ELECTRONICS AND COMMUNICATION

PHYSICS - 2 **UNIT - 10**

NAME :

STANDARD : 12 SEC :

SCHOOL :

EXAM NO :

கேடில் விழுச்செல்வம் கல்வி யொருவற்கு
மாடல்ல மற்றை யவை

கல்வி ஒன்றே அழிவற்ற செல்வமாகும். அதற்கு ஒப்பான சிறந்த செல்வம் வேறு எதுவும் இல்லை

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2 and 3 Mark Questions & Answers

1. What is called electronics?
- ✶ Electronics is the branch of physics incorporated with technology towards the design of circuits using transistors and microchips.
- ✶ It depicts the behaviour and movement of electrons in a semiconductor, vacuum, or gas.

2. What are passive components and active components?
- ✶ Components that cannot generate power in a circuit are called passive components
  (e.g.) Resistors, inductors, capacitors
- ✶ Components that can generate power in a circuit are called active components.
  (e.g.) transistors

3. What is energy band?
- ✶ When millions of atoms are brought close to each other, the valence orbitals and the unoccupied orbitals are split according to the number of atoms. Their energy levels will be closely spaced and will be difficult to differentiate the orbitals of one atom from the other and they look like a band
- ✶ *This band of very large number of closely spaced energy levels in a very small energy range is known as energy band.*

4. What is valance band, conduction band and forbidden energy gap?
- ✶ The energy band formed due to the valence orbitals is called ***valence band***.
- ✶ The energy band that formed due to the unoccupied orbitals is called the ***conduction band***
- ✶ The energy gap between the valence band and the conduction band is called ***forbidden energy gap***.

5. What is called intrinsic semiconductor?
- ✶ A semiconductor in its pure form without impurity is called an intrinsic semiconductor.
- ✶ Its conduction is low.
  (e.g.) Silicon, Germanium

6. Define dopping.
- ✶ The process of adding impurities to the intrinsic semiconductor is called ***doping***.
- ✶ It increases the concentration of charge carriers (electrons and holes) in the semiconductor and in turn, its electrical conductivity.
- ✶ The impurity atoms are called ***dopants***.

7. What is extrinsic semiconductors?
- ✶ The semiconductor obtained by dopping either pentavalent impurity or trivalent impurity is called extrinsic semiconductor.
  (e.g.) P - type and N-type semicondutor

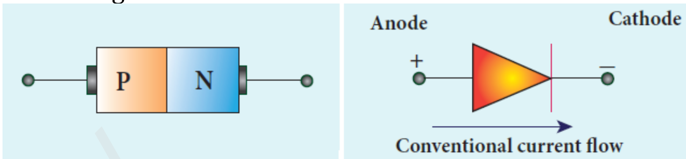
8. Define hole.
- ✶ When an electron is excited, covalent bond is broken. Now octet rule will not be satisfied.
- ✶ Thus each excited electron leaves a vacancy to complete bonding.
- ✶ This 'deficiency' of electron is termed as a 'hole'

9. What is called P-type semiconductor?
- ✶ A P - type semiconductor is obtained by doping a pure Germanium (or Silicon) crystal with a dopant of trivalent elements (acceptor impurity) like Boron, Aluminium, Gallium and Indium
- ✶ In P-type semicondutors,
  Holes are majority charge carriers
  Electrons are minority charge carriers

10. What is N-type semiconductor?
- ✶ A N - type semiconductor is obtained by doping a pure Germanium (or Silicon) crystal with a dopant of pentavalent elements (donor impurity) like Phosphorus, Arsenic and Antimony
- ✶ In N-type semicondutors,
  Electrons are majority charge carriers
  Holes are minority charge carriers

11. Define junction potential or barrier potential.
- ✶ When P - type and N - type semiconductors combine to form PN junction, due to diffusion of majority charge carriers a depletion region is formed near the junction.
- ✶ It prevents the charge carriers to further diffusion across the junction. Because a potential difference is set up by the immobile ions in this depletion region.
- ✶ This difference in potential across the depletion layer is called the barrier potential or junction potential.
- ✶ This barrier potential approximately equals ***0.7 V for Silicon*** and ***0.3 V for Germanium***.

12. What is P-N juction diode? Give its symbol.
- ✶ A P-N junction diode is formed when a P -type semiconductor is fused with a N-type semiconductor.
- ✶ It is a device with single P-N junction
- ✶ The Schematic representation and circuit symbol is given below.



13. What is called biasing? Give its types.
- ✶ Biasing is the process of giving external energy to charge carriers to overcome the barrier potential and make them move in a particular direction.
- ✶ The external voltage applied to the p-n junction is called bias voltage.
- ✶ Depending on the polarity of the external source to the P-N junction we have two types of biasing
  (1) Forward bias
  (2) Reverse bias

14. Differentiate forward bias and reverse bias.

<u>**Forward bias**</u> :
- ✶ If the positive terminal of the external voltage source is connected to the P-side and the negative terminal to the N-side, it is called forward biased
- ✶ It reduces width of the depletion region.

<u>**Reverse bias**</u> :
- ✶ If the positive terminal of the battery is connected to the N-side and the negative potential to the P-side, the junction is said to be reverse biased
- ✶ It increases width of the depletion region.

15. Define reverse saturation current.
- ✶ Under reverse bias, a small current flows across the junction due to the minority charge carriers in both regions.
- ✶ Because the reverse bias for majority charge carriers serves as the forward bias for minority charge carriers.
- ✶ The current that flows under a reverse bias is called the reverse saturation current or leakage current (I_S).
- ✶ It depends on temperature.

16. What is meant by rectification?
- ✶ The process of converting alternating current into direct current is called rectification.
- ✶ The device used for rectification is called rectifier.
- ✶ A P-N junction diode is used as rectifier.

17. What is mean by break down voltage?

- ✶ The reverse saturation current due to the minority charge carriers is small.
- ✶ If the reverse bias applied to a P-N junction is increased beyond a point, the junction breaks down and the reverse current rises sharply.
- ✶ The voltage at which this breakdown happens is called the breakdown voltage
- ✶ It depends on the width of the depletion region, which in turn depends on the doping level.

18. Write a note on Zener breakdown.

<u>Zener breakdown</u> :

- ✶ It wil occur in heavily doped P-N junction which have narrow depletion layers (< 10^{-6} m)
- ✶ When a reverse voltage across this junction is increased to the breakdown limit, a very strong electric field of strength **3×10^7 V m^{-1}** is set up across the narrow layer.
- ✶ This electric field is strong enough to break or rupture the covalent bonds in the lattice and thereby generating ***electron-hole pairs***. This effect is called Zener effect.
- ✶ Even a small further increase in reverse voltage produces a large number of charge carriers.
- ✶ Hence the junction has very low resistance in the breakdown region.
- ✶ This process of emission of electrons due to the rupture of bands in from the lattice due to strong electric field is known as ***internal field emission*** or ***field ionization***.
- ✶ The electric field required for this is of the order of **10^6 V m^{-1}**

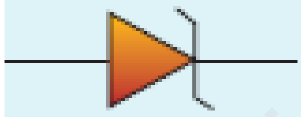
19. Write a note on avalanche break down.

<u>Avalanche breakdown</u> :

- ✶ It will occurs in lightly doped junctions which have wide depletion layers.
- ✶ Here the electric field is not strong enough to produce breakdown.
- ✶ But the minority charge carriers accelerated by the electric field gains sufficient kinetic energy, collide with the semiconductor atoms while passing through the depletion region.
- ✶ Thisleads to the breaking of covalent bonds and in turn generates electron-hole pairs.
- ✶ The newly generated charge carriers are also accelerated by the electric field resulting in more collisions and further production of charge carriers.
- ✶ This cumulative process leads to an avalanche of charge carriers across the junction and consequently reduces the reverse resistance.
- ✶ This is known as avanlanche breakdown.
- ✶ Here the diode current increases sharply.

20. What is called Zener diode? Give its circuit symbol.

- ✶ Zener diode is a reverse biased heavily doped Silicon diode which is specially designed to be operated in the breakdown region.
- ✶ The circuit symbol of Zener diode is given below.



21. Give the applications of Zener diode.

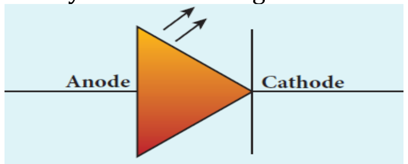
- ✶ Voltage regulators
- ✶ Peak clippers
- ✶ Calibrating voltages
- ✶ Provide fixed reference voltage in a network for biasing
- ✶ Meter protection against damage from accidental application of excessive voltage.

22. What is opto electronic devices?

- ✶ The devices which convert electrical energy into light and light into electrical energy through semiconductors are called opto electronic devices.
- ✶ Optoelectronic device is an electronic device which utilizes light for useful applications.
(e.g.) LEDs, photo diodes and solar cells.

23. What is light emitting diode (LED)?

- ✶ LED is a P-N junction diode which emits visible or invisible light when it is forward biased.
- ✶ Here electrical energy is converted into light energy, this process is also called ***electroluminescence***.
- ✶ The circuit symbol of LED is given below.

