Chapter 14

SEMICONDUCTOR ELECTRONICS

1. Classification of metals, conductors and semiconductors

	Metals	Semiconductors	Insulators
Resistivity ρ	10^{-2} to 10^{-8} Ωm	10^{-5} to 10^{6} Ωm	10^{11} - 10^{19} Ωm
Conductivity σ	10^{2} t0 10^{8} $S\ m^{-1}$	10^{5} to 10^{-6} $S\ m^{-1}$	10^{-11} to 10^{-19} $S\ m^{-1}$

Semiconductors

a. Elemental semiconductors like Si, Ge

b. Compound semiconductors

i. Inorganic - Cds, Ga As, Cdse, InP etc,

ii. Organic - antheracene, doped pthalocyanines

iii. Organic polymers - polypyrrole, polyaniline, polythiophene etc.

- The currently available semiconducting devices are mainly elemental semiconductors and compound inorganic semiconductors.

Energy band

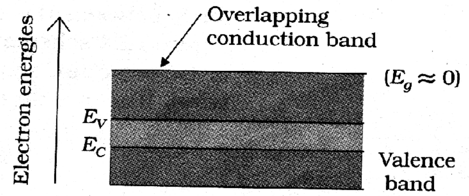
The energy level of an atom inside a crystal is different from isolated atoms due to the interaction between the neighbouring atoms.

Inside the crystal each (electron) has a unique position and there exist no two e^- with exactly the same pattern of surrounding charges. Therefore each e^- will have a different energy levels. These energy levels with continous energy variations are called energy bands.

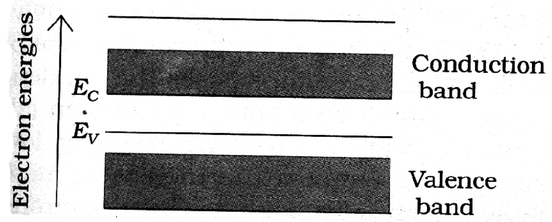
Note : Range of energy possessed by e^- in valence shell within the atom in a crystal is called valence Band and range of energy possessed by free e^- is called conduction band. At absolute zero (no external energy) all valence electrons will reside in the V.B. The gap between lowest level of conduction band and highest level of V.B is called forbidden energy gap.

Classification of Substances in terms of Energy band

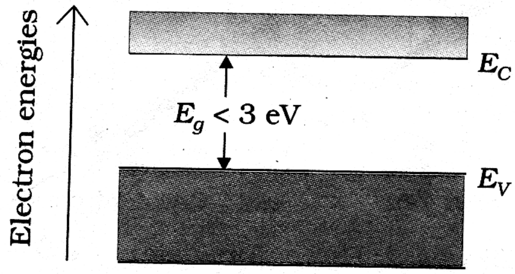
In some metallic conductors, the lowest level of C.B is lower than the V.B. Then the e^- from V.B can easily move into C.B, where normally C.B is empty. Due to overlapping of VB and CB, free e^- are availabve for conduction



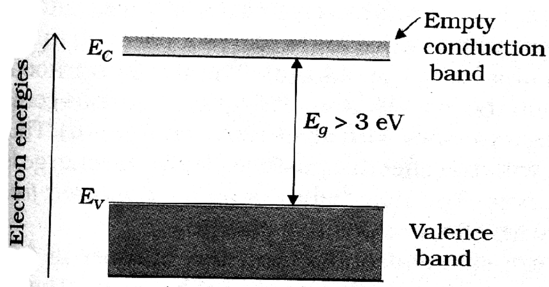
In some metals there is a gap b/n the lowest level of conduction band and highest level of VB. In such metals V.B and C.B are partially filled. Presence of e^- in C.B enables large conductivity. When the valence band is partially empty, e^- from its lower level moves to higher level making conduction possible.



In Semiconductors : the highest level of V.B and lowest level of C.B are seperated with a small energy gap (say <3eV). At absolute zero, the V.B is completely filled and C.B is completely empty and it behaves as an insulator. At room temp, some e^- from V.B can acquire enough energy to cross the energy gap and enter the conduction Band. Hence the resistivity of semiconductor decreases with increase in temp.

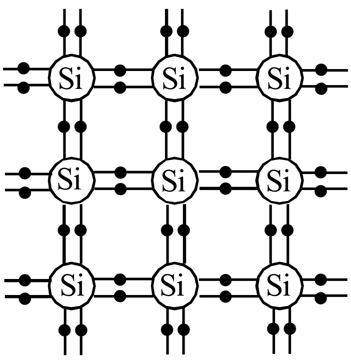


In the case of insulators, the energy gap b/n the V.B and C.B is >3ev. There are no e^-_s in the conduction band and no elelctrical conduction is possible. It is noted that the energy gap is so large that e^- cannot be excited from V.B to C.B by thermal excitation. Hence the resistance is very high and conductivity is very small.

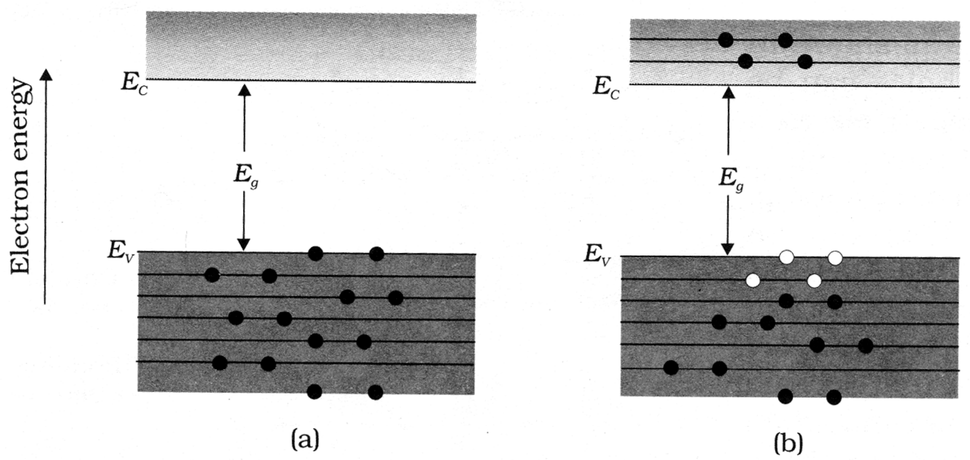


Intrinsic semi conductor

Pure elemental semi - conductors are called intrinsic semi conductor. Si and Ge are intrinsic semi conductors. In each Si and Ge atom, there are four valence e− . In its crystalline structure, every Si or Ge share one of its 4 valence e^- with each of its four nearest neighbour atoms and form covalent bond as shown in the figure. At absolute zero, all bonds are completed and no bonds are broken.



