# CHAPTER: 16
# ELECTROMAGNETIC WAVES AND ELECTRONICS

**ELECTRONICS:**
It is the branch of physics which deals with development of electron emitting devices their utilization and controlling of electron flow in electrical circuits designed for various purposes.

**CONDUCTOR:**
Substances through which electric current can pass easily are called conductor e.g. copper, silver, gold, alumunium. Metals are good conductor of electricity. They have a low value of resistivity of the order of less than $10^{-6}$ Ω.m.

**INSULATORS:**
Substances through which electric current can not pass are called insulators e.g. wood, Rubber, glass. The insulator has a high value of resistivity of the order more than $10^{6}$ Ω.m.

**SEMI CONDUCTOR:**
Substances having intermediate values of resistivity of the order $10^{-2}$ Ω.m. to $10^{2}$Ω.m. are known as semiconductor e.g. germanium and silicon. These elements have four electrons in their outer most shell. They are tetravalent. In a germanium or a silicon crystal atoms form covalent bond with each other as shown in the figure. They have no free electrons. Pure germanium or silicon are also called intrinsic semi conductor they have crystalline structure.
If a small amount of impurity from third or fifth group of periodic table is added to a semi conductor its conductivity changes and the substance is called extrinsic semi conductor.

**DOPING:**
The addition of impurity in a pure semi conducting material is called doping.

**IMPURITIES:**
To increase the conductivity of a semi conductor a small amount of an element form fifth group of periodic table e.g antimony (sb) arsenic (as) phosphorous (p) is added to germanium or silicon. Similarly to increase the conductivity of an element form third group of periodic table e.g alumunium (Al) gallium (Ga) indium (In) is added to germanium or silicon.

These substances of fifth and third group are called impurities. There are two types of impurities 1 donor are two impurities (μ) acceptor impurities.

**1. DONOR IMPURTIES (FORMATION OF n-TYPE SUBSTANCES):**
Impurities of fifth group or petravalent impurities are called donor impurities. When such type of atom is added to germanium or silicon four of its electron form covalent bond with four neighboring atoms of germanium or silicon while fifth one remains free. In this way one electron is donated to germanium or silicon crystal. The germanium or silicon becomes N-type substances.

**2. ACCEPTOR IMPURITIES: (FORMATION OF p-TYPE SUBSTANCE):**
Impurities form third group or trivalent impurities are called acceptor impurities. When such type of atom is added to germanium or silicon three of its electron forms covalent bond with three electrons of germanium or silicon while there exist a vacancy of an electron in the 4$^{th}$ covalent bond shortage of one electron is compensated by accepting an electron form its neighbor. So it is called acceptor impurities. The vacancy of electron is called hole and is considered as positive charge carrier. The germanium or silicon becomes p type substance.



**THE p-n JUNCTION OR SEMI CONDUCTOR DIODE:**
When a block of p-type material is put adjacent to a block of n-type material the common place is termed as p-n junction as the device is called semi conductor diode. At the junction there is a tendency for the free electrons to diffuse over to the p side and holes to n side. This process is called diffusion.
As the free electrons move across the junction form n type to p type a positive charge is built on the n side of the junction charge is built on the n side of the junction. At the same time a negative charge is establish on p

side of the junction and further diffusion is prevented. It is because now positive charge on n side repels holes to cross form p side to n type and negative charge on p side repels free electrons to enter form n type to p type. Thus a barrier is setup against further movements of electrons and holes. This is called potential barrier or junction barrier (V0) which is of the order of 0.1 to 0.7 volts. This potential barrier give rise to an electric field the region of the barrier is called depletion region.

When a p-n junction diode is connected across a battery it permits the flow of current in one direction.

**BIASING:**

The application of some electric potential across the diode is known as biasing. The potential difference across a pn junction can be applied in to ways which are called i) forward biasing and ii) reverse biasing.

**1. FORWARD BIASING:**

A junction is said to be forward bias if its p type side is connected to positive terminal and n type side is connected to negative terminal of a battery as shown in the figure. On p side the electric field derives the holes towards the junction and on n side. The electric field derives the electrons towards the junction the resistance of the junction decreases and almost becomes zero.

The barrier height decreases and current starts flowing though the junction. The current in p type is due to holes and current in n type is due to electrons. The current in the outer circuit is due to electrons.

**2. REVERSE BIASING:**

A junction is said to be reverse bias if its p type side is connected to negative terminal and n type side is connected to positive terminal of a battery as shown in the figure.

The holes in the p type and electrons in the n type material are attracted by the negative and positive terminals of the battery and therefore move away form the junction thus height of the potential barrier increases and no current or very small current flows through the junction. The resistance of the junction increases.

**DIODE AS A RECTIFIER:**

The device which converts alternating current/voltage in to pulsating direct current voltage is called a rectifier.

As semi conductor diode also known as crystal diode can be used for rectification purpose. Two types of rectification can be obtained using a diode i) holy wave rectification and ii) full wave rectification.

**1. HALF WAVE RECTIFICATION:**

In half wave rectification the rectifier conducts current only during the positive half cycles of input ac supply. The negative half cycles of ac supply are suppressed i.e during negative half cycles no current is conducted and hence no voltage appears across the load in the external circuit. Therefore current always flows in one direction through the load after every half cycle.