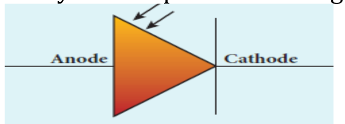


24. Give the applications of LEDs.

- ✶ Indicator lamps on the front panel of the scientific and laboratory equipments.
- ✶ Seven-segment displays.
- ✶ Traffic signals, exit signs, emergency vehicle lighting etc.
- ✶ Industrial process control, position encoders, bar graph readers.

25. What is photo diode? Give its circuit symbol.

- ✶ A P-N junction diode which converts an optical signal into electric current is known as photodiode
- ✶ Its operation exactly opposite to that of an LED.
- ✶ Photo diode words in reverse bias.
- ✶ The circuit symbol of photo diode is given below.



26. Give the applications of photo diode.

- ✶ Alarm system
- ✶ Count items on a conveyer belt
- ✶ Photoconductors
- ✶ Compact disc players, smoke detectors
- ✶ Medical applications such as detectors for computed tomography etc.

27. What are called solar cells?

- ✶ A solar cell, also known as photovoltaic cell, converts light energy directly into electricity or electric potential difference by photovoltaic effect.
- ✶ It is basically a P-N junction which generates emf when solar radiation falls on the P-N junction.

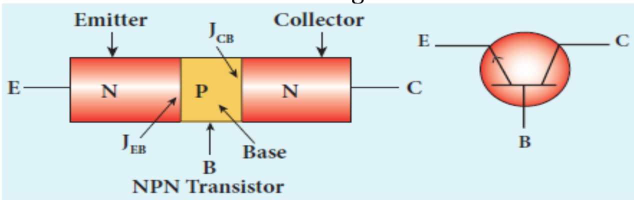
28. Give the applications of solar cells.

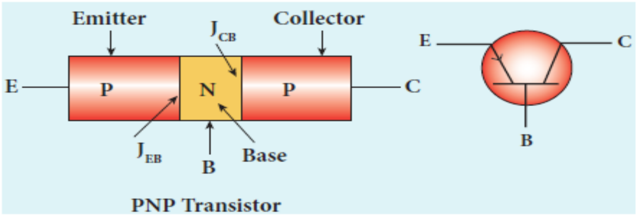
- ✶ Solar cells are widely used in calculators, watches, toys, portable power supplies, etc.
- ✶ Solar cells are used in satellites and space applications
- ✶ Solar panels are used to generate electricity.

29. Write a note on bipolar junction transistor(BJT).

- ✶ The bipolar junction transistor (BJT) consists of a semiconductor (Silicon or Germanium) crystal in which an N-type material is sandwiched between two P-type materials called ***PNP transistor*** or a P -type material sandwiched between two N-type materials called ***NPN transistor***.
- ✶ The three regions formed are called emitter (E), base (B) and collector (C)

- ✶ The schematic symbol and circuit symbol of PNP and NPN transistors are given below.





30. Discuss the different modes of transistor biasing.

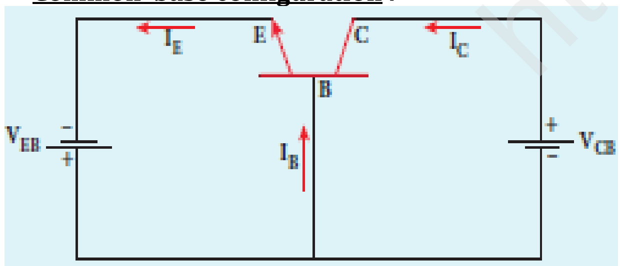
(1) <u>Forward Active</u> :
- ✶ In this bias the emitter-base junction (J_{EB}) is forward biased and the collector-base junction (J_{CB}) is reverse biased.
- ✶ The transistor is in the active mode and in this mode, the transistor functions as an amplifier.

(2) <u>Saturation</u> :
- ✶ Here, both the emitter-base junction (J_{EB}) and collector-base junction (J_{CB}) are forward biased.
- ✶ The transistor has a very large flow of currents across the junctions and in this mode, transistor is used as a closed switch.

(3) <u>Cut-off</u> :
- ✶ In this bias, both the emitter-base junction (J_{EB}) and collector-base junction (J_{CB}) are reverse biased.
- ✶ Transistor in this mode is an open switch.

31. Draw the circuit diagram of common base configurations of NPN transistor.

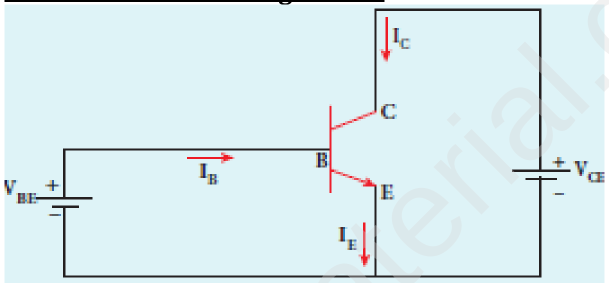
<u>Common base configuration</u> :



- ✶ Input termial - Emitter
  Output terminal - Collector
  Common terminal - Base
- ✶ Input current $= I_E$
  Output current $= I_C$
- ✶ The input signal (V_{BE}) is applied across emitter - base junction
- ✶ The output signal (V_{CB}) is measured across collector - base junction.

32. Draw the circuit diagram of common emitter configurations of NPN transistor.

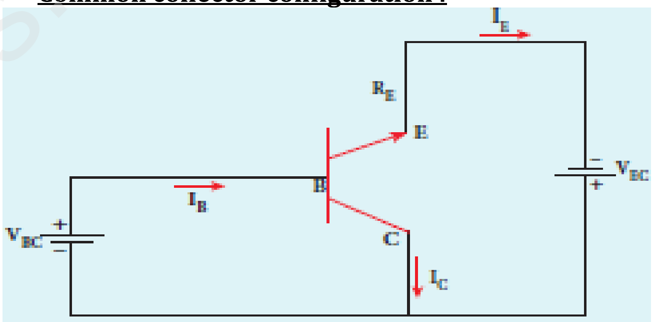
<u>Common emitter configuration</u> :



- ✶ Input termial - Base
  Output terminal - Collector
  Common terminal - Emitter
- ✶ Input current $= I_B$
  Output current $= I_C$
- ✶ The input signal (V_{BE}) is applied across base - emitter junction
- ✶ The output signal (V_{CE}) is measured across collector - emitter junction.

33. Draw the circuit diagram of common emitter configurations of NPN transistor.

<u>Common collector configuration :</u>



- ✶ Input termial - Base
  Output terminal - Emitter
  Common terminal - Collector
- ✶ Input current $= I_B$
  Output current $= I_E$
- ✶ The input signal (V_{BC}) is applied across base - collector junction
- ✶ The output signal (V_{EC}) is measured across emitter - collector junction.

34. Define input resistance of transistor.
- ✶ The ratio of the change in base-emitter voltage (ΔV_{BE}) to the change in base current (ΔI_B) at a constant collector-emitter voltage (V_{CE}) is called the input resistance (r_i).

$$r_i = \left[\frac{\Delta V_{BE}}{\Delta I_B}\right]_{V_{CE}}$$

- ✶ The input resistance is high for a transistor in common emitter configuration.

35. Define output resistance of transistor.
- ✶ The ratio of the change in collector-emitter voltage (ΔV_{CE}) to the change in collector current (ΔI_C) at a constant base current (I_B) is called the output resistance (r_o).

$$r_o = \left[\frac{\Delta V_{CE}}{\Delta I_C}\right]_{I_B}$$

- ✶ The output resistance is very low for a transistor in common emitter configuration.

36. Define forward current gain.
- ✶ The ratio of the change in collector current (ΔI_C) to the change in base current (ΔI_B) at constant collector-emitter voltage (V_{CE}) is called forward current gain (β).

$$\beta = \left[\frac{\Delta I_C}{\Delta I_B}\right]_{V_{CE}}$$

- ✶ Its value is very high and it generally ranges from 50 to 200.

37. Give the relation between α and β
- ✶ Forward current gain in common base mode,

$$\alpha = \left[\frac{\Delta I_C}{\Delta I_E}\right]_{V_{CE}}$$

- ✶ Forward current gain in common emitter mode,

$$\beta = \left[\frac{\Delta I_C}{\Delta I_B}\right]_{V_{CE}}$$

- ✶ From the above two equations, we have

$$\alpha = \frac{\beta}{1+\beta} \qquad (or) \qquad \beta = \frac{\alpha}{1-\alpha}$$

38. What is called transistor amplifier?

- ✶ A transistor operating in the active region has the capability to amplify weak signals.
- ✶ Amplification is the process of increasing the signal strength (increase in the amplitude).

39. What is called transistor oscillator?

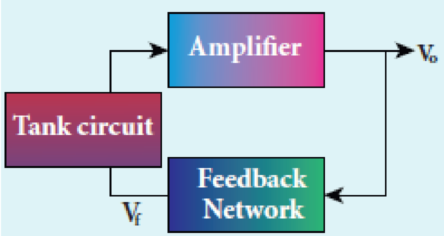
- ✶ An electronic oscillator basically converts DC energy into AC energy of high frequency ranging from a few Hz to several MHz. Hence, it is a source of alternating current or voltage.
- ✶ Unlike an amplifier, oscillator does not require any external signal source.

