PHYSICS GRADE 10
UNIT 5 SUMMARY

Introduction to Electronics

5.1 Vacuum tube device

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By the end of this section you should be able to :.

- ✓ ***Define the term electronics***
- ✓ ***State the important of electronics in your daily life***
- ✓ ***State what is meant by thermionic emission.***
- ✓ ***Describe the behavior of vacuum tube .***
- ✓ ***Describe the function of a cathode ray tube .***
- ✓ ***Represent both d.c and a.c on current – time or voltage time graph***
- ✓ ***Use the current – time or voltage – time graph to find the period and frequency of alternating current or voltage.***

Vacuum tube device

Thermionic emission

- **Thermionic emission** is the escape of electron from heated metal surface .
- Its rate negligible at ordinary temperature , and does not become significant until **high temperature** are reached .
- Thermionic emission provides a controllable supply of electron in vacuum. This is the basis of cathode ray oscilloscope.
- **cathode r**ay oscilloscope is a pieces of equipment that has important uses in studying and displaying electrical signals or oscillation.

Vacuum tube

Thermionic diode :. a vacuum tube is now almost obsolete, its **jobs** is now being preformed by the semiconductor diode.

Diode is **device** that **has two** electrode :. Which is **anode** and **cathode**.

A metal plate has been heated so as to emit electrons. This was done electrically by placing the cathode in front of what amounted to an electric heater as shown . This heater is tungsten.

It is operated off a few volts ,either a.c or d.c .

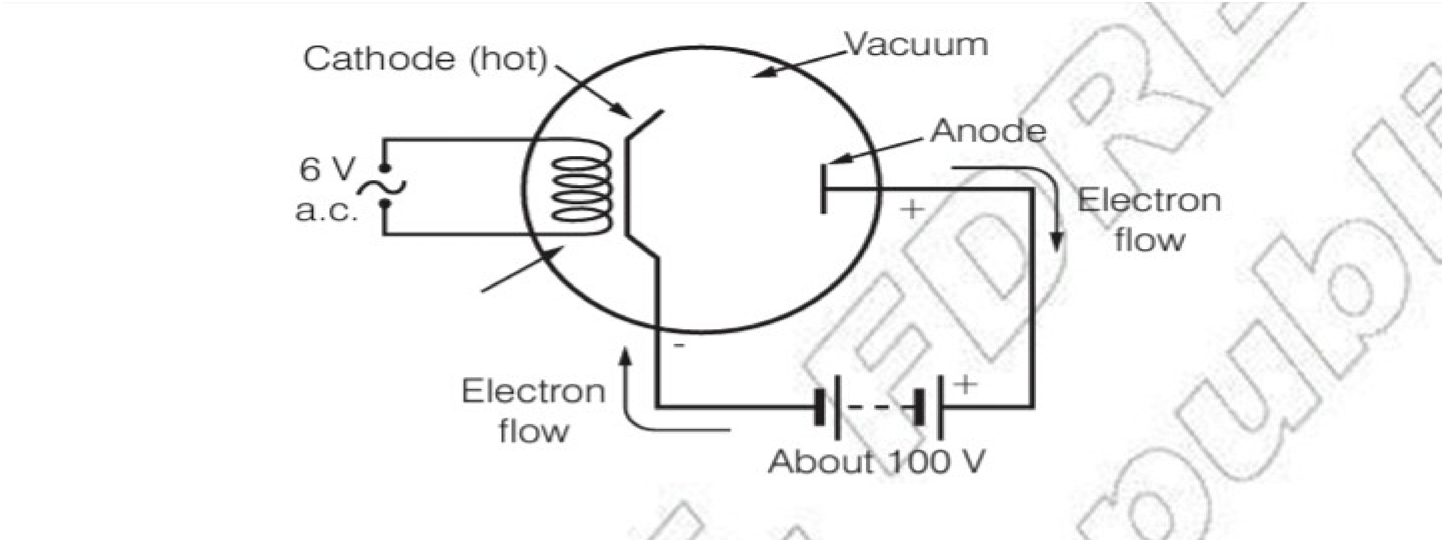


Figure 5.1 *Thermionic diode.*

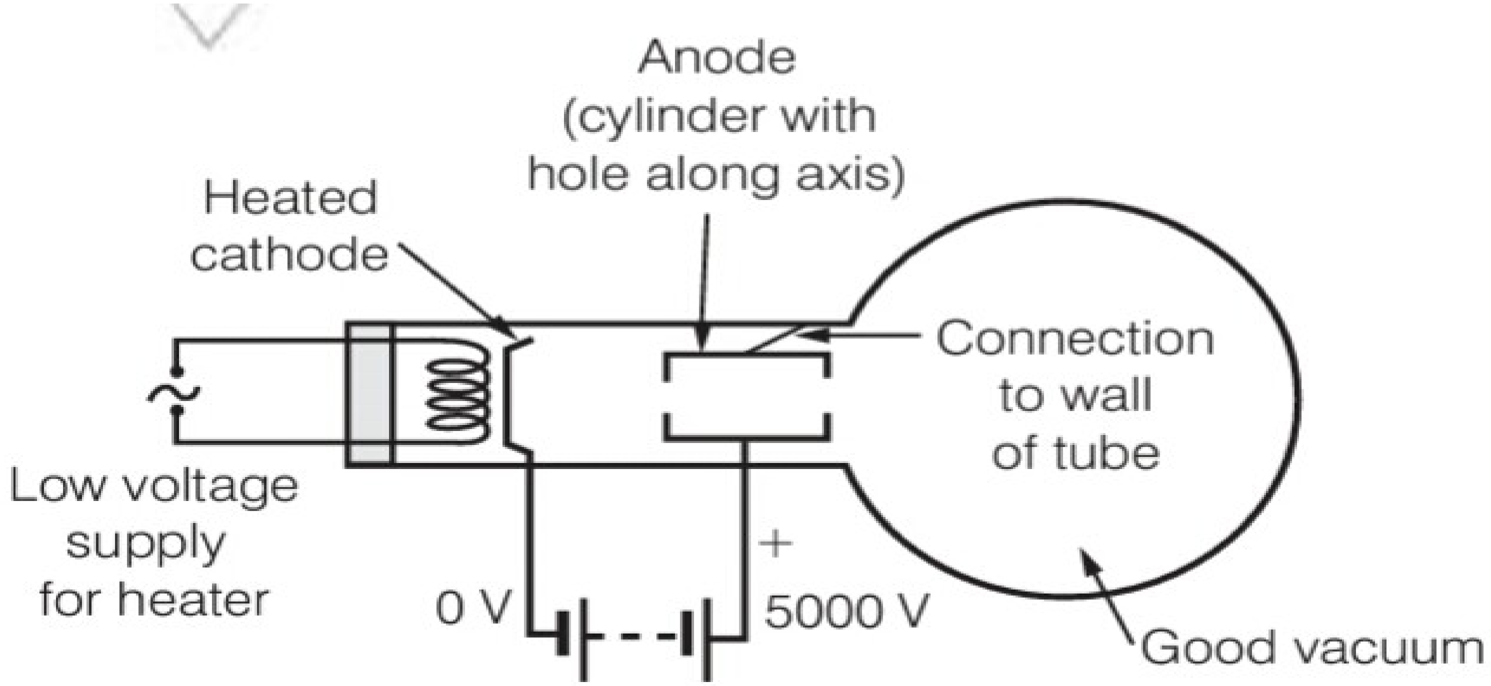
From the diagram of Thermionic diode ;

- **Electron boil off** from the heated cathode and were attracted to the anode. :- a cold metal plate which was commonly at about 100V with respect to the cathode .
- **the main use of device (diode**) was for rectification. i.e to o obtain a d.c current from alternating voltage. It behaves like a valve in a water pipe and permitted one-way flow only. Current could pass across it in the direction shown in figure 5.1 but if the polarity of the main battery was reversed the clod anode would not emit electrons in to the vacuum and so current would not flow.
- **Adiode** valve provide useful of power because of the heater.

Cathode ray

- **Cathode rays are** a beam of electrons moving through a vacuum a high speed. They are produced by an electron gun ,which is a vacuum tube device

- **Used for controlling the number of electron**



As in the thermionic diode ,electrons are realesed from heated cathode by thermionic emission and are attracted toward the anode.

- **un like the diode , the voltage on the anode may be as 5000V relative to the cathode**. The electrons are pulled to ward the center of the anode , accelerating to very high speed – of order of a tenth that of light –shooting straight through the hole along the axis of the anode.

X-ray tube

The x-ray machine is also a vacuum tube device. Electrons are released from the cathode by the thermionic emission and are then accelerating through a p.d of the order of 100kV so as to hit the anode an extremely high speed . When such fast- moving cathode rays are suddenly stopped , x-rays are produced.

Most of the beam's energy is released as heat rather than x-rays, so the anode gets very hot. To minimize this it is made of large block of copper to conduct the heat away

, the other ending being equipped with cooling or having fins or having cold liquid pumped round it.

