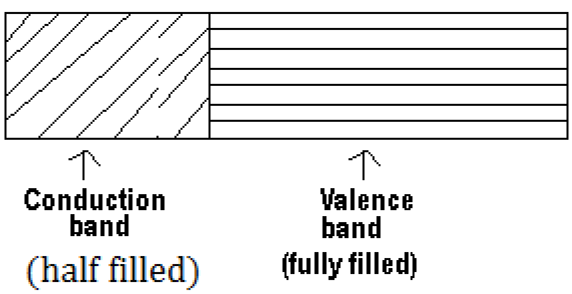
-It is wide in insulators and narrow in semiconductors , but does not exist in conductors where the valence and the conduction bands overlap.



The band theory:

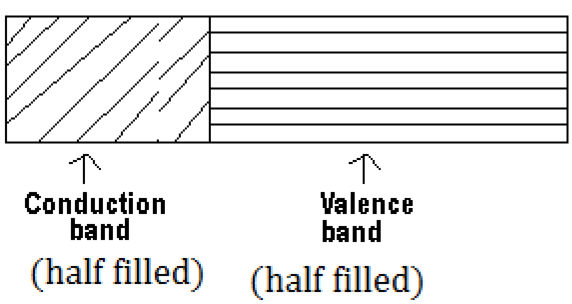
(1)**Energy bands in metals:**

(a)At absolute zero:



(half filled)

(b)At room temperature:



-At absolute zero, the valence band is full but the conduction band is half filled.

-At room temperature, electrons enter the conduction band from the valence band, so that both are incompletely filled.

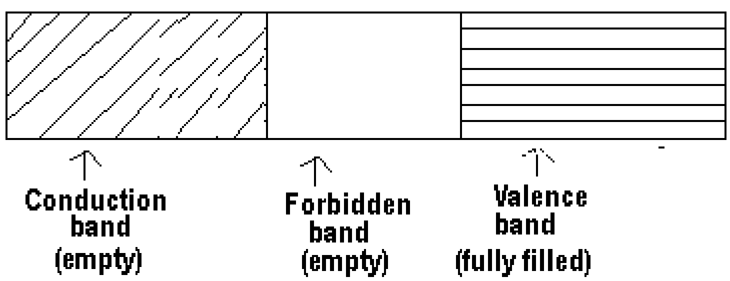
-Therefore at room temperature, there are empty states in both the conduction and the valence band.

- On receiving energy from a normal electric field, the electrons in both bands acquire enough energy to enter the empty states, which results in electrical conduction in both bands.

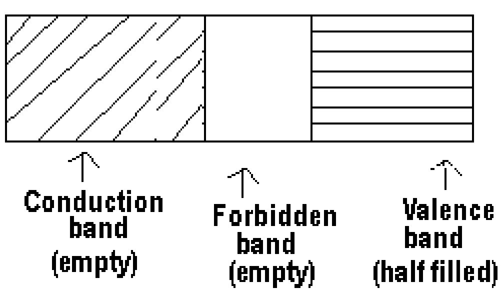
-However, the current which is obtained under the influence of an electric field, consists mainly of the movement of free electrons in the conduction band.

Energy bands in semiconductors:

(a)At absolute zero:



(b)At room temperature



- At absolute zero, the conduction band is empty and the valence band is full.

- For this reason, a semiconductor is an insulator at absolute zero.

- At room temperature, excited electrons from the valence band, cross the narrow forbidden band and enter the conduction band.

- For this reason, both the valence and the conduction bands are incompletely filled at room temperature.

-The movement of free electrons from the valence band creates holes in this band.

-In the absence of an external or an electric field, the electrons in the conduction band wander about randomly.

-However, if an external electric field is applied, the holes in the valence band move in the direction of the applied field and this constitutes a "hole current".

-At the same time, the electrons in the conduction band drift against the applied field direction, and this constitutes the "electron current".

-Therefore the current flowing in a semiconductor is made up of the hole current in the valence band, and the "electron current" in the conduction band.

The energy bands in an insulator:

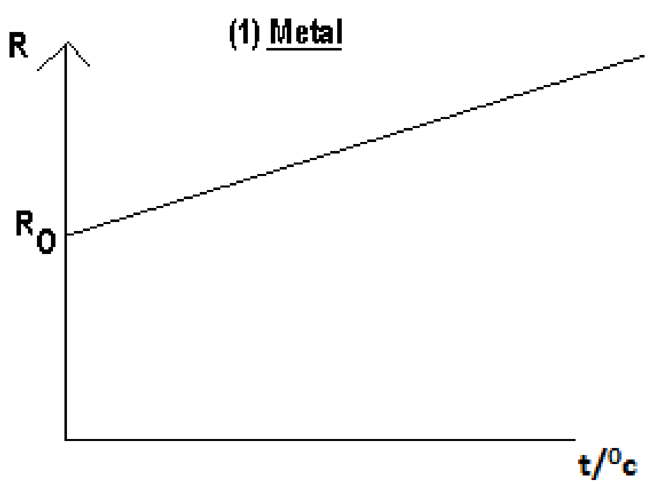
-In an insulator, the conduction and the valence bands are separated by a wide forbidden band.

-To get to the empty states in the conduction band from the filled valence band, the electrons need enough energy to cross the forbidden band.

- And under normal electric fields, these electrons do not obtain this large amount of energy.

- For this reason, they are therefore unable to drift to the conduction band, and hence there is no conduction.

Change of resistance with temperature:

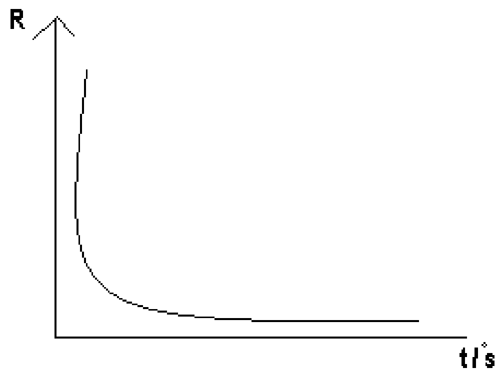


- As the temperature of the metal increases, the amplitude of vibration of its atoms increases.

- More collisions with atoms are therefore made by the drifting electrons, making it more difficult for them to drift through.

-Hence the resistance(R) of a pure metal rises with temperature.

(2)**Semi-conductor**:



- As the temperature rises, more electrons acquire enough energy to enable them break away from the valence band, and enter the conduction band, where they become available for conduction.
- Conductivity therefore rises with increasing temperature and since conductivity varies inversely with resistance, then the resistance decreases with temperature.
- The temperature co-efficient of resistance for a semiconductor is negative, but, it is positive for a metal.

Substance → Property ↓	Conductors	Semiconductors	Insulators
Conduction band	Filled completely with electrons	Partially filled with electrons	Completely empty of electrons
Forbidden band	Does not exist	Completely filled with electrons	Completely filled with electrons
Valence band	Completely filled with electrons	Completely filled with electrons	Completely filled with electrons

Resistivity	Least	Intermediate	Greatest