40. Give the types of an oscillator.

- ✶ There are two types of oscillators:
  - (1) Sinusoidal and
  - (2) Non-sinusoidal
- ✶ Sinusoidal oscillators generate oscillations in the form of ***sine waves*** at constant amplitude and frequency
- ✶ Non-sinusoidal oscillators generate complex ***non-sinusoidal waveforms*** like square wave, triangular wave or saw-toothed wave

41. Draw the block diagram of an oscillator

<u>Block diagram of oscillator</u> :



- ✶ Oscillator essensially consists three main parts,
  - (1) **<u>Tank circuit</u>** :
    - ✶ The tank circuit generates electrical oscillations and acts as the AC input source to the transistor amplifier.
  - (2) **<u>Amplifier</u>** :
    - ✶ Amplifier amplifies the input ac signal.
  - (3) **<u>Feed back network</u>** :
    - ✶ The feedback circuit provides a portion of the output to the tank circuit to sustain the
    - ✶ oscillations without energy loss.
  - ✶ Hence, an oscillator does not require an external input signal.
  - ✶ The output is said to be self-sustained.

42. Give the Barkhausen conditions for sustained oscillations.

- ✶ The loop phase shift must be 0^0 or integral multiples of 2π.
- ✶ The loop gain must be unity. $|A\beta| = 1$

  Here, A → Voltage gain of the amplifier,

  β → Feedback ratio

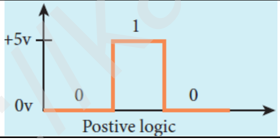
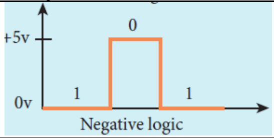
43. Give the applications of oscillator.

- ✶ To generate a periodic sinusoidal or non sinusoidal wave forms.
- ✶ To generate RF carriers.
- ✶ To generate audio tones
- ✶ To generate clock signal in digital circuits.
- ✶ As sweep circuits in TV sets and CRO.

44. Distinguish between analog and digital signal.

Analog signal	Digital signal
It is continuously varying voltage or current with respect to time	It contains only two discrete values of voltages (i.e.) low (OFF) and high (ON)
These signals are employed in rectifying circuits and transistor amplifier circuits	These signals are employed in signal processing. communication etc.,

45. Distinguish between positive and negative logic.

Positive logic	Negative logic
Binary 1 stands for +5 V Binary 0 stands for 0 V	Binary 1 stands for 0V Binary 0 stands for +5 V
	

46. Why digital signals are preferred than analog signals?

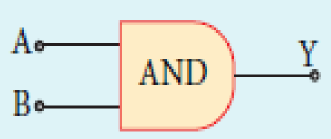
- ✶ Because of their better performance, accuracy, speed, flexibility and immunity to noice.

47. What are called logic gates?

- ✶ A logic gate is an electronic circuit which functions based on digital signals.
- ✶ They are considered as the basic building blocks of most of the digital systems.
- ✶ It has one output with one or more inputs.

48. Give the circuit symbol, Boolean expression, logical operation and truth table of AND gate .

<u>AND gate - circuit symbol</u> :



<u>Boolean expression</u> :

- ✶ Ley A and B are the inputs and Y be the output, then

$$Y = A\,.\,B$$

<u>Logical operation :</u>

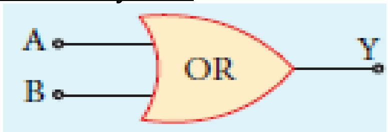
- ✶ The output of AND gate is high (1) only when all the inputs are high (1).
- ✶ The rest of the cases the output is low (0)

<u>Truth table</u> :

Inputs		Output
A	**B**	**Y = A . B**
0	0	0
0	1	0
1	0	0
1	1	1

49. Give the circuit symbol, Boolean expression, logical operation and truth table of OR gate .

<u>OR gate - circuit symbol</u> :



<u>Boolean expression</u> :

- ✶ Ley A and B are the inputs and Y be the output, then

$$Y = A + B$$

<u>Logical operation :</u>

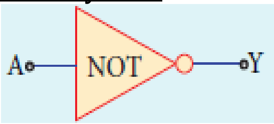
- ✶ The output of OR gate is high (1) when either of the inputs or both are high (1)

<u>Truth table</u> :

Inputs		Inputs
A	**B**	$Y = A + B$
0	0	0
0	1	1
1	0	1
1	1	1

50. Give the circuit symbol, Boolean expression, logical operation and truth table of NOT gate .

NOT gate - circuit symbol :



Boolean expression :

- ✶ If A be the input and Y be the output, then

$$Y = \overline{A}$$

Logical operation :

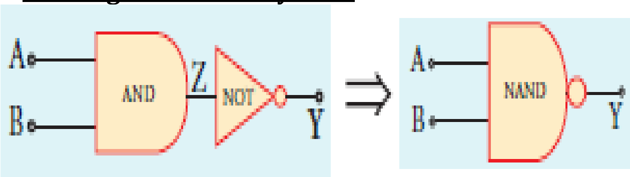
- ✶ The output is the complement of the input. It is represented with an overbar.
- ✶ It is also called as inverter.
- ✶ The output Y is high (1), when input is low (0) and vice versa.

Truth table :

Input	Output
A	$Y = \overline{A}$
0	1
1	0

51. Give the circuit symbol, Boolean expression, logical operation and truth table of NAND gate .

NAND gate - circuit symbol :



Boolean expression :

- ✶ Ley A and B are the inputs and Y be the output, then

$$Y = \overline{A\,.\,B}$$

Logical operation :

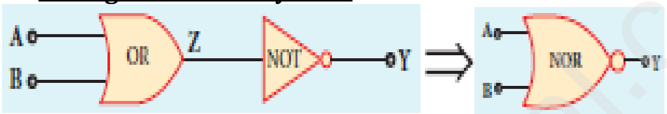
- ✶ The output Y equals the complement of AND operation.
- ✶ The circuit is an AND gate followed by a NOT gate. Therefore, it is summarized as NAND.
- ✶ The output is at low (0) only when all the inputs are high (1).
- ✶ The rest of the cases, the output is high (1)

Truth table :

Input		Output (AND)	Output (NAND)
A	**B**	**Z = A . B**	$Y = \overline{A\,.\,B}$
0	0	0	1
0	1	0	1
1	0	0	1
1	1	1	0

52. Give the circuit symbol, Boolean expression, logical operation and truth table of NOR gate .

NOR gate - circuit symbol :



Boolean expression :

- ✶ Ley A and B are the inputs and Y be the output, then

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

Logical operation :

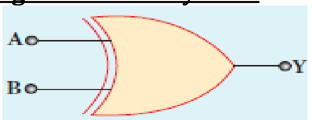
- ✶ The output Y equals the complement of OR operation
- ✶ The circuit is an OR gate followed by a NOT gate and is summarized as NOR
- ✶ The output is high (1) when all the inputs are low (0).
- ✶ The rest of the cases, the output is low (0)

Truth table :

Input		Output (OR)	Output (NOR)
A	**B**	**Z = A + B**	$Y = \overline{A + B}$
0	0	0	1
0	1	1	0
1	0	1	0
1	1	1	0

53. Give the circuit symbol, Boolean expression, logical operation and truth table of EX-OR gate .

EX-OR gate - circuit symbol :



Boolean expression :

- ✶ Ley A and B are the inputs and Y be the output, then

$$Y = A\,.\,\overline{B} + \overline{A}\,.\,B$$

$$Y = A \oplus B$$

Logical operation :

- ✶ The output Y is high (1) only when either of the two inputs is high (1).
- ✶ In the case of an Ex-OR gate with more than two inputs, the output will be high (1) when odd number of inputs are high (1)

Truth table :

Input		Output
A	**B**	$Y = A \oplus B$
0	0	0
0	1	1
1	0	1
1	1	0

54. State Demorgan's theorems.

Theorem - 1 :

- ✶ The complement of the sum of two logical inputs is equal to the product of its complements.

$$\overline{A + B} = \overline{A}\,.\,\overline{B}$$

Theorem - 2 :

- ✶ The complement of the product of two logical inputs is equal to the sum of its complements.

$$\overline{A\,.\,B} = \overline{A} + \overline{B}$$

55. What is an integrated circuit?

- ✶ An integrated circuit (IC) or a chip or a microchip is an electronic circuit, which consists of thousands to millions of transistors, resistors, capacitors, etc. integrated on a small flat piece of Silicon.

56. What are the application of integrated circuits (ICs)

- ✶ Low cost
- ✶ great performance.
- ✶ Very small in size
- ✶ High reliability
- ✶ They can function as an amplifier, oscillator, timer, microprocessor and computer memory.

57. Distinguish between digital IC and analog IC

Digital IC :

- ✶ Digital ICs uses digital signals (logical 0 and 1). They usually find their applications in computers, networking equipment, and most consumer electronics.

Analog IC :

- ✶ Analog (or) linear ICs work with continuous values. Linear ICs are typically used in audio and radio frequency amplification.