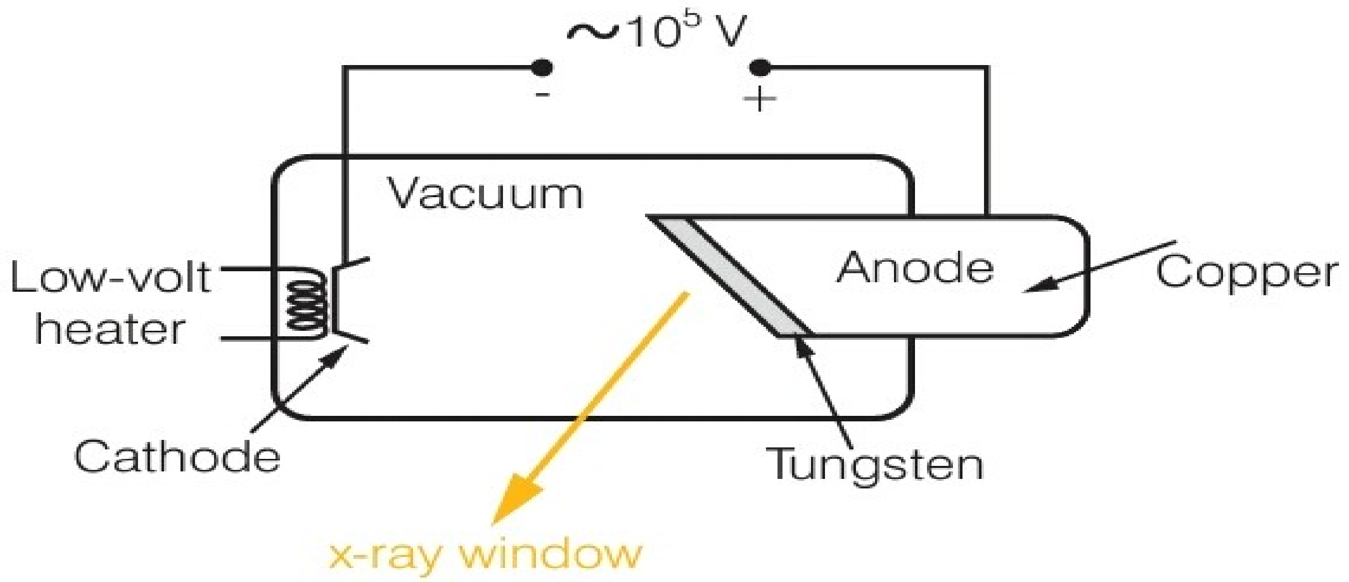
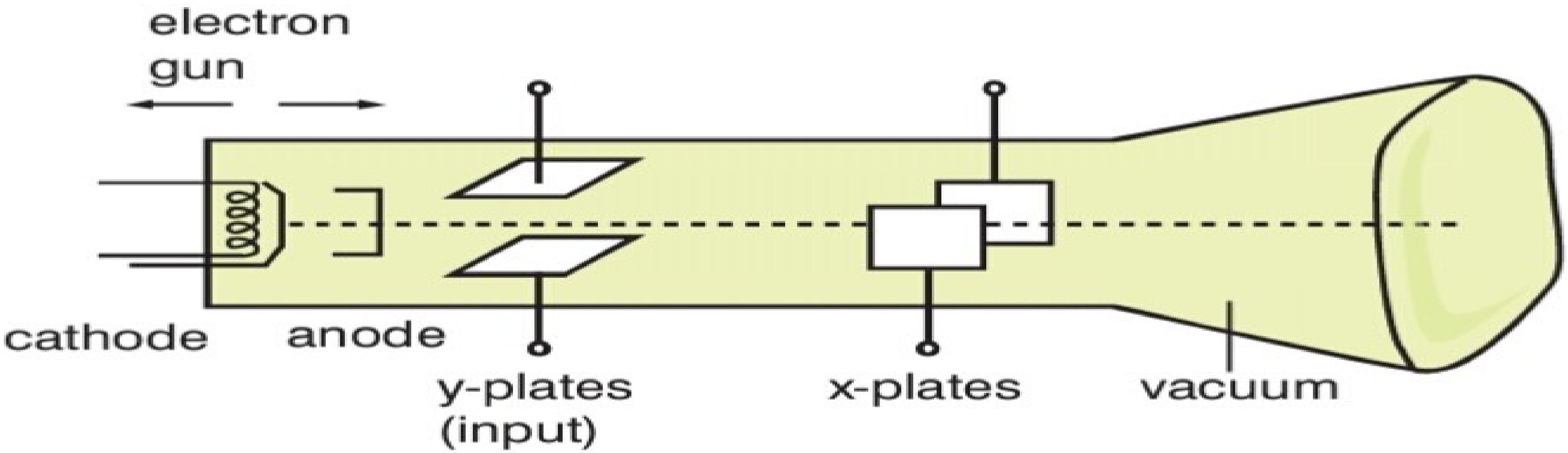


***Figure 5.3** X-ray tube.*

CATHODE RAY OSCILLOSCOPE (CRO)



95.4 *The cathode ray oscilloscope.*

- Another very useful vacuum tube device is the cathode ray oscilloscope.
- In cathode ray oscilloscope the beam of electrons are produces a spot on fluorescent screen at the end of the tube. Before reaching the screen it pass between two set of deflecting plate- one pair to deflect it in the y- direction and the other in the x- direction.

Cathode rays are:-

- Travel in straight line
- Start normally from the surface of the cathode
- Exert mechanical pressure on the surface at which it fall.
- Produce fluoresce on certain substance on which they fall.
- Penetrate through thin layer of matter.
- produce ionization in the gas through which they pass.
- Are attracted by electric field.
- Are deflected by magnetic field.
- Posses large amount of kinetic energy.

From these properties of cathode ray it was conclude that cathode rays are actually stream of negatively charged particles .We now knows these rays are actually a **shower** of electrons.

<u>Some use of the CRO</u>

It use as direct current:-

The CRO can be used as voltmeter and will represent the voltage of a source of direct current as stationary spot of light on the screen.

It uses as sensitivity

The sensitivity – the size deflection caused by the voltage applied across the y-plate of a CRO- can be adjusted using the gain control.

For example:- If the sensitivity is set to 3V per cm and the spot is deflected by 2cm by unknown potential difference . Then the unknown potential difference can be calculated as follow:-

Look the diagram below.

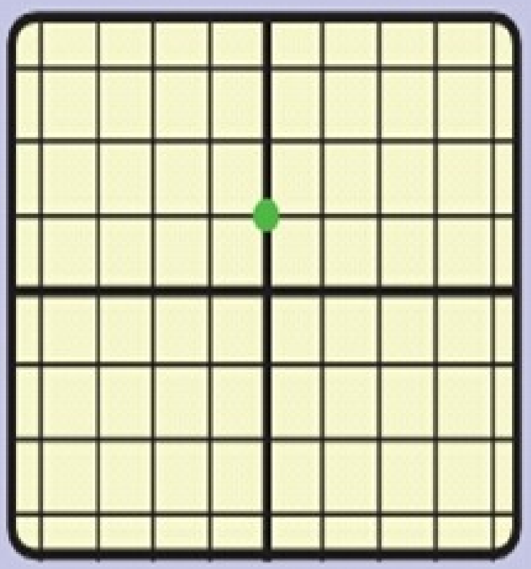


Figure 5.5a

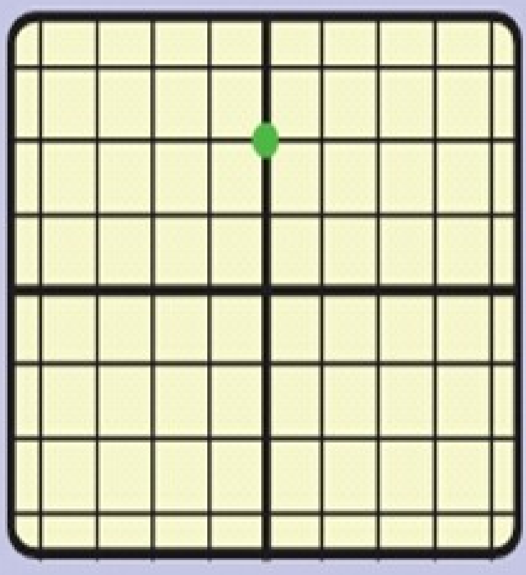


Figure 5.5b

Then if 1cm represent 3V

2cm = ?

Solution

1cm = 3V

2cm = X

$$X = \frac{2cm \times 3V}{1cm}$$

X=6cm

Example 2:- A 1.5 V cell is connected to the y- plate of a CRO and the gain control adjust so the trace is 1cm above the zero line (Figure 5.5a) .The cell is removed , unknown potential difference is applied to the y- plate and new trace is seen on the screen of the CRO (Figure 5.5b)

What is the size of the unknown potential difference?