As the temp increases more internal energy becomes available to these e^-s and some of these e^-s may break the bond and become free e^-s. The thermal energy creats a vacancy in bond called holes. The hole behaves as an apparent free particle of charge +e. The thermal energy ionise the si atom and free an e^-



The conductivity of Si increases with temp. In a semiconductor concudctivity is due to free e's in the conducting band and holes in the V.B. In intrinsic semiconductor no. of e's in C.B is equal to no. of holes in the V.B which is equal to intrinsic carrying conductor ne = nh = ni the equilibrium no.of holes created is equal to no of holes the carrier concentration of e^- constant at equilibrium

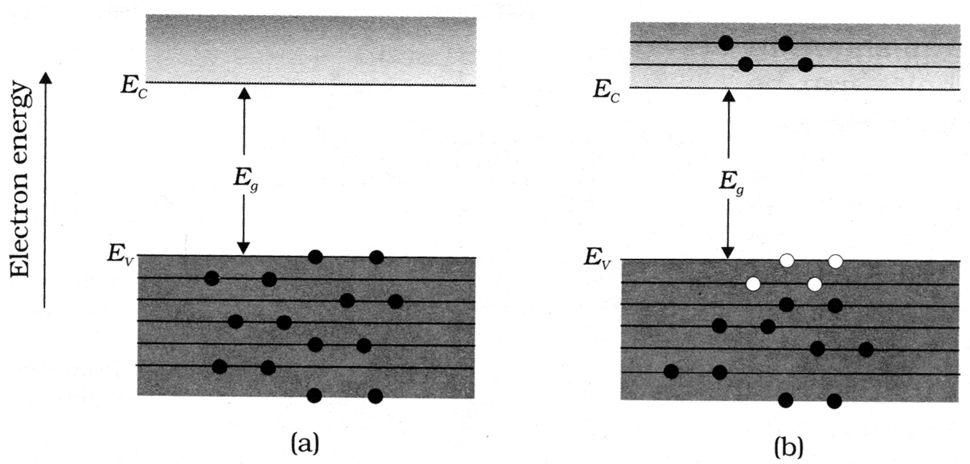
The total current I = Ie + Ih

Note

At 0K an intrinsic semiconductor behaves like an insulator T>0K, it behaves like better conductor.

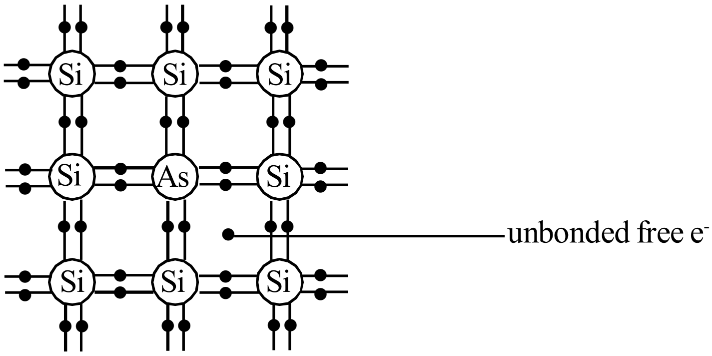
Q1. C, Si, Ge have same lattice structure. Why is C insulator while S and Ge are instrinsic semiconductor?

Q2. Identify the material, by using energy band diagram at T> 0K



Extrinsic semiconductor

The conductivity of the pure semiconductor is increased by adding suitable impurity atoms. The impure semi conductor is called extrinsic semiconductor.



Doping

The deliberate addition of a desirable impurity atom in to a pure semiconductor is called doping and material used for doping is called dopant. The dopant has to be added such that it doesnot distort the original pure semiconductor crystal. Therefore the size of the dopant and semiconductor atoms should be nearly same size.

Q. Why the dopant elements are pentavalent or trivalent?

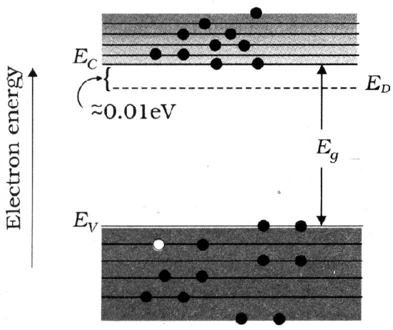
The pure semi conductor Si and Ge belongs to group 14 in the periodic table and therefore we choose the dopant element from 15^{th} and 13^{th} group for taking care that size of the dopant atom is nearly the same size as Si or Ge.

n type semiconductor

The pure semiconductor si or Ge is doped with pentavalent impurity like Arsenic (As), Antimony (Sb), Phosphoras (P), etc. the crystal obtained is called n-type semiconductor.

When an atom of pentavalent element is added to pure semiconductor, si crystal, the pentavalent (As) impurity occupies the position of an atom in the crystal lattice of si four of its e^-s bond with the four Si atoms while the 5^{th} e^- remains very weakly bound to its parent atom As as a result the ionization energy required to set this electrons free is very small and even at room temp. it will be free to move in the lattice of semiconductor.

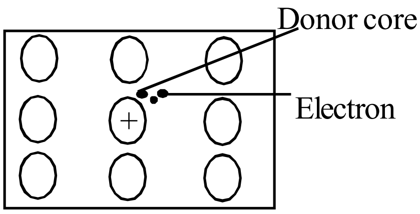
By using energy band diagrams, we can explain the conductivity of n- type semiconductor. The energy level of As atom 0.05ev below the CB energy level of Si atom. Therefore the free electron of the pentavalent atoms easily occupy the CB.



(a) $T > 0K$
one thermally generated electron-hole pair + 9 electrons from donor atoms

Pentavalent is donatting an electron to the crystal lattice. Therefore, pentavalent impurity is called donar impurity. The no.of free e^{-}s, in the C.B. is depends on the doping concentration.

In a doped semiconductor no.of holes (n_h) is depends on temp. while no.of. e^{-}s (ne) is due to contribution of donars and themally generated e^{-}s in the pure semiconductor. Thus with proper level of doping ne>>nh. Hence in an extrinsic semiconductor, doped with pentavalent impurity, e^{-}s becomes the majority carriers and holes are the minority carriers. Therefore, the semiconductors are called 'n' semiconductor.