58. How electron-hole pairs are created in a semiconductor material?

- A small increase in temperature is sufficient enough to break some of the covalent bonds and release the electrons free from the lattice.
- Hence a vacant site is created in the valanceband and this vacancies are called holes which are treated to possess positive charges.
- Thus electrons and holes are the two charge carriers in semiconductors.

59. A diode is called as a unidirectional device. Explain

- An ideal diode behaves as conductor when it is forward biased and behaves as an insulator when it is reverse biased.
- Thus diode coducts current only from P -type to N -type through the junction when it is forward biased.
- Hence Diode is a unidirectional device.

60. What is called modulation? Give its types.

- For long distance transmission, the low frequency base band signal (input signal) is superimposed on to a high frequency carrier signal (radio signal) by a process called modulation.
  (1) Amplitude Modulation (AM)
  (2) Frequency Modulation (FM)
  (3) Phase Modulation (PM)

61. What is the necessity of modulation?

- When the information signal of low frequency is transmitted over a long distances, there will be information loss occurs.
- As the frequency of the carrier signal is very high, it can be transmitted to long distances with less attenuation.
- Thus in the modulation process, carrier signal of very high frequency signal (radio signal) is used to carry the baseband signal(information)

62. Define amplitude modulation (AM)

- If the amplitude of the carrier signal is modified according to the instantaneous amplitude of the baseband signal, then it is called amplitude modulation (AM)

63. Give the advantages and limitations of amplitude modulation (AM)

<u>**Advantages of AM**</u> :

- Easy transmission and reception
- Lesser bandwidth requirements
- Low cost

<u>**Limitations of AM**</u> :

- Noise level is high
- Low efficiency
- Small operating range

64. Define frequency modulation (FM)

- If the frequency of the carrier signal is modified according to the instantaneous amplitude of the baseband signal then it is called frequency modulation (FM)

65. Give the advantages and limitations of frequency modulation (FM)

<u>**Advantages of FM**</u> :

- Large decrease in noise. This leads to an increase in signal-noise ratio.
- The operating range is quite large.
- The transmission efficiency is very high as all the transmitted power is useful.
- FM bandwidth covers the entire frequency range which humans can hear. Due to this, FM radio has better quality compared to AM radio.

<u>**Limitations of FM**</u> :

- FM requires a much wider channel.
- FM transmitters and receivers are more complex and costly.
- In FM reception, less area is covered compared to AM.

66. Define phase modulation (PM)

- The instantaneous amplitude of the baseband signal modifies the phase of the carrier signal keeping the amplitude and frequency constant is called phase modulation

67. What is called centre frequency (resting frequency)?

- When the frequency of the baseband signal is zero (no input signal), there is no change in the frequency of the carrier wave.
- It is at its normal frequency and is called as centre frequency or resting frequency.
- Practically **75 kHz** is the allotted frequency of the FM transmitter.

68. Compare FM and PM ?

<u>**Comparison between FM and PM**</u> :

- PM wave is similar to FM wave.
- PM generally uses a smaller bandwidth than FM. In other words, in PM, more information can be sent in a given bandwidth.
- Hence, phase modulation provides high transmission speed on a given bandwidth.

69. What is called base band signals?

- Information can be in the form of a sound signal like speech, music, pictures, or computer data.
- The electrical equivalent of the original information is called the baseband signal.

70. Define band width.

- The frequency range over which the baseband signals or the information signals such as voice, music, picture, etc. is transmitted is known as bandwidth.
- Bandwidth gives the difference between the upper and lower frequency limits of the signal.
- If ν_1 and ν_2 are the lower and upper-frequency limits of a signal, then the bandwidth,

$$BW = \nu_2 - \nu_1$$

71. Define the size of the antenna.

- Antenna is used at both transmitter and receiver end.
- Antenna height is an important parameter to be discussed. The height of the antenna must be a multiple of $\frac{\lambda}{4}$. (i.e.)

$$h = \frac{\lambda}{4} = \frac{c}{4\,\nu}$$

72. What are the three modes of propagation of electromagnetic waves through space.

- Ground wave propagation (or) surface wave propagation (nearly 2 kHz to 2 MHz)
- Sky wave propagation (or) ionospheric propagation (nearly 3 MHz to 30 MHz)
- Space wave propagation (nearly 30MHz to 400GHz)

73. Write a note on ground wave propagation.

- If the electromagnetic waves transmitted by the transmitter glide over the surface of the earth to reach the receiver, then the propagation is called ground wave propagation.

- The corresponding waves are called ground waves or surface waves.
- It is mainly used in local broadcasting, radio navigation, for ship-to-ship, shipto-shore communication and mobile communication.

74. **Give the factors that are responsible for transmission impairments.**

Increasing distance :

- The attenuation of the signal depends on
  (1) power of the transmitter
  (2) frequency of the transmitter, and
  (3) condition of the earth surface.

Absorption of energy by the Earth :

- When the transmitted signal in the form of EM wave is in contact with the Earth, it induces charges in the Earth and constitutes a current.
- Due to this, the earth behaves like a leaky capacitorwhich leads to the attenuation of the wave.

Tilting of the wave: As the wave :

- As the wave progresses, the wavefront starts gradually tilting according to the curvature of the Earth.
- This increase in the tilt decreases the electric field strength of the wave.
- Finally, at some distance, the surface wave dies out due to energy loss.

75. **Define sky wave propagation.**

- The mode of propagation in which the electromagnetic waves radiated from an antenna, directed upwards at large angles gets reflected by the ionosphere back to earth is called sky wave propagation or ionospheric propagation.
- The corresponding waves are called sky waves

76. **Define skip distance.**

- The shortest distance between the transmitter and the point of reception of the sky wave along the surface is called as the skip distance

77. **Define skip zone.**

- There is a zone in between where there is no reception of electromagnetic waves neither ground nor sky, called as skip zone or skip area.

78. **What is space wave propagation?**

- The process of sending and receiving information signal through space is alled space wave communication
- The electromagnetic waves of very high frequencies above 30 MHz are called as space waves.

79. **Define fibre optical communication.**

- The method of transmitting information from one place to another in terms of light pulses through an optical fiber is called fiber optic communication.
- It works on the principle of total internal reflection.

80. **What is mean by RADAR?**

- Radar basically stands for **RA**dio **D**etection **A**nd **R**anging System.
- It is one of the important applications of communication systems and is mainly used to sense, detect, and locate distant objects like aircraft, ships, spacecraft, etc.

81. **Write a note on mobile communication and give its applictions.**

- Mobile communication is used to communicate with others in different locations without the use of any physical connection like wires or cables
- It enables the people to communicate with each other regardless of a particular location like office, house, etc.
- It also provides communication access to remote areas.

Applictions :

- It is used for personal communication and cellular phones offer voice and data connectivity with high speed.
- Transmission of news across the globe is done within a few seconds.
- Using Internet of Things (IoT), it is made possible to control various devices from a single device. Example: home automation using a mobile phone.
- It enables smart classrooms, online availability of notes, monitoring student activities etc. in the field of education.

82. **Write a note on internet and give itsapplications.**

- Internet is a fast growing technology in the field of communication system with multifaceted tools.
- Internet is the largest computer network recognized globally that connects millions of people through computers.
- It finds extensive applications in all walks of life.

Applications :

Search engine :

- The search engine is basically a web-based service tool used to search for information on World Wide Web.

Communication :

- It helps millions of people to connect with the use of social networking: emails, instant messaging services and social networking tools.

E-Commerce :

- Buying and selling of goods and services, transfer of funds are done over an electronic network.

83. **What do you mean by Internet of Things?**

- Using Internet of Things (IoT), it is made possible to control various devices from a single device. (e.g.) Home automation using a mobile phone.

84. **Distinguish between wireline and wireless communication? Specify the range of electromagnetic waves in which it is used.**

Wirelinecommunication

- It is apoint-point communication) uses mediums like wires, cables and optical fibers.
- These systems cannot be used for long distance transmission as they are connected physically. Examples are telephone, intercom and cable TV.

Wireless communication

- It uses free space as a communication medium.
- The signals are transmitted in the form of electromagnetic waves with the help of a transmitting antenna.
- Hence wireless communication is used for long distance transmission.
  Examples are mobile, radio or TV broadcasting, and satellite communication.

85. What are called noises?

- It is the undesirable electrical signal that interfaces with the transmitted signal.
- Noise attenuates or reduces the quality of the transmitted signal.
- It may be man-made (automobiles, welding machines, electric motors etc.) or natural (lightning, radiation from sun and stars and environmental effects).

86. What are repeaters?

- Repeaters are used to increase the range or distance through which the signals are sent.
- It is a combination of transmitter and receiver.
- The signals are received, amplified, and retransmitted with a carrier signal of different frequency to the destination.
- The best example is the communication satellite in space.

87. Define attenuation.

- The loss of strength of a signal while propagating through a medium is known as attenuation.

88. Define Range.

- It is the maximum distance between the source and the destination up to which the signal is received with sufficient strength.