Solution

1cm = 1.5V ,2cm deflection is represent

2cm = X

$$X = \frac{2cm \times 1.5}{1cm}$$

X = 3V

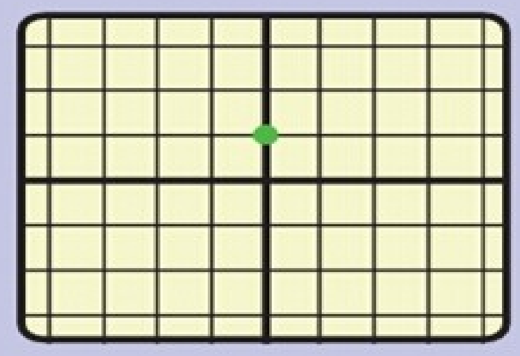


Figure 5.5a

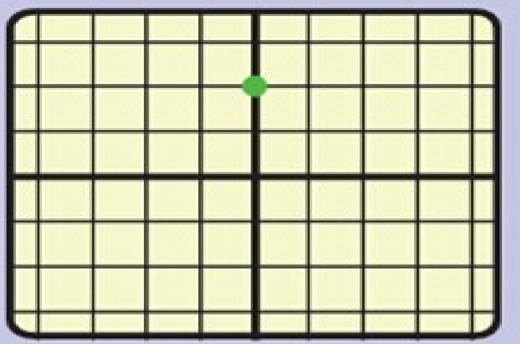


Figure 5.5b

Cathode ray oscilloscope use as time base

- ✓ Time base is applied along the x- plate. This pulls the spot across the screen from left right at steady rate , it then flies backs to the left hand side and represents its movement.
- ✓ If the time base is applied to a signals made by a direct current the trace change from dot (Figure 5.6a) to line (Figure 5.b)

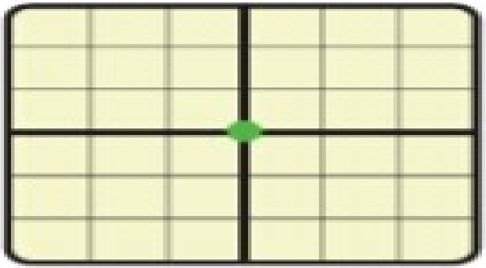


Figure 5.6a *Time base off.*

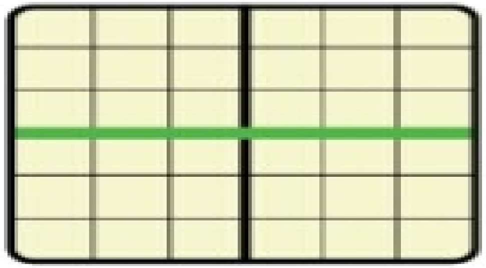


Figure 5.6b *Time base on.*

CRO is used as Alternating current

The voltage of alternating current varies between (a positive maximum to (a negative) minimum . If the time base is switched off this is represented as vertical line on the screen of a CRO.

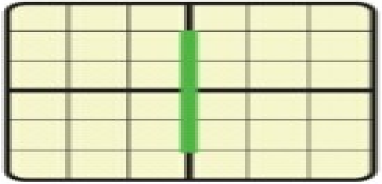


Figure 5.7a Time base off.

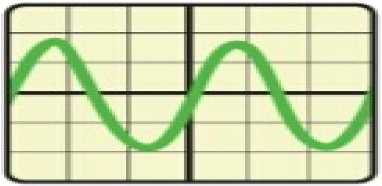


Figure 5.7b Time base on.

From the above figure 5.7b if the time base is switched on, this become a curve whose shape is known as **sine wave.**

Finding the period and frequency of alternating currents or voltage using CRO

In the same way that an unknown p.d can be measured using a CRO by **comparing its trace** with that made by a known a p.d , **The CRO** can measure frequency by comparing a wave of unknown frequency with known frequency.

- The Known signals is applied to the CRO and the time base adjusted so that one complete wave appears on the screen (In figure 5.8a) .The known signals is then applied in place of the known signals ,with out alternating any of the CRO controls and the trace on the screen is studied (figure 5.8b)

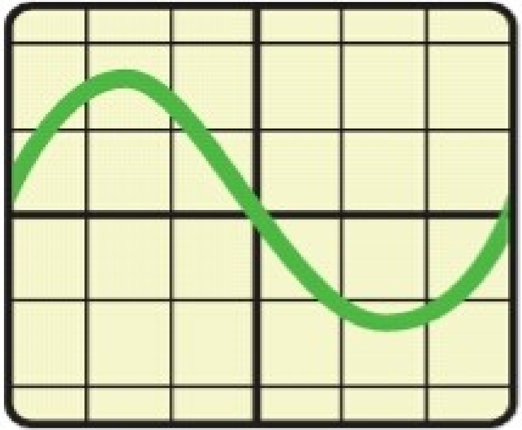


Figure 5.8a *(50 Hz).*

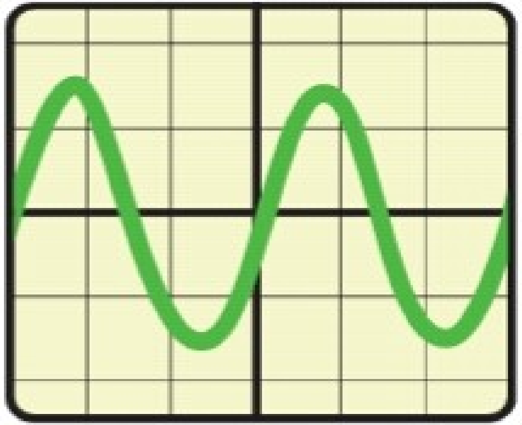


Figure 5.8b *(unknown).*

As figure 5.8 b shown to complete waves it follows that the unknown frequency is twice that of known signals . Then find unknown frequency.

The known frequency = 50HZ

Since the unknown frequency twice that of known frequency

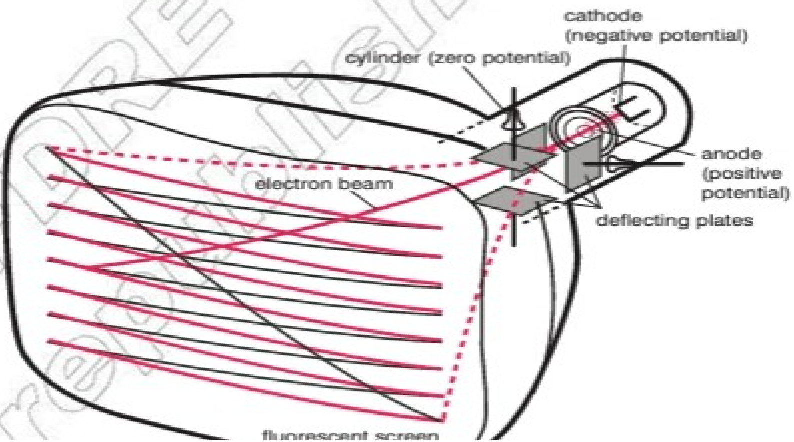
Then unknown frequency = 2 x 50Hz

= **100HZ**

TV picture tube

- The older sort of television , with the big heavy tube ,is similar to CRO. The receiver sends currents through coil that are mounted just out side the tube; their magnetic field deflect the spot of light on the screen so it moves rapidly to trace an order path all over the screen.

the screen.



cathode
(negative potential)
cylinder (zero potential)
anode
(positive
potential)
electron beam
deflecting plates
fluorescent screen

5.2 Conductor, semiconductor and insulator

Material can be divided in to three classes.

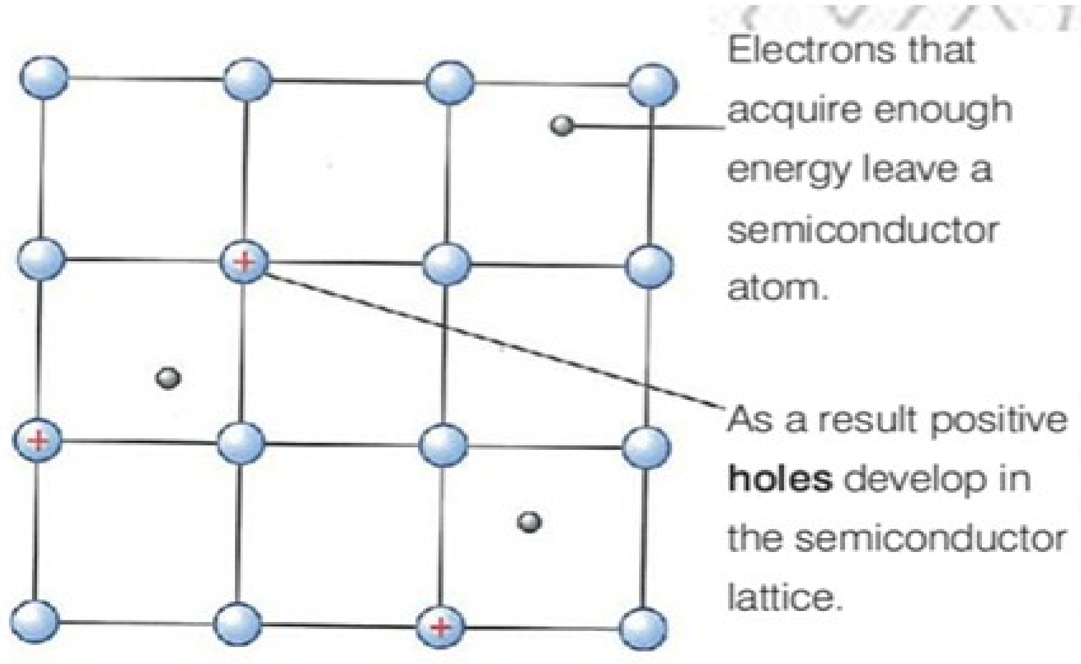
- **Insulator** :- Such as glass, and plastic , which do not conduct electricity because every electron in them is tightly bound to its parent atom.
- **Conductor** :- Such as metal:- All the electron in the inner shell are still tightly bound to their atoms . However ,those electrons in the outer most shell of ever atoms are free to move with in the metal.
- **Semiconductor**:- Just the few of the outer most electrons have enough energy to be in the conduction (that is to break free from their parent atom, but this number rises as the material because hotter , silicon , germanium , leadsulphide , selenium and gallium arsenide are all semi conductor.