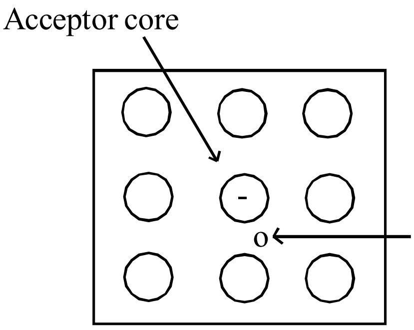


In n type semiconductor the donar is charged +vely by donating e^{-} to the crystal.

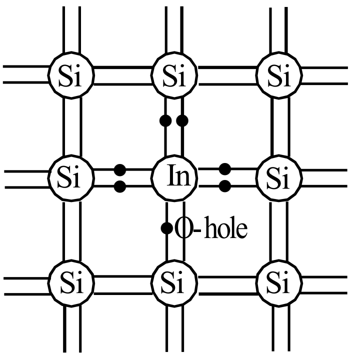
P type semiconductor

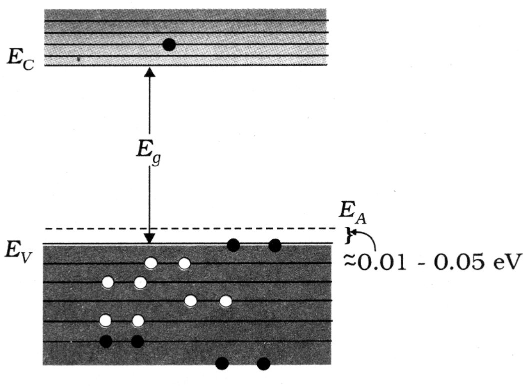
P type semiconductor is obtained when si or Ge is doped with trivalent impurities like Al, B, In, etc.

Due to defficiency of electrons in the bond after sharing 3 e^{-}s with neighbouring si atoms, hole is created in the bond. This vaccancy is filled by accepting an e^{-} from crystal lattice it in turn creats a hole in the V,B of Si Now, the trivalent atom atom become negatively charged by accepting e^{-} from si atom. In p type semiconductor trivalent atom is called as acceptor because it accepts the e^{-} from the pure semiconductor crystal and ionise - vely.]



In p type semiconductors no. of holes are more than the thermally generated electron. Therefore holes are majority carries and e^{-}s are the minority carries. In p type semiconductor, the recombined process will further reduce the number of intrinsic carrier concentration.





(b) $T > 0K$

Intrinsic		Dopant	=	extrinsic
Sior Ge	+	5 valent	$\rightarrow$	n type
Sior Ge	+	3 Valent	$\rightarrow =$	p type

Note :

1. In n type or p type semiconductor is maintained charge neutralites.
2. By adding dopant numbers, which become majority carriers, indirectly helps to reduce the intrinsic concentration of minority carriers.
3. At room temp. in an extrinsic semiconductor at thermal equilibrium is given by $n_e n_h = n_i^2$
4. Pentavalent dopant is donar, Trivalent dopant is acceptor.

Band gap of group IV or XIV

Elements	Band gap	
C	5.4 ev	Insulator
Si	1.1ev	Semi conductor
Ge	0.72 ev	Semiconductor
Sn	0.1ev	Conductor

Q. Suppose a pure Si crystal has $5x10^{28}$ atom per m^3. It is doped by 1ppm concentration of pentavalent As. Calculate no of e^-s and holes (given $ni = 1.5x10^6/m^3$)

It is a ntype semiconductor

$n_e\, n_h = n_i^2$

$$n_h = \frac{ni^2}{ne} = \frac{(1.5x10^6)^{22}}{5x10^{22}}$$

$4.5\ x10^9\ m^{-3}$

$n_e = 5x10^{22}\ m^{-3}$

Note : 1PPm - 1 Part per million

$$n(d) = n_e = 5x10^{28}\, x\, \frac{1}{10^6}$$

$$= 5x10^{22}\, m^{-3}$$

Q. Intrinsic semiconductor

a. Si + X $\rightarrow$ n type semiconductor

b. Ge + Y $\rightarrow$ p type semiconductor

Choose X and Y from the following

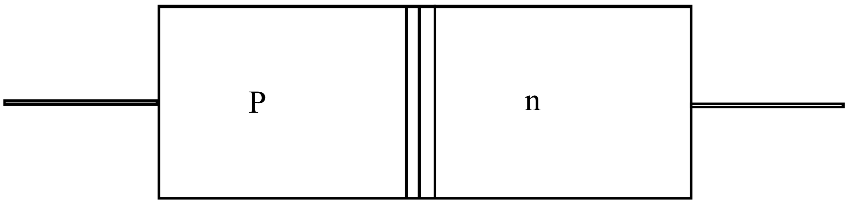
Cu, Ag, Al, C, Sn, Sb

c. Explain how to prepare n type semiconductor?

d. Explain how to prepare p type semi conductor?

How to form a pn junction

Take a thin p type si semiconductor wafer by adding controlled amount of pentavalent impurity. Now, part of p type si wafer can be converted into n type si. The wafer contains p region and n region and a interforce of p and n called pn junction as shown in fig.



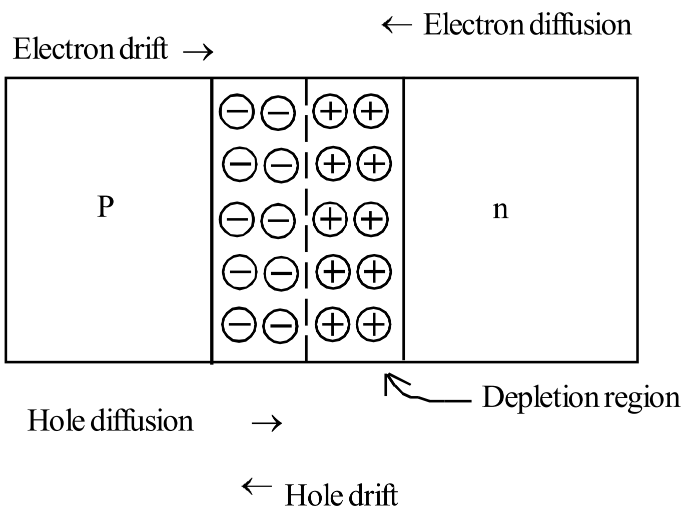
Explain important process occur during the formation of a pn junction

Diffusion

We know that in n type semi conductors, electron concentration is more compare to the concentration of holes. Similarly in a p type semiconductor, the concentration of holes is more than e^-s. During the formation of p-n junction, and due to the concentraiton gradient, holes are diffuse from p side to n and electrons diffuse from n side to p side. This motion of charge carriers gives diffusion current.