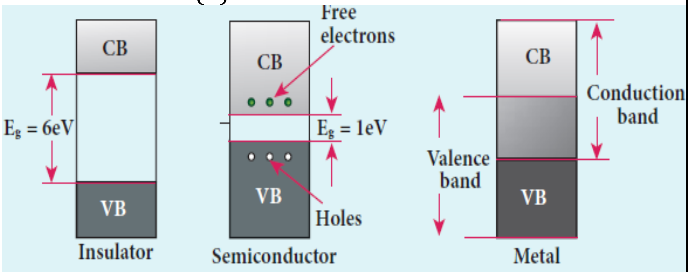
5 marks Questions & Answers

1. Explain the classification of solids on the basis of energy band theory.

Classification of solids :

✶ Based on the energy band theory, solids are classified in to three types, namely

(1) Insulators
(2) Metals (Condutors)
(3) Semiconductors



Insulators :

✶ In insulator the valence band (VB) and the conduction band (CB) are separated by a large energy gap.

✶ The forbidden energy gap (E_g) is approximately 6 eV in insulators.

✶ The gap is very large that electrons from valence band cannot move into conduction band even on the application of strong external electric field or the increase in temperature.

✶ Therefore, the electrical conduction is not possible as the free electrons are almost nil and hence these materials are called insulators.

✶ Its resistivity is in the range of $\mathbf{10^{11} - 10^{19}\ \Omega\, m}$

Metals (Conductors) :

✶ In metals, the valence band and onduction band overlap

✶ Hence, electrons can move freely into the conduction band which results in a large number of free electrons in the conduction band.

✶ Therefore, conduction becomes possible even at low temperatures.

✶ The application of electric field provides sufficient energy to the electrons to drift in a particular direction to constitute a current.

✶ For metals, the resistivity value lies between $\mathbf{10^{-2} - 10^{-8}\ \Omega\, m}$

Semiconductors :

✶ In semiconductors, there exists a narrow forbidden energy gap ($E_g < 3\ eV$) between the valence band and the conduction band.

✶ At a finite temperature, thermal agitations in the solid can break the covalent bond between the atoms.

✶ This releases some electrons from valence band to conduction band.

✶ Since free electrons are small in number, the conductivity of the semiconductors is not as high as that of the conductors.

✶ The resistivity value of semiconductors is from $\mathbf{10^{-5} - 10^{6}\ \Omega\, m}$.

✶ When the temperature is increased further, more number of electrons is promoted to the conduction band and increases the conduction.

✶ Thus, the electrical conduction increases with the increase in temperature. (i.e.) resistance decreases with increase in temperature.

✶ Hence, semiconductors are said to have negative temperature coefficient of resistance.

✶ The most important elemental semiconductor materials are ***Silicon (Si)*** and ***Germanium (Ge).***

✶ At room temperature,

forbidden energy gap for Si ; $\mathbf{E_g = 1.1\ eV}$ and

forbidden energy gap for Ge ; $\mathbf{E_g = 0.7\ eV}$

2. Explain in detail the intrinsic semiconductor.

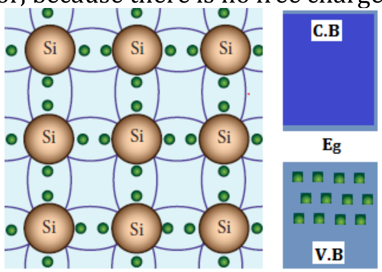
Intrinsic semiconductor :

✶ A semiconductor in its pure form without impurity is called an intrinsic semiconductor.

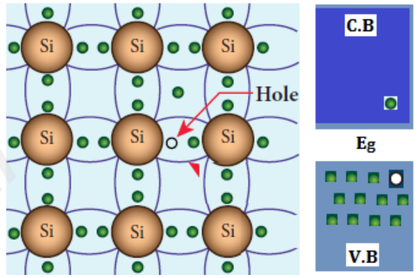
(e.g) silicon, germanium

✶ Consider Silicon lattice. Each Silicon atom is covalently bonded with the neighbouring four atoms to form the lattice.

✶ At absolute zero (0 K), this will behaves as insulator, because there is no free charges.



✶ But at room temperature, some of the covalent bonds are brakes and releases the electrons free from the lattice.



✶ As a result, some states in the valence band become empty and the same number of states in the conduction band will be occupied.

✶ The vacancies produced in the valence band are called holes which are treates as positive charges.

✶ Hence, electrons and holes are the two charge carriers in semiconductors.

✶ In intrinsic semiconductors, the number of electrons in the conduction band is equal to the number of holes in the valence band.

✶ The conduction is due to the electrons in the conduction band and holes in the valence band

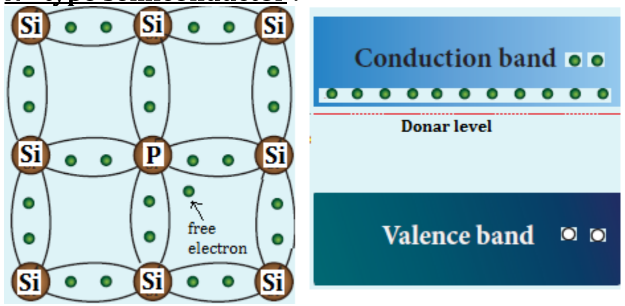
✶ The total current (I) is always the sum of the electron current ($\boldsymbol{I_e}$) and the hole current ($\boldsymbol{I_h}$)

$$\boldsymbol{I = I_e + I_h}$$

✶ The increase in temperature increases the number of charge carriers (electrons and holes).

3. Elucidate the formation of a N-type and P-type semiconductors.

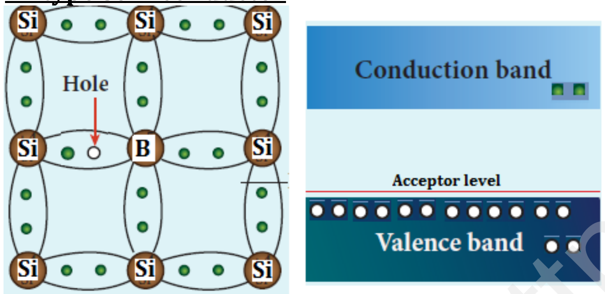
N - type semiconductor :



✶ A n-type semiconductor is obtained by doping a pure Silicon (or Germanium) crystal with a dopant from pentavalent elements like Phosphorus, Arsenic, and Antimony

- ✶ The dopant has five valence electrons while the Silicon atom has four valence electrons.
- ✶ During the process of doping, four of the five valence electrons of the impurity atom are bound with the 4 valence electrons of the neighbouring replaced Silicon atom.
- ✶ The fifth valence electron of the impurity atom will be loosely attached with the nucleus as it has not formed the covalent bond.
- ✶ The energy level of the loosely attached fifth electron is found just below the conduction band edge and is called the ***donor energy level***
- ✶ The energy required to set free a donor electron is only 0.01 eV for Ge and 0.05 eV for Si.
- ✶ At room temperature, these electrons can easily move to the conduction band with the absorption of thermal energy.
- ✶ The pentavalent impurity atoms donate electrons to the conduction band and are called ***donor impurities***.
- ✶ Therefore,each impurity atom provides one extra
- ✶ electron to the conduction band in addition to the thermally generated electrons
- ✶ Hence, in an N - type semiconductor, the
  majority carriers - Electrons
  minority carriers - Holes

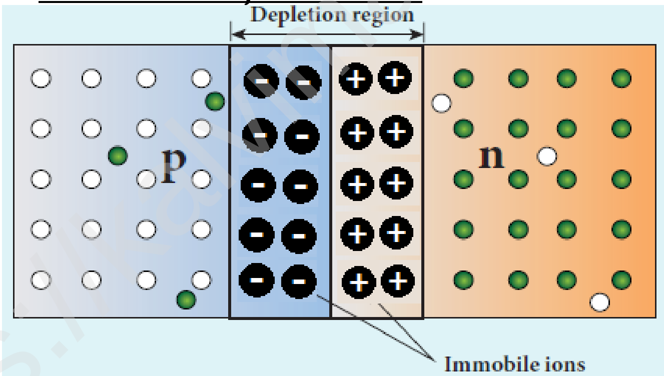
P - type semiconductor :



- ✶ A n-type semiconductor is obtained by doping a pure Silicon (or Germanium) crystal with a dopant from trivalent elements like Boron, Aluminium, Gallium and Indium
- ✶ The dopant has three valence electrons while the Silicon atom has four valence electrons.
- ✶ During the process of doping, the dopant with three valence electrons are bound with the neighbouring three Silicon atoms.
- ✶ As Silicon atom has four valence electrons, one electron position of the dopant in the crystal lattice will remain vacant.
- ✶ The missing electron position in the covalent bond is denoted as a hole.
- ✶ To make complete covalent, the dopant is in need of one more electron.
- ✶ These dopants can accept electrons from the neighbouring atoms. Therefore, this impurity is called an ***acceptor impurity***.
- ✶ The energy level of the hole created by each impurity atom is just above the valence band and is called the ***acceptor energy level***.
- ✶ For each acceptor atom, there will be a hole in the valence band in addition to the thermally generated holes.
- ✶ Hence, in an P - type semiconductor, the
  majority carriers - Holes
  minority carriers - Electrons