Intrinsic semiconductor

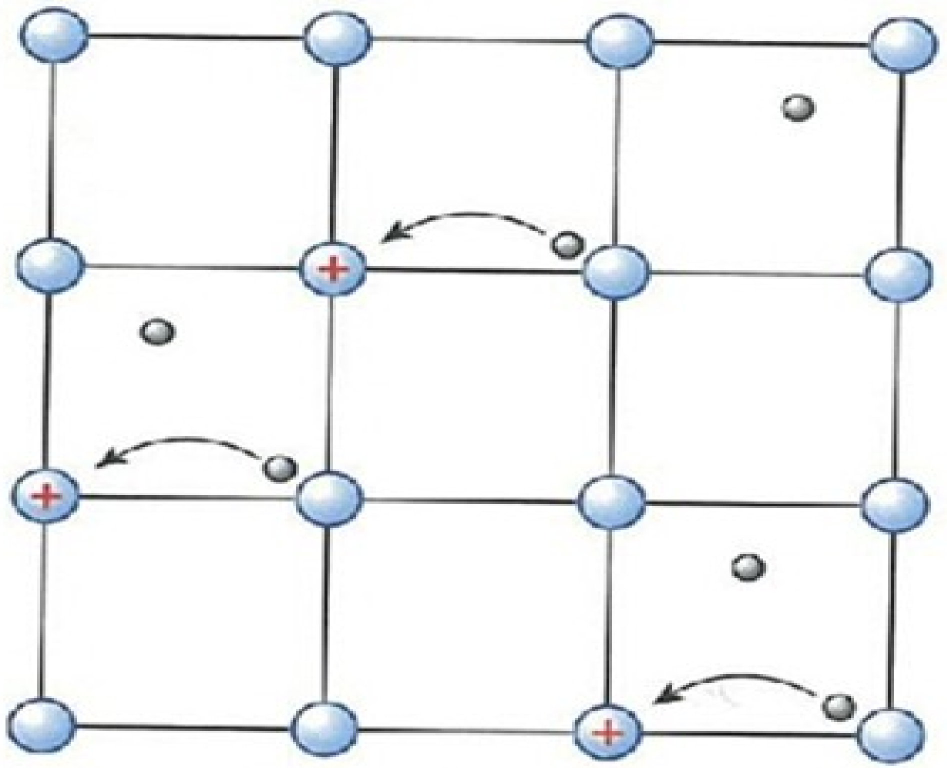
- ✓ Intrinsic semiconductor is a pure semiconductor not contain any dopant.
- ✓ **Pure semiconductor** are usually referred to as intrinsic semiconductor . Such as silicon , germanium etc
- ✓ **Such substance have resistivity between those of insulator and those of conductor .**
- ✓ In intrinsic semiconductor ,electric current is carried by moving electrons , as it is in metal, although the number of charge carriers in silicon is perhaps a billion times fewer than in copper.
- ✓ Intrinsic semiconductor can also be considered to contain moving positive charges that carry current

Lattice structure of an intrinsic semiconductor.

- **Some** of electron in atom of an intrinsic semi conductors are held less tightly than others . This means that in a piece of intrinsic semiconductors materials at room temperature there will be always be a few free electrons that have been ‘shaken free’ of their atoms by thermal excitation (when material has absorbed energy from the surrounding).
- **When** an electron leaves an atom in this way the atoms becomes positively charged . The effect of electron leaving an atoms is therefore to create a positive charge in the semiconductor lattice . This positive charge is called a hole


Electrons that acquire enough energy leave a semiconductor atom.
As a result positive **holes** develop in the semiconductor lattice.

When an electric field is applied to the semi conductor (that is when it connected to the source of e.m.f) the electron and the holes move in opposite direction and semi conductor exhibit intrinsic conduction. This happens because , under the influence of this electric field electron still bound to atom in the lattice are able to move through the lattice from an atom to near by hole.



Thus cause the hole to appear to move through the lattice. This motion happens in the opposite direction to the motion of electron.

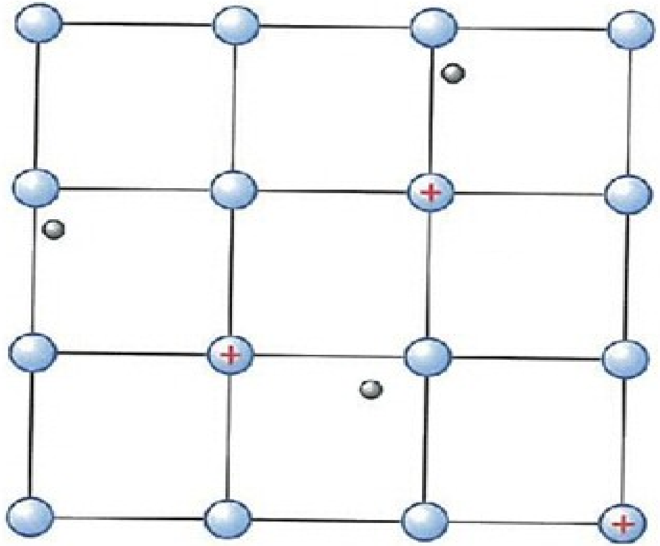
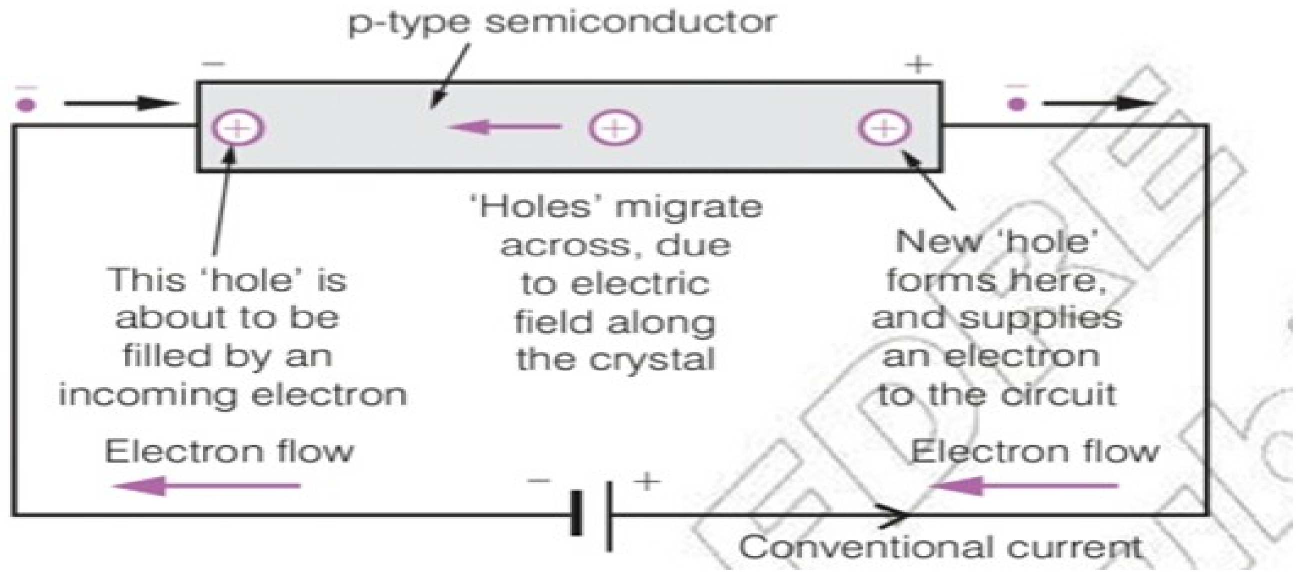


Figure 5.13c

The current in a pure semiconductor consist of free electron moving through the semiconductor lattice in one direction ,with the equilibrium of positive charged holes moving in the other direction.



Charge carrier resistance in semiconductor—

While the resistance of metallic conductor rise as they warm the resistance of semiconductor falls greatly as their temperature goes up. This because when the temperature of semiconductor is raised , more electron (charge carrier) have enough energy to break free.

- As the number of charge carrier increase ,the resistance of semiconductor decrease the material conduct current.

5.3 Semiconductor (impurities doping)

- Introducing extra charge carrier to some conductor materials is called **doping.**
- Doping is deliberately introducing impurities into a semiconductor to change its electrical properties.
- **When semiconductor increasing their conductivity by introducing extra charge** carrier to semiconductor lattice ,forming what is called extrinsic semiconductor.

- Extrinsic semiconductor is a semiconductor that is doped.

Majority and minority charge carrier

If phosphorous atoms with five outer electros are substituted as an impurities for some of the silicon atoms , the fifth electron is not needed for binding to adjacent atoms and is free to move through the solid. Such extrinsic semiconductor with an impurities donating free electrons to the crystal is known as **n- type** semiconductor

Extrinsic semiconductor is a semiconductor that is doped.