Explain depletion region.

When an electron diffuses from n to p side due to the concentration gradient, it leaves an ionized donar on n side. Similarly when a hole diffuses from p to n side it leaves an ionized acceptor on p side. This iones are immobile due to continuous diffusion of electrons and holes a layer of negative space charge region on p side and +ve space charge region on a n side of the pn junction. This region is called depletion region



Drift

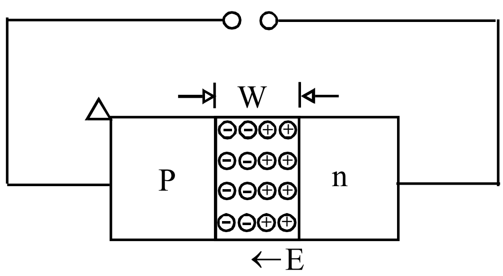
Due to the +ve space charge region on n side of the junction, and -ve charge on p side of the junction, an electric field directed from n side to p side of the junction. Due to this field the minority carriers, ie, electrons from p side moves to n side and holes move n side to p side. The motion of minority carriers due to electric field is called drift.

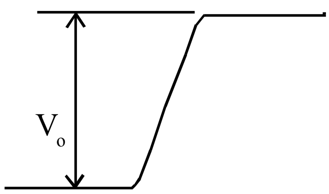
Note

1. Diffusion of majority carriers givs diffusion current and drift of minority carriers gives drift current. Diffusion current and drift current are opposite in directions.
2. Initially, diffusion current is large and drift current is small, As the diffusion process continuous the space charge region either side of the junction extend thus increases the electric field strength and hence drift current. This process continuous untill the diffusion current equals the drift current. Thus a pn junction is formed. In a pn junction under equilibrium there is no net current.

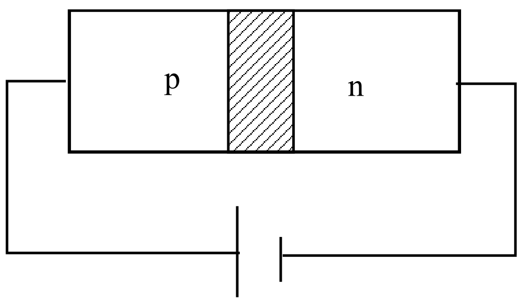
Explain Barrier potential

Due to diffusion, the loss of e^-s from n region & gain of e^-s to the p region causes a difference of potential across the junctions of the 2 regions. Thus potential creats an electricfield which opposes further flow of carriers. So that the equilibrium is reached. At equilibrium a constant potential difference exists across the junction. This potential difference is called barrier potential.





Explain the action of P- n junction diode under Forward bias? When an external voltage V is applied across a diode such that P is to +ve and n is to -ve, the biasing is called forward biasing.



The external applied voltage (v) is opposite to that of barrier potential (V_0) As a result the width of depletion region decreases and the barrier height is reduced. The barrier height under forward bias condition is (V_0 - V)

If $V<V_0$, the barrier potential will be reduced slightly and only a small number of carrier will possess enough energy to cross the junction. So the current will be small. If we increase the

applied voltage ($V>V_0$) the barrier height will be reduced further and more number of carriers will have the sufficient energy. Thus current increases.

In the forward blased condition, the minority carrier injection towards P side and towords n side takes place Due to applied votage, electrons from n side cross the depletion region and reach p side. Simillary holes one from P side to n side at the junction boundary on each side, the minority carrier concentration increases. This injected minority carrier diffuse toward edges of the crystal and constitute of the current. Total current is the sum of hole diffusion current and electron diffusion current.

$I = Ie + In$

Note :

At room temperature the barrier potential are ① 0.2v to o.3v for Ge

② 05.v to o.7v for si

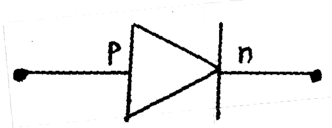
Q. Can we take on slab of P type semiconductor and physically join it to another n type semiconductor to get P - n junction?

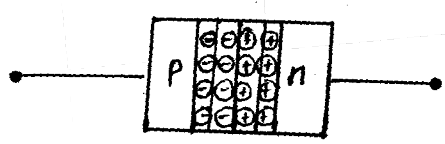
No. An slab, how ever flat, will have roughness, much larger than inter atomic crystal spacing hence continuous contact at atomic level will not be possible. The junction will behave as a discontinnutily for the flowing charges carriers.

Q. Why the resistance of depletion region is higher than other part of the P.n junction?

Depletion region is the region in which no free charge carrier . While other part of the P and n semiconductor have free charge carrier.

Q. What is P-n junction diode and draw its circuit symbol? Semi conduction diode is a Pn junction with 2 external terminal for external voltage supply. It is a t

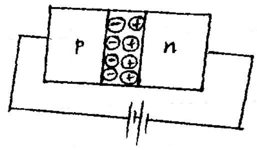




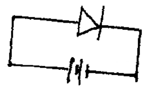
Forward bias and P-n junction diode

The P side of the diode is connected to positive of the external voltage source and n side is connected to the negative of the voltage source as shown in Figure. a

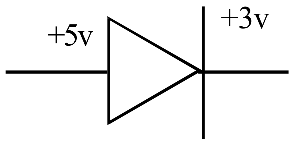
Note : P side connected to high potential and n side conncetal to lower potential is also forword biased forward biased pn junction as shown fig (b)



or



(a)



(b)

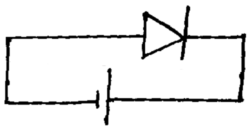
Q Explain Pn junction diods under reverse bias?

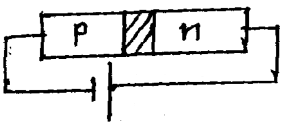
When reverse potential (V) is applied to the diode the sense of direction of applied voltage and barrier potential are same. As a result, barrier potential and width of depletion region increases. The effective barrier height is $(V+V_0)$. Then electric field at the junction is not favourable for majority carrier holes from P to n and electron from n to P. Thus diffusion current decreases enormously compared to the diode forward biased conduction.