4. Explain the formation of PN junction diode. Discuss its V–I characteristics.

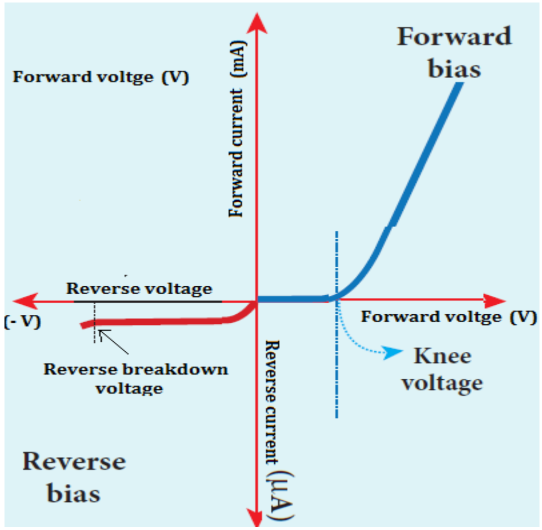
Formation of PN junction diode :



- ✶ A P-N junction is formed by joining N -type and P-type semiconductor materials.
- ✶ Here the N-region has a high electron concentration and the P-region a high hole concentration.
- ✶ So the electrons diffuse from the N-side to the P-side. Simillarly holes also diffuse from P - side to the N- side. This causes ***diffusion current***.
- ✶ In a P-N junction, when the electrons and holes move to the other side of the junction, they leave behind exposed charges on dopant atom sites, which are fixed in the crystal lattice and are unable to move.
- ✶ On the n-side, positive ion cores are exposed and on the p- side, negative ion cores are exposed
- ✶ An electric field E forms between the positive ion cores in the n-type material and negative ion cores in the p-type material.
- ✶ The electric field sweeps free carriers out of this region and hence it is called ***depletion region*** as it is depleted of free carriers.
- ✶ A ***barrier potential*** (V_b) due to the electric field E is formed at the junction.
- ✶ As this diffusion of charge carriers from both sides continues, the negative ions form a layer of negative space charge region along the p-side.
- ✶ Similarly, a positive space charge region is formed by positive ions on the n-side.
- ✶ The positive space charge region attracts electrons from P-side to n-side and the negative space charge region attracts holes from N-side to P -side.
- ✶ This moment of carriers happen in this region due to the formed electric field and it constitutes a current called ***drift current***.
- ✶ The diffusion current and drift current flow in the opposite direction and at one instant they both become equal.
- ✶ Thus, a P-N junction is formed.

V -I characteristics :

- ✶ It is the study of the variation in current through the diode with respect to the applied voltage across the diode when it is forward or reverse biased.



Forward bias characteristics :

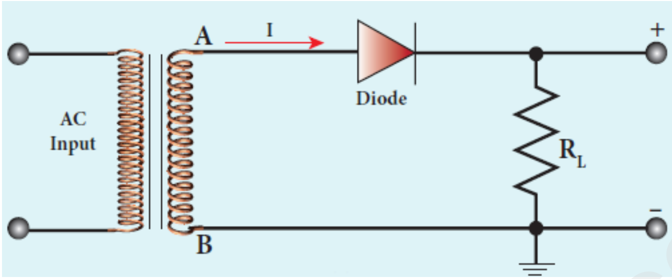
- ✶ If the positive terminal of the external voltage source is connected to the P-side and the negative terminal to the N-side, it is called forward biased.
- ✶ A graph is plotted by taking the forward bias voltage (V) along the x-axis and the current (I) through the diode along the y-axis. This graph is called the ***forward V-I characteristics.***
- ✶ From the graph,
  (1) At room temperature, a potential difference equal to the barrier potential is required before a reasonable forward current starts flowing across the diode. This voltage is known as ***threshold voltage*** or ***cut-in voltage*** or ***knee voltage (V_{th})***.
  For Silicon ; $V_{th} = 0.7\ V$
  For Germanium ; $V_{th} = 0.3\ V$
  (2) The graph clearly infers that the current flow is not linear and is exponential. Hence it does not obey Ohm's law.
  (3) The forward resistance (r_f) of the diode is the ratio of the small change in voltage (ΔV)to the small change in current(ΔI),
  $$r_f = \frac{\Delta V}{\Delta I}$$
  (4) Thus the diode behaves as a conductor when it is forward biased.

Reverse bias characteristics :

- ✶ If the positive terminal of the battery is connected to the n-side and the negative potential to the p-side, the junction is said to be reverse biased.
- ✶ A graph is drawn between the reverse bias voltage and the current across the junction, which is called the ***reverse V - I characteristics.***
- ✶ Under this bias, a very small current in μA, flows across the junction. This is due to the flow of the minority charge carriers called the ***leakage current*** or ***reversesaturation current***.
  For Silicon ; $I_{leakage} = 20\ \mu A$
  For Germanium ; $I_{leakage} = 50\ \mu A$
- ✶ Besides, the current is almost independent of the voltage.
- ✶ The reverse bias voltage can be increased only up to the rated value otherwise the diode will enter into the breakdown region.

5. Draw the circuit diagram of a half wave rectifier and explain its working.

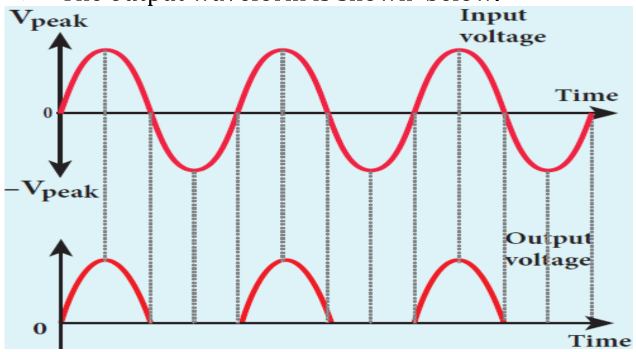
Half wave rectifier :



- ✶ In a half wave rectifier circuit, either a positive half or the negative half of the AC input is passed through while the other half is blocked.
- ✶ Only one half of the input wave reaches the output. Therefore, it is called half wave rectifier.
- ✶ This circuit consists of a transformer, a P-N junction diode and a resistor (R_L)
- ✶ Here, a P-N junction diode acts as a rectifying diode.

During positive half cycle of input AC	During negative half cycle of input AC
Terminal A becomes positive with respect to terminal B.	Terminal B becomes positive with respect to terminal A.
The diode is forward biased and hence it conducts	The diode is reverse biased and hence it does not conducts
The current flows through the load resistor R_L and the AC voltage developed across R_L constitutes the output voltage V_0	No current passes through R_L and there is no voltage drop across R_L (The reverse saturation current in a diode is negligible)

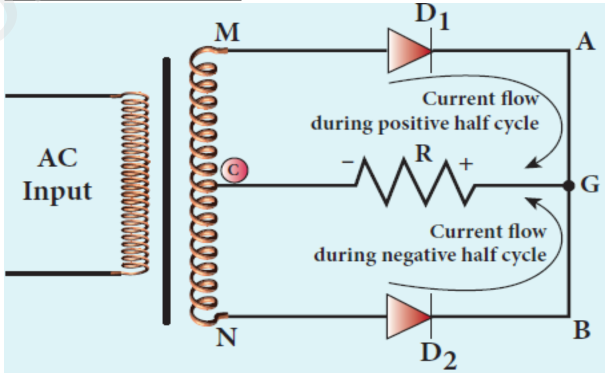
- ✶ The output waveform is shown below.



- ✶ The output of the half wave rectifier is not a steady dc voltage but a pulsating wave.
- ✶ A constant ora steady voltage is required which can be obtained with the help of filter circuits and voltage regulator circuits.
- ✶ Efficiency (η) is the ratio of the output dc power to the ac input power supplied to the circuit. Its value for half wave rectifier is **40.6 %**

6. Explain the construction and working of a full wave rectifier.

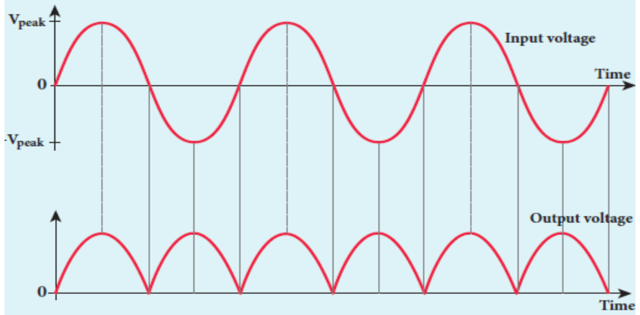
Full wave rectifier :



- ✶ The positive and negative half cycles of the AC input signal pass through this circuit and hence it is called the full wave rectifier.
- ✶ It consists of two P-N junction diodes, a center tapped transformer, and a load resistor (R_L).
- ✶ The centre (C) is usually taken as the groundor zero voltage reference point.
- ✶ Due to the centre tap transformer, the output voltage rectified by each diode is only one half of the total secondary voltage.