Majority and minority charge carrier

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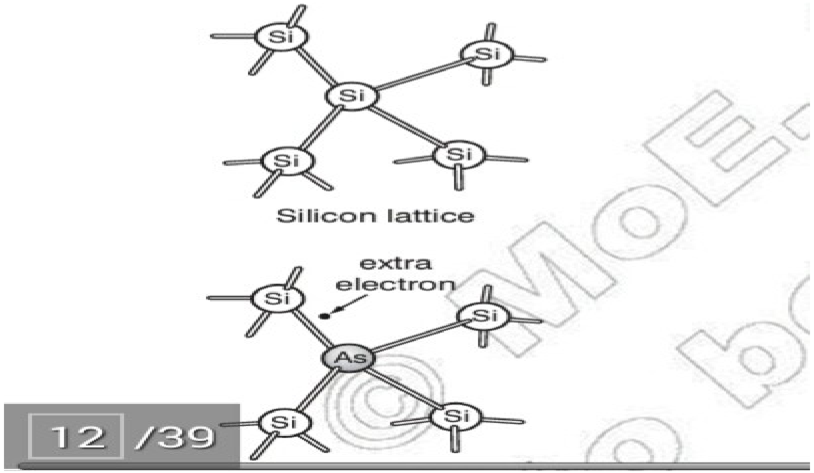


- **when** boron doped to semiconductor such as silicon one deficiency of electron is formed . Such extrinsic semiconductor is called **p- type** semiconductor , because it accept one electron from the neighboring atoms . The majority charge carriers in n-type semiconductor is called electro while the minority charge carrier in p- type semiconductor is called a hole

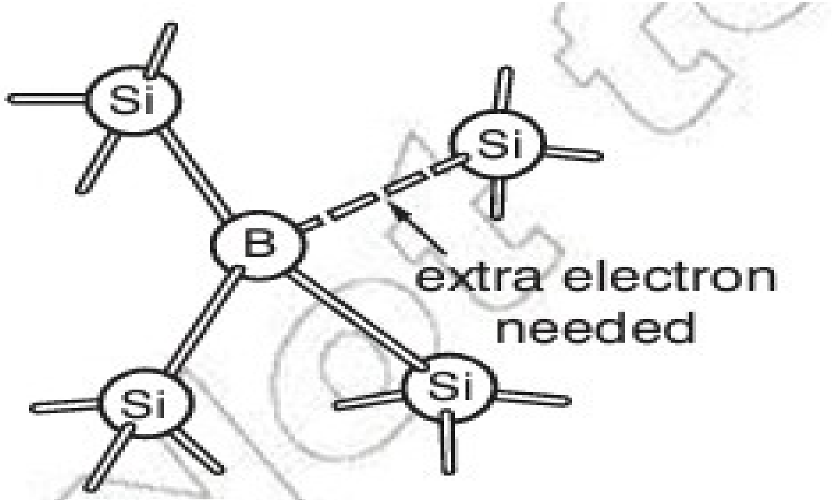


***Figure 5.16** Dopants in a silicon lattice.*

- The number of free electrons and holes can be altered dramatically by doping. For example the addition only arsenic atoms per millions silicon atoms increase the conductivity 100,000 times.

The p-n junction diode.

Suppose the p-n type semiconductor is in contact with an n-type one. At the junction where they meet some of the n- type electron moves or fall in to the p-type holes. This movement is known as diffusion.

This diffusion current cause the p-type became slightly become negative while the n-type is left equally positive a depleting zone for small distance each side of the boundary.

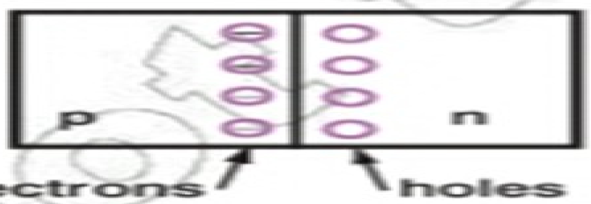
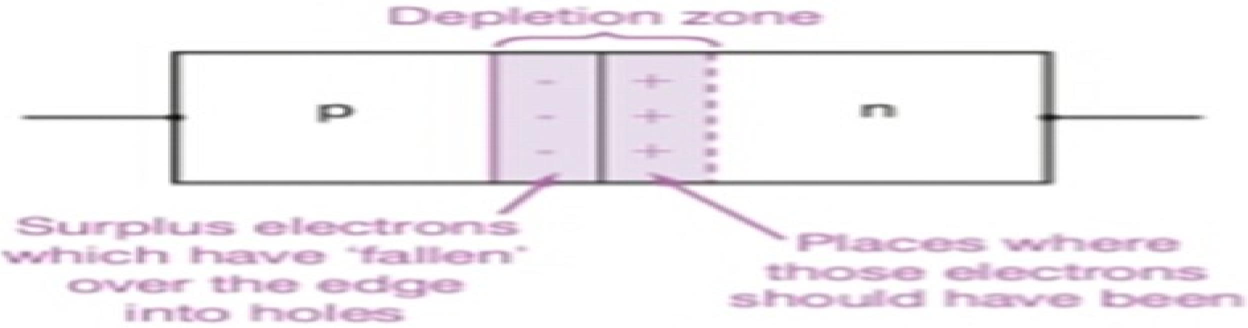


Figure 5.19 p–n junction.



In the depletion zone there are no more ‘holes’ so it forms non conducting strip which block all current .

Forward and reveres bias

- When the positive terminals of the cell connected to the **p- side** and the negative terminals to the n-side the applied voltage of the junction is called forward bias. In forward bias the extra field drives the majority charge carriers (electron n-type and holes in p- type) of each region to ward the junction .
- When negative terminals of the battery is connected to the p- type of the p-n junction , the junction is said to be reverse bias. In reverse bias no current.

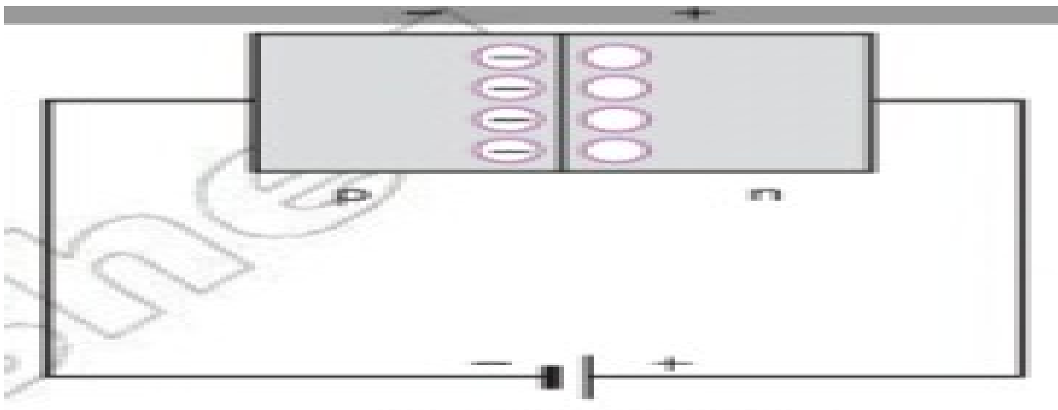
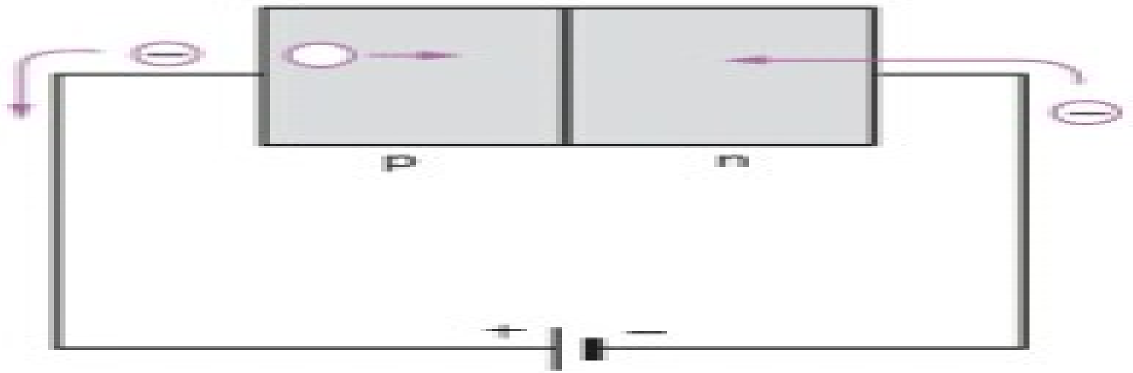


Figure 5.21 Reverse biased, no current.



Current –voltage characteristics of semiconductor diode

- **The p-n junction** as describe acts as a diode ,in the other direction it will conduct , in the other direction it will not. The behavior of this diode can be illustrated by current voltage as shown figure below.
- In forward direction , silicon require a bout 0.6v before conduction will start , after current usually limited by the resistance of the resistance of the circuit. In the other direction notice there will be a tiny leakage current. If the reverse potential be come to great for the device the barrier at the junction breaks and permit large current to flow.