The electric field at reverse condition is favourable for minority carrier to cross the junction ie, electrons from P to n and holes from n to P. This give rise the drift current of order of microamphere.

Q. How to reverse bias P - n junction

When an external voltage (v) is applied across the diode such that n side is +ve and P side is -ve. It is said to be reverse biased.





Q. Is the reverse current or drift current depends on applied voltage why?

No because a small reverse enough to sweep the minority carrier from one side of the junction to the other side. This current not controlled by the magnitude of the applied voltage but it limited due to the minority carrier concentration.

Q. What is breakdown Voltage?

The current through the diode under reverse bias is essentialy voltage independent upto critical reverse voltage (V_{br}) when applied voltage is equal to V_{br}, the diode reverse current increases sharply. Even a slight increase in the bias voltage causes large change in the current. This voltage is called break down voltage.

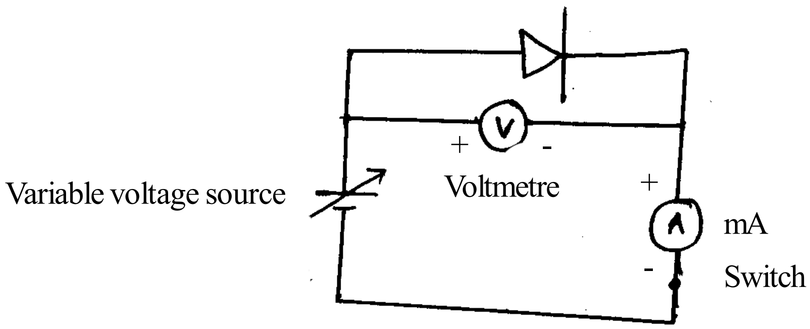
Q. What happens to the diode. If we operate the diode in reverse biased condition equal or greater than V(br) ?

The diode gets destroyed due to over heating, for safety operation of the reverse diode applied should be below the specified rated value of the manufacturer.

Q. How to explain the breakdown?

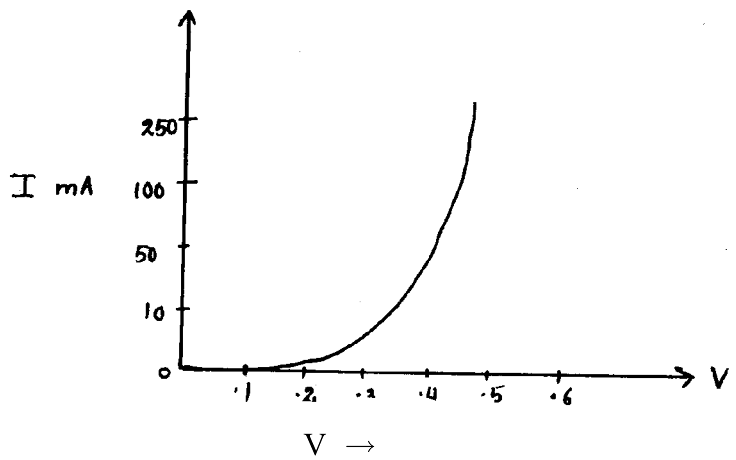
At higher applied voltages the breakdown is believed to be caused by avalanche of charge. The electrons of reverse. Saturated current are accelerated to high velocities by the electric field across the depletion region. At some critical field these charges acquire sufficient velocity to break valence bonds upon collision with the atoms of the semiconductor. This process generate more e^- - hole pair and current builds up in large amount.

Q. Draw the circuit diagram to study the forward characteristics.

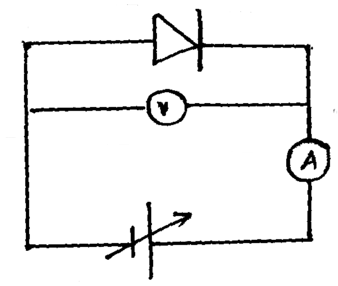


The circuit arrangement to study the forward characteristic as shown in figure.

The forward voltage is gradually increases from zero corresponding current is noted in milliammetre. The graph between V and I is obtained. It is noted that the current initially increases very slowly almost negligible, till the voltage across the diode reaches to a certain value. After this characteristics voltage, the diode current increases exponentially with applied forward voltage. This critical voltage of which the current increases very sharply is called threshold voltage or cut in voltage (0.2 to 0.3 v for Ge and 0.5 to 0.7 v for si)



Explain the reverse characteristic of a diode



The circuit diagram to study the reverse characteristics as shown in the figure.

The reverse voltage is increase from zero. The reverse current is small of the order of micro ampere and almost remains constant with change in bias voltage. The current is called reverse satuiration current. At high reverse voltage (Vbr) the current increases suddenly. In general purpose diode are not used beyond the break down voltage.

Q. Explain unidirectional conducting property of diode?

The forward biased resistance of the diode is low as compared to the reverse bias resistance. The diode conduct only when its forward biased and it is not conducting when its reverse biased. This properly of the diode is called unidirectional conducting property.

Q. Which property of the diode is used Rectifier?

Unidirectional conducting property.

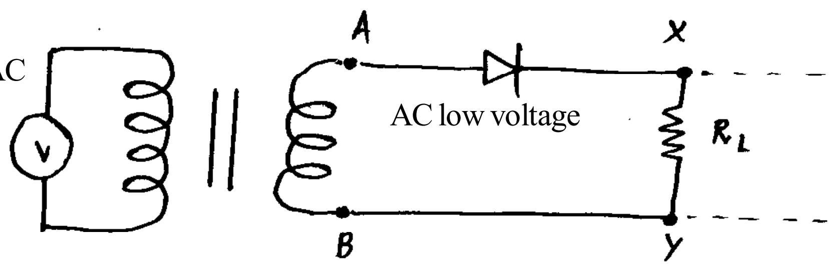
Q. What is a rectifier?

It is the device used to convert high voltage AC in to low voltage pulsating DC

Q. Explain how a diode act as a rectifier?

The unidirectional conducting property of the diode is used for rectification. It means diode allows current only when it is forward biased. An alternating voltage is applied across the diode the current flows only in that of cycle when the diode is forward biased.

Explain half wave rectifier with circuit diagram?



If an alternating voltage is applied across the diode in series with a load, a pulsating voltage will appear across the load only during the half cycle of the input ac during which the diode is forword biased. This type of rectifier is called half wave rectifier.