During positive half cycle of input AC	During negative half cycle of input AC
Terminal M is positive, G is at zero potential and N is at negative potential	Terminal M is negative, G is at zero potential and N is at positive potential
Diode D_1 is forward biased Diode D_2 is reverse biased	Diode D_1 is reverse biased Diode D_2 is forward biased
D_1 conducts and current flows along the path **MD_1AGC**	D_2 conducts and current flows along the path **ND_2 BGC**
The voltage appears across R_L in the direction G to C	The voltage appears across R_L in the same direction G to C

- Hence in a full wave rectifier both postive and negative half cycles of the input signal pass through the circuit in the same direction
- The output waveform is shown below.

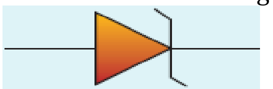


- Though both positive and negative half cycles of ac input are rectified, the output is still pulsating in nature.
- The efficiency (η) of full wave rectifier is twice that of a half wave rectifier and is found to be 81.2 %.

7. Write a note on Zener diode. Explain the V - I characteristics of Zener diode.

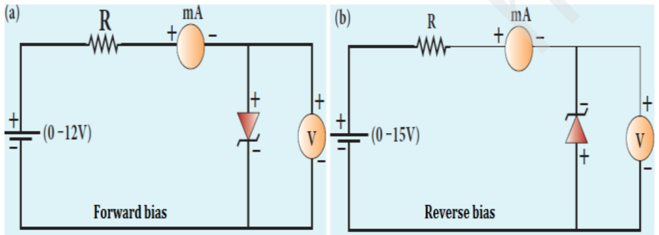
Zener diode :

- Zener diode is a reverse biased heavily doped Silicon diode, designed to be operated in the breakdown region.
- Zener breakdown occurs due to the breaking of covalent bonds by the strong electric field set up in the depletion region by the reverse voltage.
- It produces an extremely large number of electrons and holes which constitute the reverse saturation current.
- The circuit symbol of Zener diode is given below.

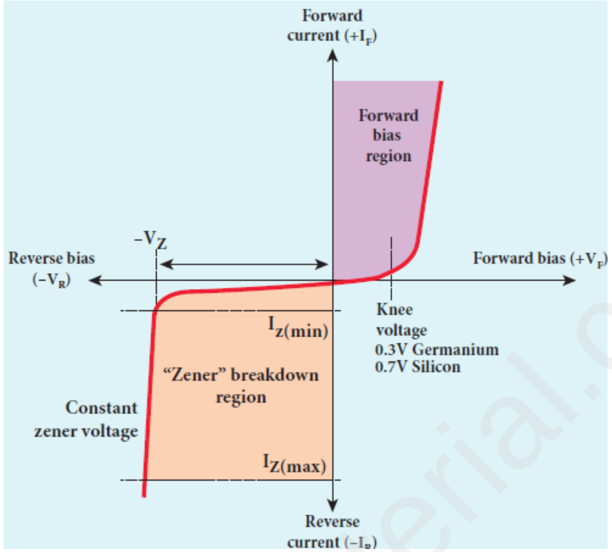


V-I Characteristics of Zener diode :

- The circuit to study the forward and reverse characteristic s of a Zener diode is shown below.



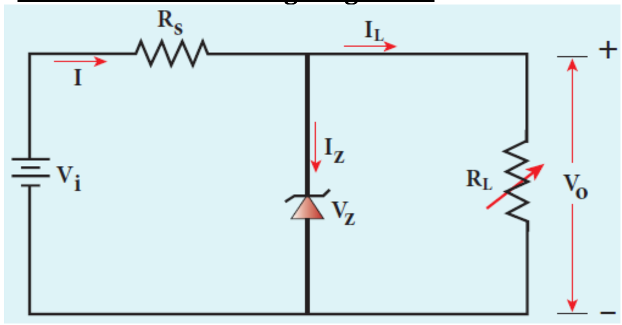
- The V-I characteristics of a Zener diode is shown below.



- The forward characteristic of a Zener diode is similar to that of an ordinary P-N junction diode.
- It starts conducting approximately around 0.7 V.
- However, the reverse characteristics is highly significant in Zener diode.
- The increase in reverse voltage normally generates very small reverse current.
- While in Zener diode, when the reverse voltage is increased to the breakdown voltage (V_Z), the increase in current is very sharp.
- The voltage remains almost constant throughout the breakdown region.
- Here, I_Z(max) represents the maximum reverse current.
- If the reverse current is increased further, the diode will be damaged.
- The important parameters on the reverse characteristics are
  V_Z→Zener breakdown voltage
  I_Z(min)→minimum current to sustain breakdown
  IZ(max)→maximum current limited by maximum power dissipation.
- The Zener diode is operated in the reverse bias having the voltage greater than V_Z and current less than I_Z(max).
- The reverse characteristic is not exactly vertical which means that the diode possesses some small resistance called Zener dynamic impedance.
- Zener resistance is the inverse of the slope in the breakdown region. It means an increase in the Zener current produces only a very small increase in the reverse voltage which can be neglected.
- Thus the voltage of an ideal Zener diode does not change once it goes into breakdown.
- It means that V_Z remains almost constant even when I_Z increases considerably.

8. Explain the working of Zener diode as a voltage regulator.

Zener diode as a voltage regulator :



- A Zener diode working in the breakdown region can serve as a voltage regulator.
- It maintains a constant output voltage even when input voltage (V_i) or load current (I_L) varies.
- Here, in this circuit the input voltage V_i is regulated at a constant voltage V_Z (Zener voltage) at the output represented as V_0 using a Zener diode.
- The output voltage is maintained constant as long as the input voltage does not fall below V_Z .
- When the potential developed across the diode is greater than V_Z, the diode moves into the Zener breakdown region.
- It conducts and draws relatively large current through the series resistance R_S .
- The total current I passing through R_S equals the sum of diode current I_Z and load current I_L (i.e.)

$$I = I_Z + I_L$$

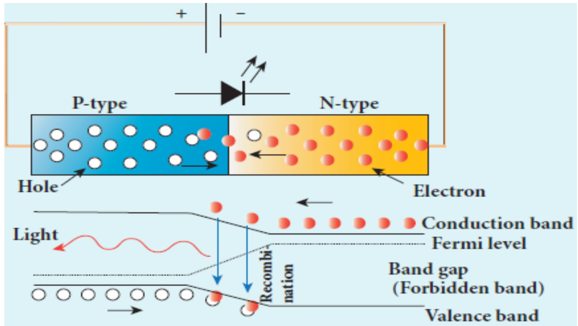
- It is to be noted that the total current is always less than the maximum Zener diode current.
- Under all conditions $V_O = V_Z$
- Thus, output voltage is regulated.

9. What is meant by light emitting diode? Explain its working principle with diagram.

Light Emitting Diode (LED) :

✶ LED is a p-n junction diode which emits visible or invisible light when it is forward biased.

✶ Since, electrical energy is converted into light energy, this process is also called electro luminescence.



✶ It consists of a P-layer, N-layer and a substrate.

✶ A transparent window is used to allow light to travel in the desired direction.

✶ In addition, it has two leads; anode and cathode.

✶ When the P-N junction is forward biased, the conduction band electrons on N-side and valence band holes on P-side diffuse across the junction.

✶ When they cross the junction, they become excess minority carriers (electrons in P-side and holes in N-side).

✶ These excess minority carriers recombine with oppositely charged majority carriers in the respective regions, i.e. the electrons in the conduction band recombine with holes in the valence band

✶ During recombination process, energy is released in the form of light (radiative) or heat (non-radiative).

✶ For radiative recombination, a photon of energy hv isemitted. For non-radiative recombination, energy is liberated in the form of heat.

✶ The colour of the light is determined by the energy band gap of the material.

✶ Therefore, LEDs are available in a wide range of colours such as blue (SiC), green (AlGaP) and red (GaAsP). Now a days, LED which emits white light (GaInN) is also available.

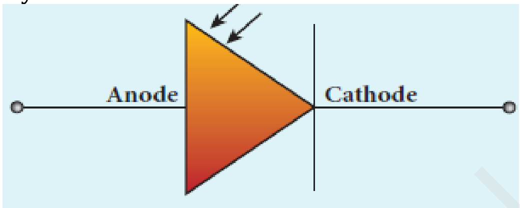
10. Explain in detail about the photo diode.

Photo diode :

✶ A P-N junction diode which converts an optical signal into electric current is known as photodiode.

✶ Thus, the operation of photodiode is exactly opposite to that of an LED.

✶ Photo diode works in reverse bias. Its circuit symbol below.



✶ The direction of arrows indicates that the light is incident on the photo diode.

✶ The device consists of a P-N junction semiconductor made of photosensitive material kept safely inside a plastic case

✶ It has a small transparent window that allows light to be incident on the P-N junction.

✶ Photodiodes can generate current when the P-N junction is exposed to light and hence are called as ***light sensors***.

✶ When a photon of sufficient energy (hν) strikes the depletion region of the diode, some of the valence band electrons are elevated into conduction band, in turn holes are developed in the valence band.

✶ This creates electron-hole pairs.

✶ The amount of electronhole pairs generated depends on the intensity of light incident on the P-N junction.

✶ These electrons and holes are swept across the P-N junction by the electric field created by reverse voltage before recombination takes place.

✶ Thus, holes move towards the N-side and electrons towards the P-side.