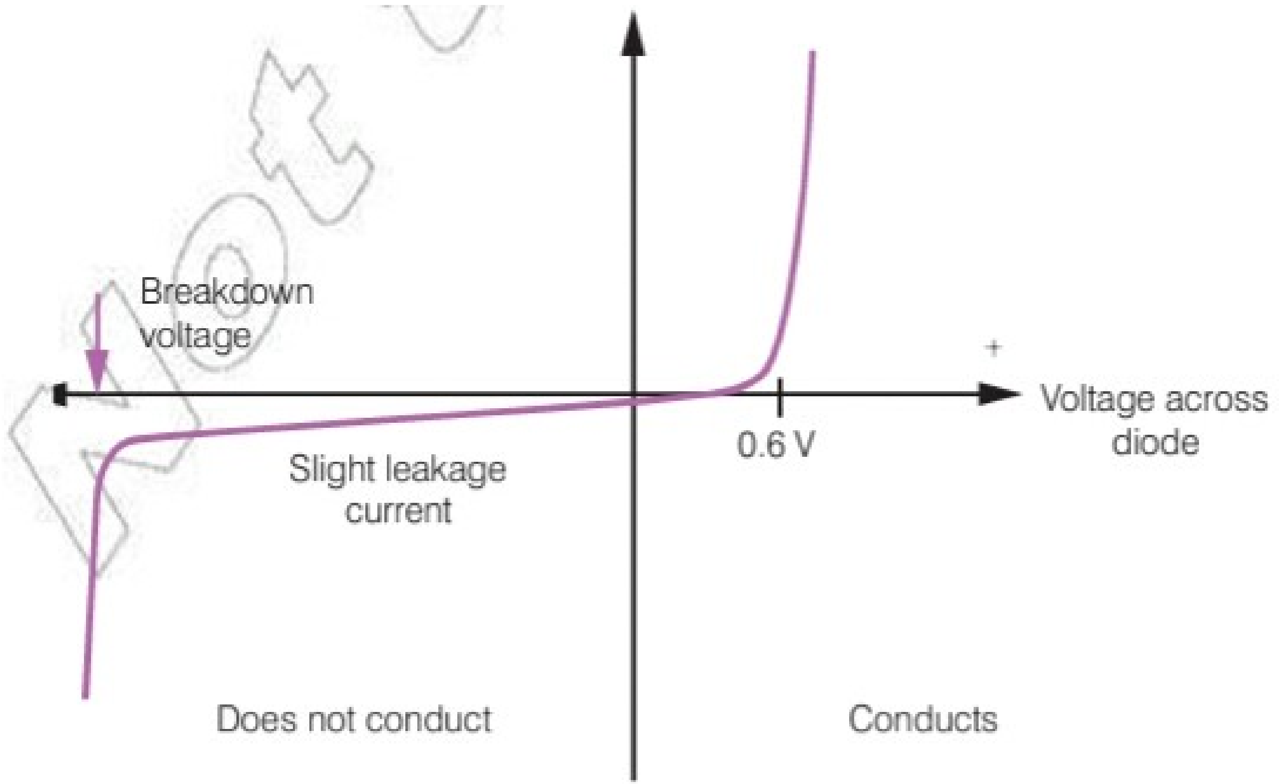

Breakdown
voltage
Voltage across
diode
0.6 V
Slight leakage
current
Does not conduct
Conducts

Figure 5.23

Some conductor device

Diode is an electronic component with two two electrode – an anode and cathode- which will only allow the electric current to pass through it in one direction.

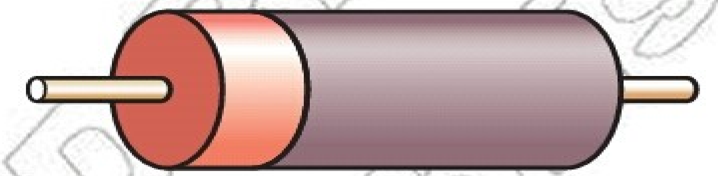


Figure 5.24a *An example of a diode (ringed end shows cathode).*

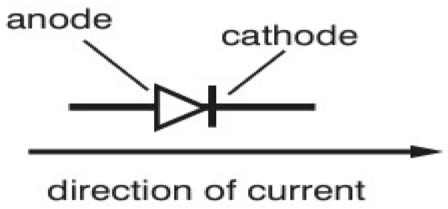


Figure 5.24b *Symbol for a diode.*

- Some conductor diode – formed from a layer of p- type semiconductor joined to a layer of n- type semiconductor materials . It is very important electric component.

LDR(Light dependent resistor)

A light dependent resistor (LDR for short) conducts electricity but in the dark it has very high resistance . Shining light on it appears to (“ unjam”) it because its resistance falls. The brighter the light the better it conduct .The symbol LDR is given below.

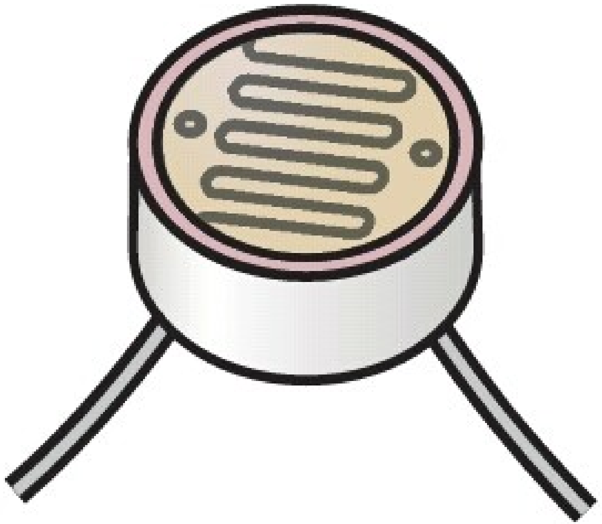


Figure 5.25a *LDR.*

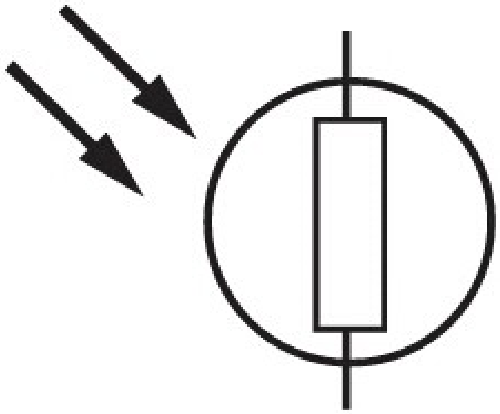


Figure 5.25b *Symbol for LDR.*

Thermistor

Thermistor is a piece of semiconductor for material that has a high resistance in the cold. The resistance drops as it become warmer.

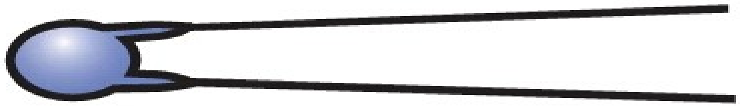


Figure 5.26a Thermistor.

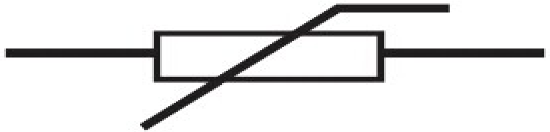
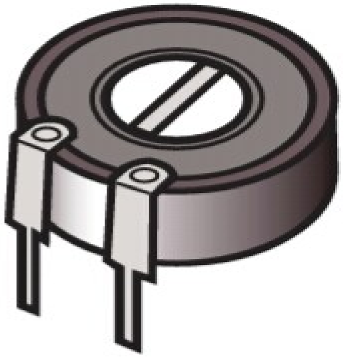


Figure 5.26b Symbol for

Variable resistance

A variable resistance is very useful component in electronic circuit ,particularly in circuit contain transistor



e 5.27a Variable resistor.

Figure 5.27b Symbol for

LED(light emitted diode)

LED is used in multitude device. When a current is passed in forward direction an LED emit light . The LED is very useful component – if there is one in a circuit. It is possible to see immediately if current is flowing . LED have many colours, red , green ,blue and white.

***Figure 5.28a** LED.*

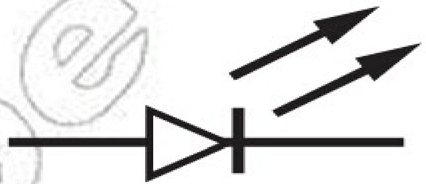


***Figure 5.28b** Symbol for LED.*

Transistor

The transistor is a very significant semiconductor component

Figure 5.29a Transistor.

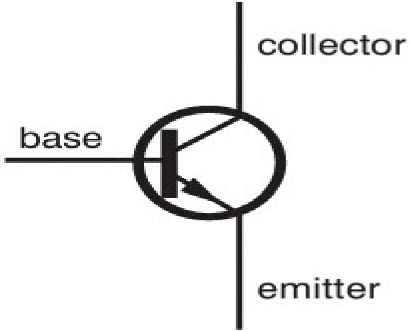


Figure 5.29b Symbol for transistor

- A bipolar junction transistor is made of three layers of doped semiconductor and has three terminals- the base is connected to central layer ,the other two (the collector and the emitter) are each connected one of the outer layer. Figure above shows n-p-n transistor ,which has a layer of p-type semiconductor sandwiched between two layers of n- type.

Photo diode

The photodiode is a light sensitive diode used to detect light or to measure its intensity . Photo diode are reverse bias so they don't conduct. Light incident on photo diode frees a few more electrons and device start to conduct.