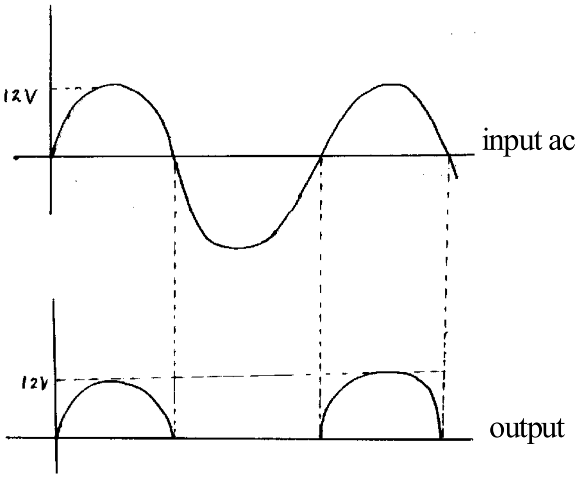
The secondary of a transformer supplies the desired ac voltage across terminals A and B. When voltage at A in +ve, the diode forward biased and it conduct. When A is negative, the diode is reverse biased and it not conduct.

Therefore, in the +ve half cycle of ac there is a current through the load resistor R_l and we get an output voltage. Where as no current in the negative half cycle. This process is repeated and get output when the diode is forward biased. Thus, the output voltage, though still varying is restricted to only one direction and is said to be rectified. Since the rectified output of this circuit is only for half of the input ac wave it is called the half wave rectifier.

Q. An input ac voltage of frequency 50Hz is given to half wave rectifier.

a. Show the output wave form

b. What is the frequency of pulsating dc.

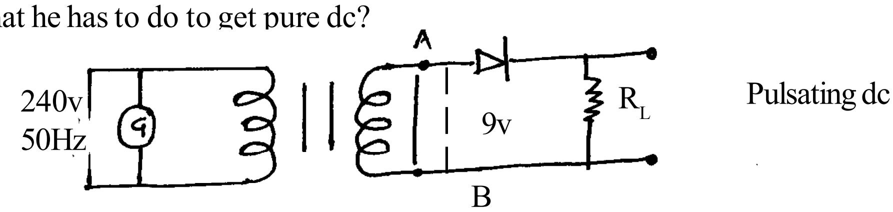


b. 50 Hz, Frequency, remains same.

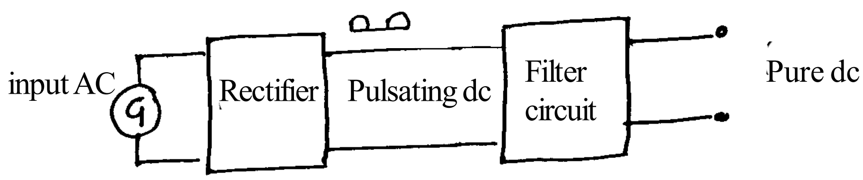
Q. A boy like design a half wave rectifier with pulsating dc of max 9v

a. Give the circuit diagram with essential components?

b. What he has to do to get pure dc?

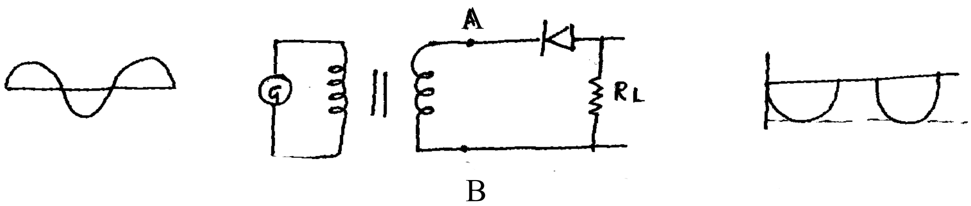


b



To get a pure dc a filter circuit should be cascaded with a rectifer

Q. Circuit diagram shown in figure is acted as half wave rectifier or not justify your answer?

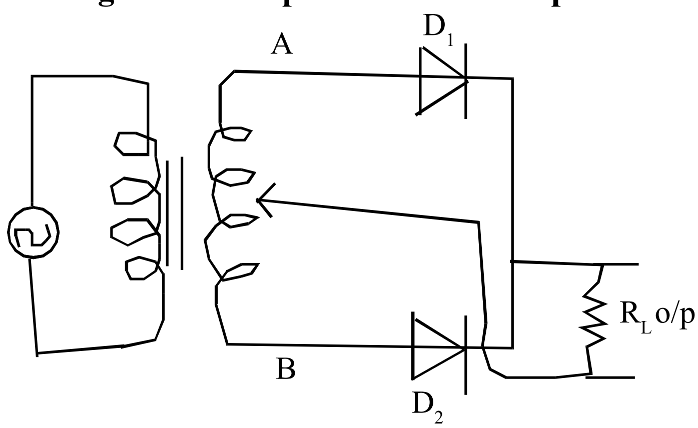


yes. At every negative cylce of input of ac at A, the diode is forward biased and output voltage across R_L. At every positive cylce of input of ac at A, the diode is reverse biased and not conduct.

Q. Explain full wave rectifier?

By using two or more diodes, gives output voltage corresponding to both the positive as well as negative half of a ac input. Hence the rectifier is called full wave rectifier.

Draw circuit diagram and explain the centre tap full wave rectifier.

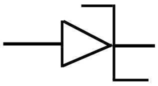


Two diodes D_1 and D_2 are connected to the ends of secondary of the transformer. Then n side of the diodes are connected together and the output is taken b/n the common points of diodes and centre tap of the secondary of the transformer. Here is called central tap full wave rectifier.

In positive half cycle of input ac, A is +ve and B is -ve. The diode D_1 conduct and D_2 does not conduct, there is output across R_L In negative half cycle of ac, B is +ve and A is -ve D_2 conduct and D_1 does not conduct, there is output across R_L. Here pulsating output is obtained for both input ac cycles. It is more efficient circuit for getting rectified voltage than half wave rectifier.

- Who invented zener diode and Draw its circuit symbol

  a. C.Zener

  b. 

  i) A junction diode which works only in the reverse break down voltage or zener voltage.

  ii) Maximum reverse voltage that can be applied without damage

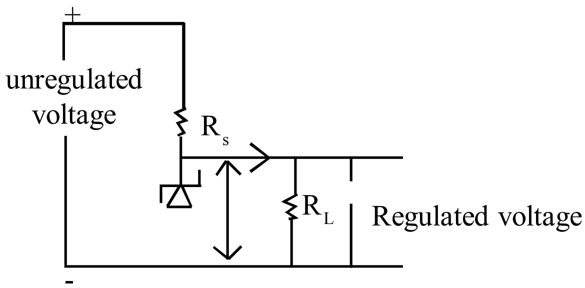
  (iii) Voltage across the diode is constant.