**Circuit details:**

A half wave rectifier consists of.

1) A transformer which increases or decrease the ac supply voltage.

2) A semi conductor diode which acts as a half wave rectifier.

3) A load resistance $R_L$ at which dc output is obtained.

All the components are connected according to the circuit shown in the diagram.



**OPERATION:**

The a, c voltage across the secondary winding AB changes polarities after every half cycle during the positive half cycle of input ac voltage and A becomes positive with respect to and B. it repels the holes towards the junction i.e. the diode becomes forward biased and hence it conducts current. During the negative half cycle end A is negative with respect to end B. it attracts the holes i.e the diode becomes reversed biased and it conducts no current. Thus the current flows through diode during positive half cycles of input ac voltage and it is blocked during the negative half cycles. In this way current flows though load $R_L$ always in the same direction hence pulsating dc output is obtained across $R_L$.

**2. FULL WAVE ECITIFICATION:**

In full wave rectification current flows through the load in the same direction for both half cycles of input ac voltage. This can be achieved with two diodes working alternating. For the positive half cycles of input voltage and diode supplies current to the load and for the negative half cycle the other diode supplies current to the load.

**Circuit details:**

A full wave rectifier consists of.

1. A center topped transformer.
2. Two semi conductor diodes $D_1$ and $D_2$ which acts as rectifier.
3. A load resistance $R_L$ at which dc output is obtained.

All the components are connected according to the circuit shown in the diagram.



**OPERATION:**

During the positive half cycle of secondary voltage the end A of the secondary winding becomes positive and end B negative. This makes the diode $D_1$ forward biased and diode $D_2$ reverse biased. Therefore diode $D_1$ conducts while $D_2$ does not. Thus current flows through diode $D_1$ load resistor $R_L$ and the upper half of the secondary winding OA. During the negative half cycle end A of the secondary winding becomes negative and end B positive. Therefore diode $D_2$ conducts while diode $D_1$ does not. D2 load R2 and lower half winding OB as shown in the figure. Since current in the load Rs is in the same direction for both half cycles of the input voltage therefore pulsating dc output is obtained across the load Rs for both cycles of the input a. c. voltage and it is blocked during the negative half cycles in this way current flows through load R always in the same direction hence pulsating d. c. output is obtained across R

**2- Full wave rectification**

In full wave rectification current flows through the load in the same direction for both half cycles of input a. c. voltage this can be achieved with two diodes working alternately for the positive half cycle of input voltage one diode supplies current to the load and for the negative half cycle the other diode supplies current to the load

**TRANSISTOR:**

The word transistor is the combination of two words (i) transfer and (ii) resistor transistor is a semiconductor device that has three electrons the first device that was invented was the "Bipolar Junction transistor" (BJT)

**Construction:**

A transistor consists of their central layer of one type of semiconductor material sandwiched between the two relatively thick pieces of the other type of semiconductor the central port is known as the BASE (B) and the pieces at the either side are called the EMITTER (E) and the COLLECTOR (C).

There are two types of transistor

1) n-p-n Transistor and

2) p-n-p Transistor

**1- npn Transistor:**

The npn transistor has a thin piece of p –type material sandwiched between two pieces of n- type material

**2- pnp Material:**

The pnp transistor has a thin pieces of n- type an material sandwiched between two pieces of p- type material as symbols of transistor. The arrows of the transistor show the direction of conventional current from p to n

**TRANSISTOR OPERATION:**

The emitter – base junction of a transistor is forward biased whereas the collector – base junction is reverse biased the current in the collector circuit depends upon the emitter current

**1) Working of npn transistor:**

Consider a npn transistor whose emitter – base junction is forward biased while collector- base junction is reverse biased as shown in the figure the forward bias causes the electrons in the n- type emitter flow towards the base this constitutes the emitter current "$I_E$" as electron flow through p –type base they tend to combine with holes since the base is lightly doped and is very thin therefore only a few electrons (less than 5%) combine with holes the remainder (more than 95%) cross over the collector region to constitute collector current "$I_C$" the loss of holes in the base is compensated by some holes flowing to it from the base power supply this forms a small base current "$I_B$" since the current leaving the transistor equal that entering $I_E = I_B + I_C$

**Current Gain:**

The ratio of $I_C$ and $I_E$ is called current gain i.e.



Current gain $= \propto = \frac{I_C}{I_E}$

**Working of pnp Transistor:**

Consider pnp transistor whose emitter base junction is forward biased while collector base junction is serve biased as shown in the figure

The forward biase causes the holes in te p- type emitter to flow towards the base which constitutes the emitter current "$I_E$" as these holes flow through the n- type base they tend to combine with electrons since the base is lightly doped and very thin therefore only a few holes combine with electrons the remaining holes cross into the collector region to constitute the collector current "$I_C$" the loss of electrons in the base is compensated by some electron flowing to it from the base power supply this forms a small base current "$I_B$" since the current leaving the transistor

$$I_E = I_B + I_C$$

Here the current conducted in the transistor is by holes but in the external connecting wire the current is by electrons