Photovoltaic **cell**

The photovoltaic cell is a form of photodiode .The layer of photovoltaic cell solar cell is made up of p-type semiconductor materials. This is covered with layer of n-type semiconductor materials. when light strikes the junction between n- and p-type of semiconductor ,electrons flow through the structure of the cell

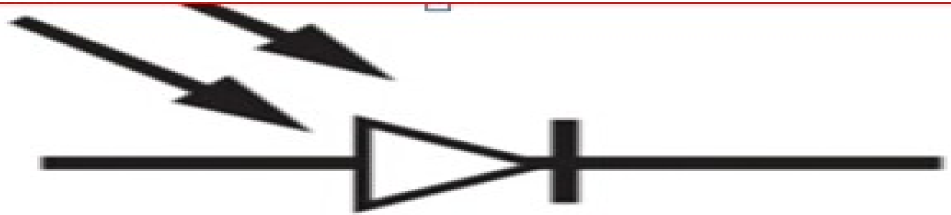


Figure 5.30 Symbol for photodiode.

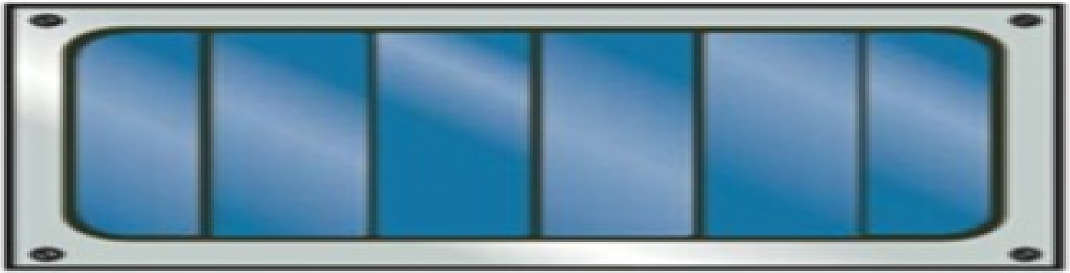
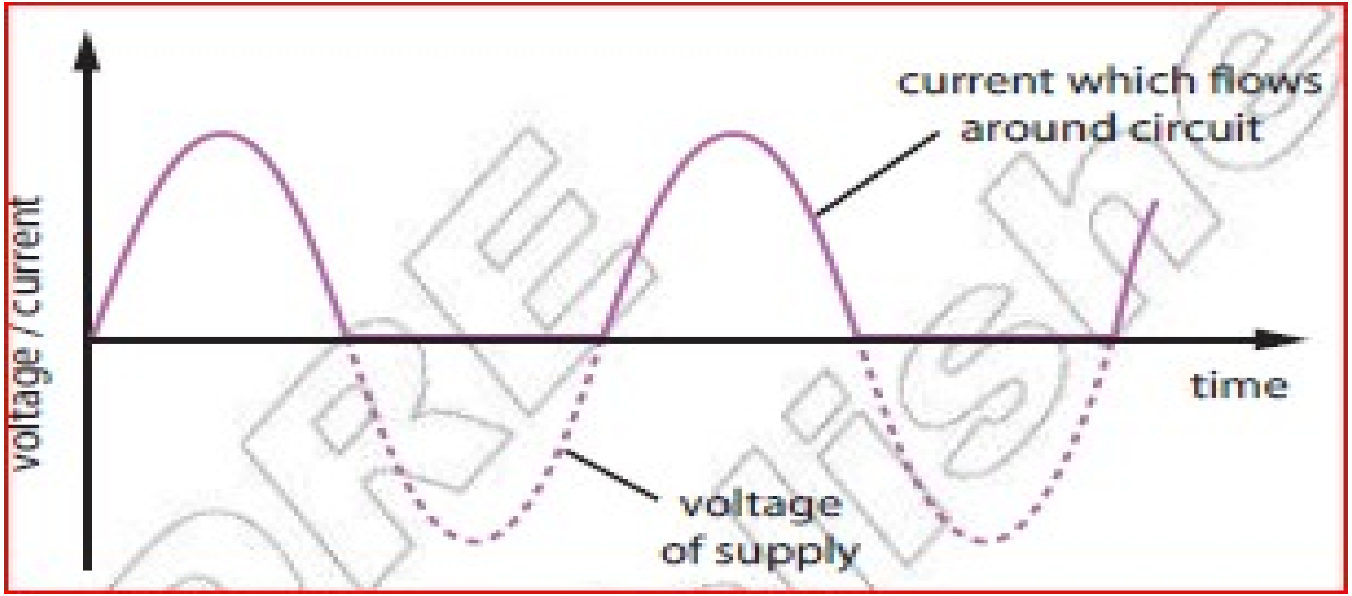


Figure 5.31a Photovoltaic cell .

Rectification using the p-n junction.

Using diode:- diode is allow current to flow current in one way. But on the other half cycle the current can not flow. Back again through the diode but not only diode by using diode and capacitor we can rectify current.



5.4 . Transistor (p-n-p, n-p-n)

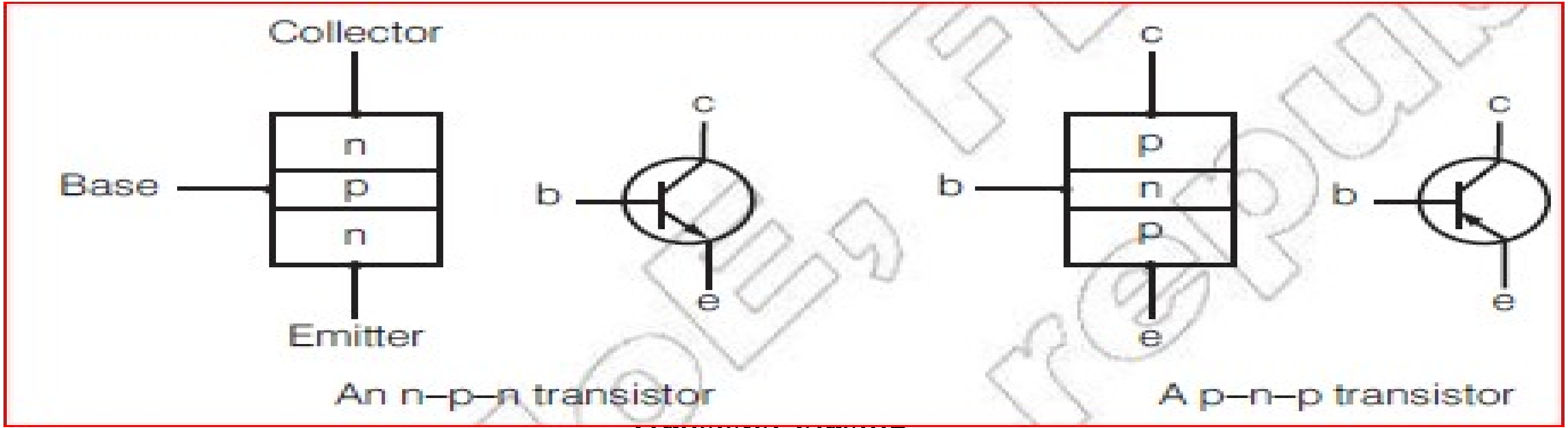
The bipolar transistor

Bi- means two:- therefore , two types of transistor;-

1. p-n-p transistor and
2. n-p-n transistor

Transistor of this type has three terminals one to each semiconductor layer.

- The connection to the central is the base , while the outer two are called the collector and the emitter.
- The two essential feature of transistors are
- The base layer has to be extremely thin
- The collector must be arranged so as to be in physical contact with and surround as much of the bass as possible.