- Give one use of zener diode : It is used as voltage regulator.
- Explain the zener diode and how it act as voltage regulator.

Zener diode is a heavily doped P-n junction diode. Due to heavily doping, the width of the depletion region is very thin less than micron and electrified at the junction is very high (E=v/d) of the order of $5x10^6$ v/m for small reverse voltage.

Zener is always operated in reverse based condition. The applied reverse voltage is equal to break down voltage ($v_1=V_{br}$) large change in current for a small negilible change of reverse voltage. That is, zener voltage remains constant, even through current through the zener changes, over a wide range. This property of zener is used for regulating the voltages.

Draw circuit diagram of zener diode as voltage regulator



- In case of ordinary diode, the large heating effect produced, destroyed the diode when it is operated more than breakdown voltage, but zener diode is safe when it is operated in reverse biased state. Why?

In the case of ordinary diode in reverse biased condition the width of depletion region is so large and has high resistance of the order of 106 Ω . The large current passing through the junction due to field emission produces more joule's heating effect. In the case of zener diode, it is heavily doped and hence the depletion region is thin and is less than that of ordinary diods. Hence total heating effect is lessand its safe in the reverse biased condition.

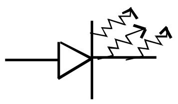
- What is opto electronic junction devices?

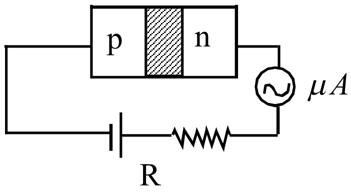
  Semi conducting diode in which the carrier are generated by light or photons.

  Name different opto electronic devices.

  1. Photo diode
  2. Light emitting diod (LED)
  3. Photo voltaic device (Solar all)

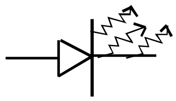
- Mention uses of photo diode?
  1. It used in optical communication as photo detector
  2. Its used in electronic equipment TV which can operated with remote controller.
- Draw the circuit symbol and circuit diagram of photo diode.





- What LED, Draw its circuit symbol

It is heavily doped special pn junction diode which is operating forward biased condition. The diode is enclosed in a transparent cover so that emitted tight can come out.



- What are the used of LED?
  i. It is used as light source.
  ii. Remote control - (Infrared LED)
  iii. Burglar alram
  iv. Optical communication
- What are the advantages of LED?
  i. Low operated voltage.
  ii. Fast action and no warm up time required
  iii. Band width of light (100A to 500A) therefore it nearly
  iv. Long life
  v. Environmental friendly
  vi. Fast on-off switching actions.
- What are the solar cells? Draw it's circuit symbol?

A solarcell is a Pn junction which generates emf when the solar radiation falls on the pn junction. It is based on principle of photo diode except that no external bias is applied and junction area is kept much larger for solar radiation.

- Write the suitable material for solarcell

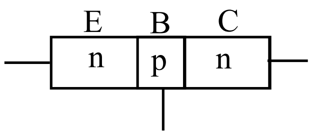
For solarcell the band gap nearly 1.5ev are suitable materials for solar cell.

1. Si $\rightarrow$ (Eg - 1.1ev)
2. GaAs $\rightarrow$ (Eg - 1.4ev)
3. S cd Te $\rightarrow$ (Eg - 1.45ev)
4. Cu in S_{e2} $\rightarrow$ (Eg - 1.04 ev)

- What are the important criteria for the selection of material for solar cell?
  1. Based gap (Eg 1.0ev to 1.8ev)
  2. High optical absorption
  3. High electrical conductivity
  4. Availability of rawmaterial
  5. Low cost
- Uses
  1. It is used in power electronic devices in satellites and space vehicle.
  2. It is the power supply to save electronic devices such as calculator.
  3. Solar heater
  4. Solar lamps
  5. Solar charger etc.
- Why Si and Ga As are preffered material for solar cell? Why not cds, edSe Reffer NCERT Text Eg: 14.7.
- Who invented point contact transistor which consists of two pn junction connected back to back?

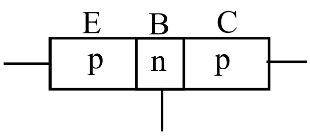
  William shottkey in 1951.
- What is BJT (Bipolar Junction Transistor)

  This transistor operate with holes and electrons.
- Name two types of bipolar junction transistor.
  1. npn : The emmiter and collector n type and are seperated by a thin segment of P- type called base.



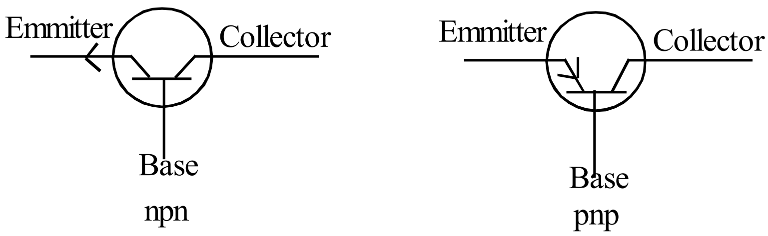
  2. The emmitter and collectorare p-type and are seperated by a thin segment of n type called Base.

Fig 14.27



- Explain the 3 segment of a transistor?
  1. **Emmiter** : It is moderate in size and heavily doped. It supplies as large number of majority carriers for current flow through the transistor.
  2. **Base :** It is in between emmiter and collector. It's very thin as lightly doped.
  3. **Collector** : Collects major portion of the majority carriers emmitted by this emmitter, larger in size, moderately doped.

- Show the circuite symbol npn and pnp transistor



- Name 3 transistor configuration
  1. CB (Common Base) Base in common to input and output
  2. CE (Common Emmitor) Emmitor is connected to input and output
  3. CC (Common collector) Collectors common to input and output
- Is the transistor is a power of generating device? No, power of ac input signal is amplified by the expenses of biasing voltage.

  Why CE is generally preffered for amplification

  CE configration have current gain, voltage gain and power gain.
- Defferentiate between amplifier and oscillator

In any amplifier, by the aid of external biasing battery strength of the low input signal is amplified and obtained at the output and input is necessary to obtains output. In an oscillator sustained oscillation of ac signal is obtained at the output without the aiding external inout ignal ie, input oscillating signal is not necessary to obtain output sustained oscillating.