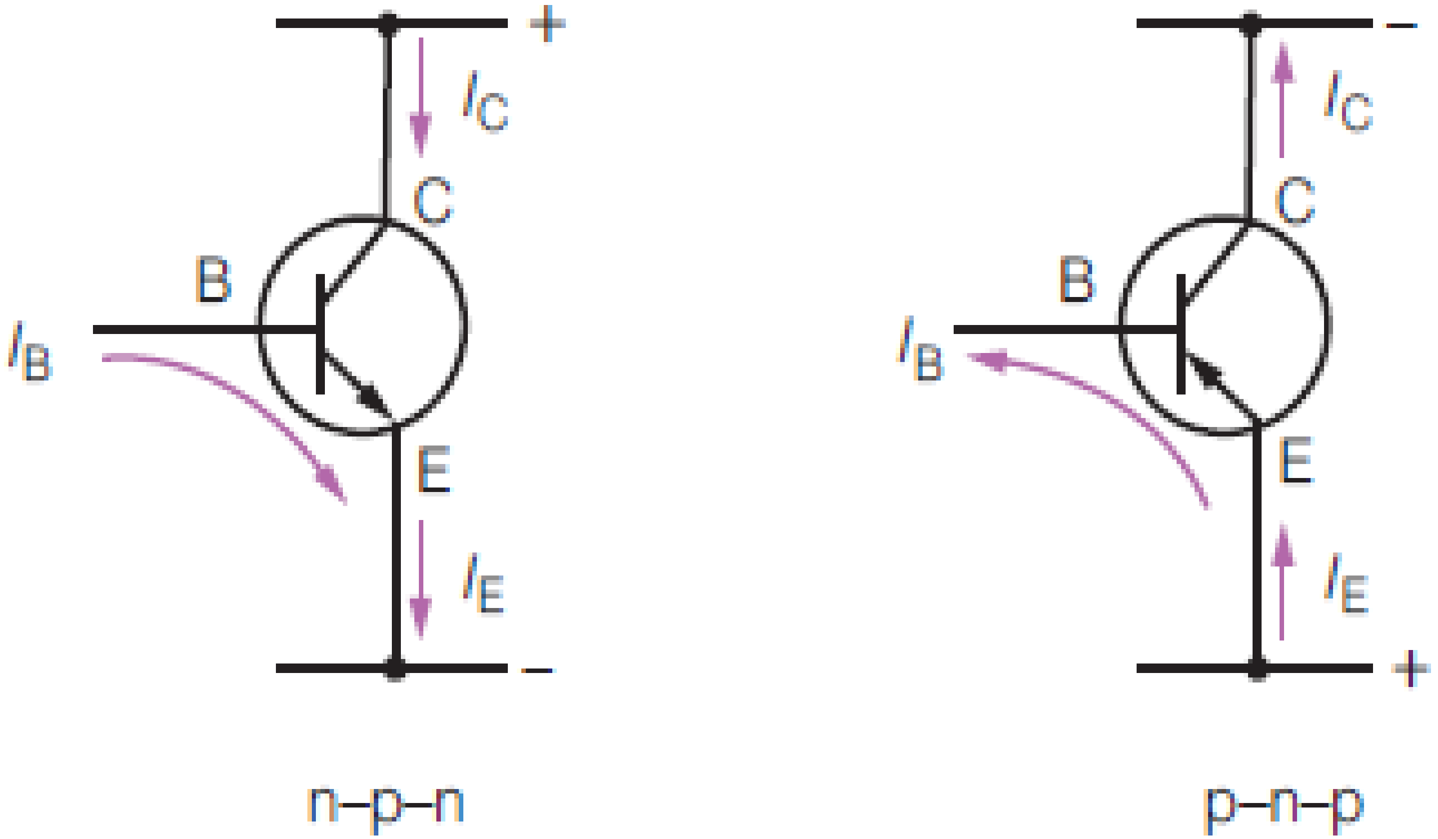


An n–p–n transistor A p–n–p transistor

Transistor biasing

A diode said to be forward if the voltage of the source (positive terminals) connected to the p-type and n- type connected to the negative terminals. For the transistor biasing the arrow on the emitter of the transistor shows the direction of the convectional current flow.

- Current sent to the base has only one possible route out. The junction toward the collector is reverse biased so it all has to escape via the emitter.



+
I_C
C
B
I_B
E
I_E
–
n–p–n
–
I_C
C
B
I_B
E
I_E
+
p–n–p

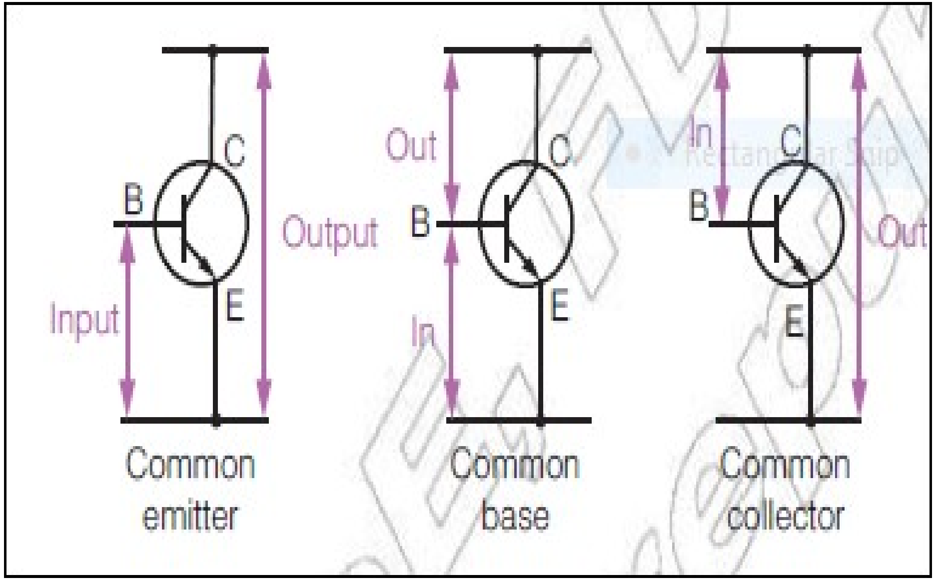
Transistor characteristics

Transistor has three terminals , so one of them is inevitable be common to both. It can be any of the three , so the circuit can be classified as

common emitter

common base

common collector



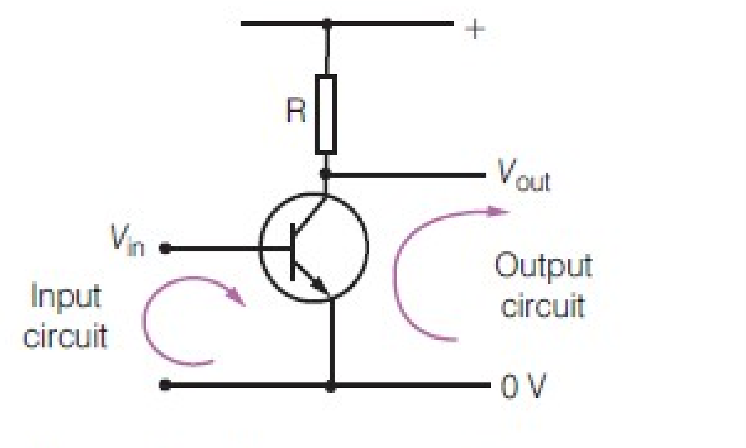


Figure 5.48 A common emitter.

Logic gate

Logic gates are tiny silicon chips which are etched combination of transistor and resistor. They typically have two input and one output. What happened to the out put is determined by the situation at those in put. An example is the AND gate.

The AND gates

The power supply for this by two wire. One at +5V and the other is at 0V.

For the in put 0V in case we say the in put is “0”

For the in put +5V in case we say the input is “1”

For this gate the out put is “1” if and only both the input is “1” unless “0”

The truth table for the NAD Gate

INPUT A	INPUT B	OUTPUT
0	0	0
0	1	0
1	0	0
1	1	1

The NAD gate act like two switch in series. Both switch must be placed in the one position to make the out put live

The OR gate

The OR gate behaves like the same two switch in parallel. The truth table for the OR gate is shown below .The output always at +5 except when both switches are at “0” .

INPUT A	INPUT B	OUTPUT
0	0	0
0	1	1
1	0	1
1	1	1

The NOT gate

This has a single input and its output always the opposite . A “0” at input means “1” at the out put.

INPUT	OUTPUT
0	1
1	0

The NAND and NOR gates

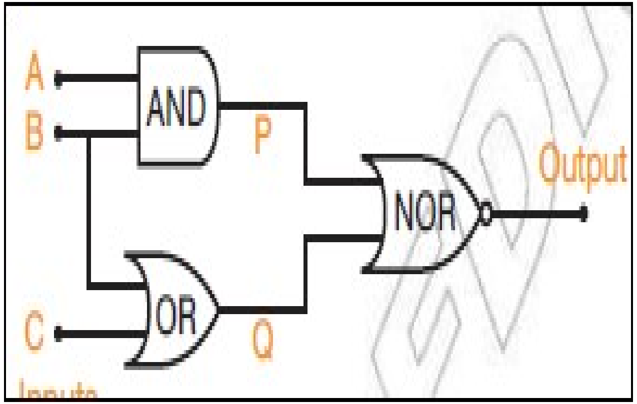
There are final gate to consider the NAND and NOR gate . These are just the AND gate the OR gate respectively but the out put is inverted. In steady of a “0” there is a “1” and instead of a “1” there is a “0” .

			Output		
INPUT A	INPUT B	AND	NAND	OR	NOR
0	0	0	1	0	1
0	1	0	1	1	0
1	0	0	1	1	0
1	1	1	0	1	0

Combination of Logic the gate

More than one logic gate may be combined to increase the range of control tasks can be preformed.

Example. consider the arrangement shown below.



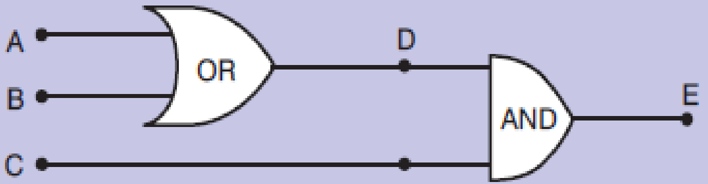
INPUT A	INPUT B	INPUT C	POINT P	POINT Q	OUTPUT
0	0	0			
0	0	1			
0	1	0			
0	1	1			
1	0	0			
1	0	1			
1	1	0			
1	1	1			

The truth table for the combination of logic

INPUT A	INPUT B	INPUT C	POINT P	POINT Q	OUTPUT
0	0	0	0	0	1
0	0	1	0	1	0
0	1	0	0	1	0
0	1	1	0	1	0
1	0	0	0	0	1
1	0	1	0	1	0
1	1	0	1	1	0
1	1	1	1	1	0

Exercise

Consider the arrangement shown in Figure 5.75. How does it behave?



Find the truth table

INPUT A	INPUT B	INPUT C	POINT D	POINT E
0	0	0		
0	0	1		
0	1	0		
0	1	1		
1	0	0		
1	0	1		
1	1	1		

INPUT A	INPUT B	INPUT C	POINT D	POINT E
0	0	0	0	0
0	0	1	0	0
0	1	0	1	0
0	1	1	1	1
1	0	0	1	0
1	0	1	1	1
1	1	1	1	1

Thank you

END OF UNIT- 5