Oscillator - The process of converting dc signals into ac signals of desired frequency. A device which does this function is oscillator

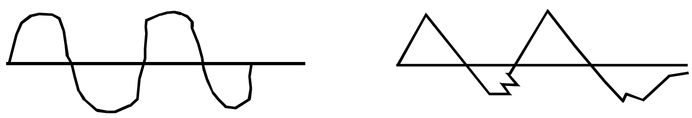
Alternator (ac dynamo) - Produces ac of frequency up to 1000Hz.

Essential parts of oscillator (i) Tank circuit - LC circuit to produce electrical oscillations (ii) Amplifying circuit (iii) feedback circuit.

- Digital Electronics

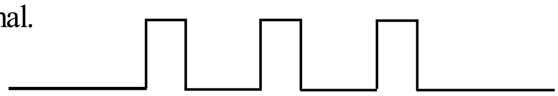
  What is analogue signal

  The signal has been in the forming continous, time varying voltage or current is called analogue signal.



- What is Digital Signal

  The voltage or current representated by two levels of voltage or current. Such signal is called digital signal.



Pulse wave from of digital signal

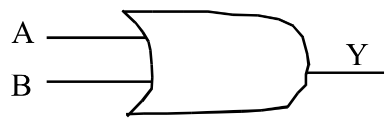
- What is logic gate

Logic gates are the building block of digital electrons. Logic gates are based on some logic operation between the input and output.

Or gate

OR gate has two or more inputes with one output. The output OR gate is 1 for any one of the two input is 1. And output in zero, if both input are zeros.

a) Circuit symbol of OR gate



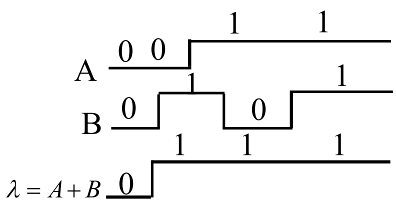
A input	B input	Y=A+B Output
0	0	0
0	1	1
1	0	1
1	1	1

b) Truth table of OR gate

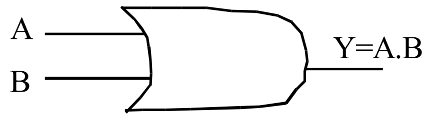
It is the display of input output relation with all possible functions.

c) Timing diagram

Input - output wave forms in called timing diagram

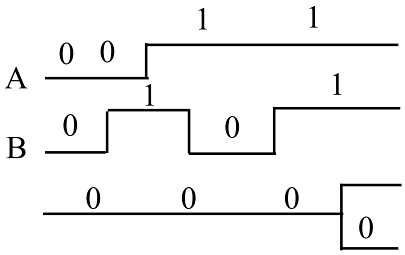


- The output of AND gate is one, if only of both inputs are I's and zero, if any one of the two input is zero circuit symbol.



- Truth table of AND

A	B	Y=A.B
0	0	0
0	1	0
1	0	0
1	1	1



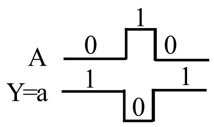
- NOT Gate

This is most basic gatem with one input and only one output it gives 1 output of the inout is 0 and output 0 if input is 1.

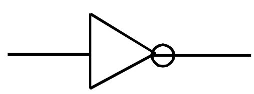
Truth table

A	$\bar{A}$
0	1
1	0

Timing diagram

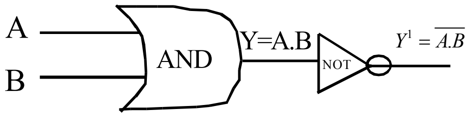


Circuit symbol

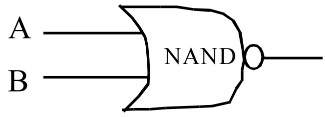


- NAND

The output of AND gate is followed by NOT gate



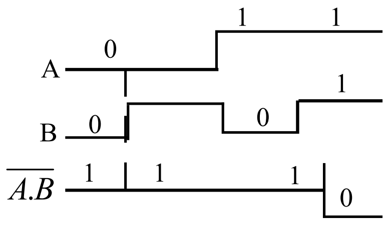
Circuit symbol



- **Truth table of NAND**

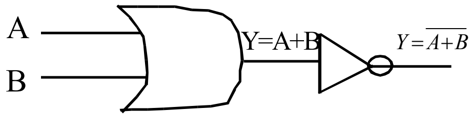
A	B	$\overline{A.B}$
0	0	1
0	1	1
1	0	1
1	1	0

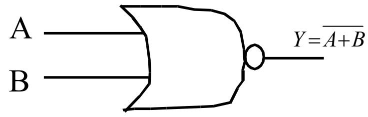
Timing diagram of NAND



- NOR Gate

This is an OR gate is following NOT gates

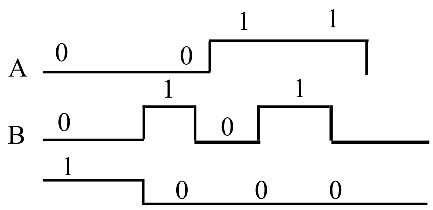




- **Truth table**

A	B	$\overline{A+B} = Y$
0	0	1
0	1	0
1	0	0
1	1	0

Timing diagram



- Which gate and NAND are universal gates because we can obtain all the gate like AND, OR and NOT by using only NOR or NAND.
- Write a note on

IC (Integrated Circuit)

It is the circuit consisting of passive components like resistor, inductor, capacitor and active devices like diode and transistor on a single block. It is based on Monolithic fabrication technology. The entire fabrication is done in a single silican crystal called chips.

What is analogue IC

The linear Ic's process analogue signals which change smoothly and continously over a range of values between maximum and minimum the output almost linearly proportional to input. It is used operational amplifies.

What digital Ic's, It is operating by using binary numbers, ligh and low. They contains logic gates.

- What are different types of ICS-ICS are classified as per no.of components.

ICS type	No.of logic gates
1. Small scale integrated (SSI)	< 10 (less than or equal to 10)
2. Medium scale integral (MSD)	< 100 (less than or equal to 100)
3. Large scale integral (LSI)	< 1000 (less than or equal to 1000)
4. V large scale integral (VLSI)	> (1000 greater than thousand)

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