✶ When the external circuit is made, the electrons flow through the external circuit and constitute the ***photocurrent***.

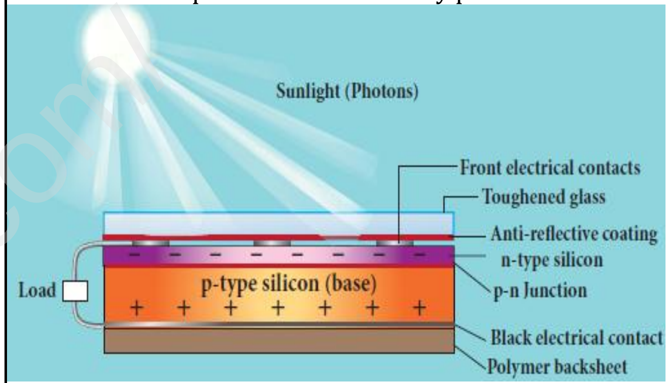
✶ When the incident light is zero, there exists a reverse current which is negligible.

✶ This reverse current in the absence of any incident light is called ***dark current*** and is due to the thermally generated minority carriers.

11. Explain the working principle of Solar cell. Mention its applications.

Solar cell :

✶ A solar cell, also known as photovoltaic cell, converts light energy directly into electricity or electric potential difference by photovoltaic effect.



✶ It is basically a P-N junction which generates emf when solar radiation falls on the P-N junction.

✶ A solar cell is of two types : P-type and N-type.

✶ Both types use a combination of P-type and N-type Silicon which together forms the P-N junction of the solar cell.

✶ The difference is that P-type solar cells use P-type Silicon as the base with an ultra-thin layer of N-type Silicon, while N-type solar cell uses the opposite combination.

✶ The other side of the P-Silicon is coated with metal which forms the back electrical contact.

✶ On top of the N-type Silicon, metal grid is deposited which acts as the front electrical contact.

✶ The top of the solar cell is coated with anti-reflection coating and toughened glass.

✶ In a solar cell, ***electron–hole pairs*** are generated due to the absorption of light near the junction.

✶ Then the charge carriers are separated due to the electric field of the depletion region.

✶ Electrons move towards N–type Silicon and holes move towards P-type Silicon layer.

✶ The electrons reaching the N-side are collected by the front contact and holes reaching P-side are collected by the back electrical contact.

✶ Thus a potential difference is developed across solar cell.

- ✶ When an external load is connected to the solar cell, photocurrent flows through the load.
- ✶ Many solar cells are connected together either in series or in parallel combination to form solar panel or module.
- ✶ Many solar panels are connected with each other to form solar arrays. For high power applications, solar panels and solar arrays are used.

Applications :

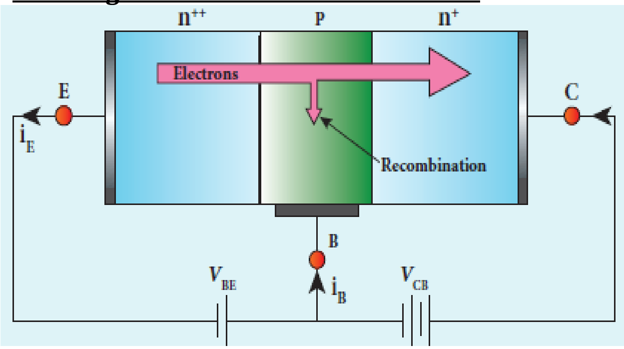
(1) Solar cells are widely used in calculators, watches, toys, portable power supplies, etc.

(2) Solar cells are used in satellites and space applications

(3) Solar panels are used to generate electricity.

12. Explain transistor action in common base configuration.

Working of NPN transistor in CB mode :



- ✶ Basically, a BJT can be considered as two P-N junction diodes connected back to- back.
- ✶ In the forward active bias of the transistor, the emitter-base junction is forward biased by V_{EB} and the collector-base junction is reverse biased by V_{CB}.
- ✶ The forward bias decreases the depletion region across the emitter-base junction and the reverse bias increases the depletion region across the collector-base junction.
- ✶ Hence, the barrier potential across the emitter-base junction is decreased and the collector-base junction is increased.
- ✶ In an NPN transistor, the majority charge carriers in the emitter are electrons. As it is heavily doped, it has a large number of electrons.
- ✶ The forward bias across the emitter-base junction causes the electrons in the emitter region to flow towards the base region and constitutes the ***emitter current*** **(I_E).**
- ✶ The electrons after reaching the base region recombine with the holes in the base region.
- ✶ Since the base region is very narrow and lightly doped, all the electrons will not have sufficient holes to recombine and hence most of the electrons reach the collector region.
- ✶ Eventually, the electrons that reach the collector region will be attracted by the collector terminal as it has positive potential and flows through the external circuit.
- ✶ This constitutes the ***collector current*** **(I_C).**
- ✶ The holes that are lost due to recombination in the base region are replaced by the positive potential of the bias voltage V_{EB} and constitute the ***base current*** **(I_B).**
- ✶ The magnitude of the base current will be in micoamperes as against milliamperes for emitter and collector currents.
- ✶ It is to be noted that if the emitter current is zero, then the collector current is almost zero.
- ✶ It is therefore imperative that a BJT is called a ***current controlled device***.
- ✶ Applying Kirchoff 's law, we can write the emitter current as the sum of the collector current and the base current.

$$I_E = I_B + I_C$$

- ✶ Since the base current is very small, we can write,

$I_E \approx I_C$

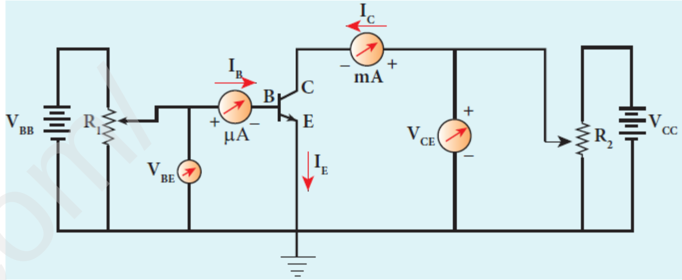
- ✶ There is another component of collector current due to the thermally generated electrons called reverse saturation current, denoted as I_{CO}.
- ✶ This factor is temperature sensitive.
- ✶ The ratio of the collector current to the emitter current is called the forward current gain (α_{dc}) of a transistor.

$$\alpha_{dc} = \frac{I_C}{I_E}$$

- ✶ The α of a transistor is a measure of the quality of a transistor. Higher the value of α better is the transistor.
- ✶ The value of α is less than unity and ranges from **0.95** to **0.99**.

13. Sketch the static characteristics of a common emitter transistor and bring out the essence of input and output characteristics.

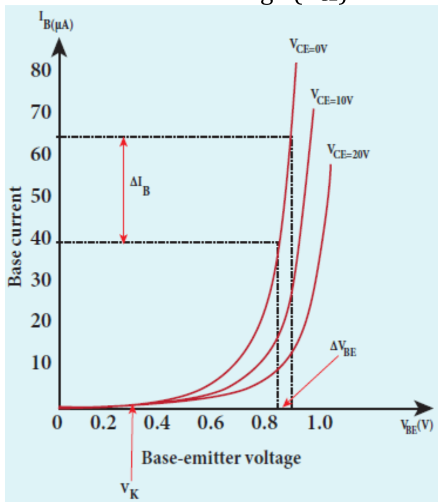
Static characteristics of NPN transistor in CE mode :



V_{BE} – Base - emitter voltage
V_{CE} – Collector - emitter voltage
I_B – Base current
I_C – Collector current
V_{BB} & V_{CC} –Biasing voltages
R_1 & R_2 – Variable resistors

(1) **Input characteristics** :

- ✶ Input Characteristics curves give the relationship between the base current (I_B) and base to emitter voltage (V_{BE}) at constant collector to emitter voltage (V_{CE})



- ✶ The curve looks like the forward characteristics of an ordinary P-N junction diode.
- ✶ There exists a threshold voltage or knee voltage (V_K) below which the base current is very small.

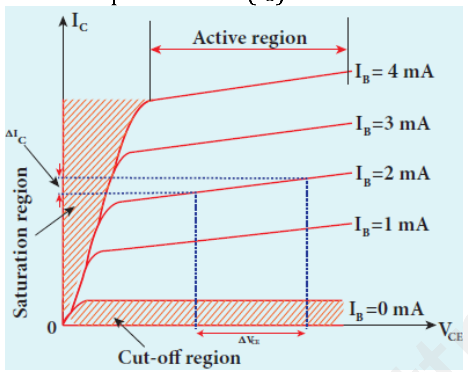
- ✶ Beyond the knee voltage, the base current increases with the increase in base-emitter voltage.
- ✶ It is also noted that the increase in the collector-emitter voltage decreases the base current. This shifts the curve outward.
- ✶ This is because the increase in collector-emitter voltage increases the width of the depletion region in turn, reduces the effective base width and thereby the base current.
- ✶ The ratio of the change in base-emitter voltage (ΔV_{BE}) to the change in base current (ΔI_B) at a constant collector-emitter voltage (V_{CE}) is called the ***input resistance*** (r_i).

$$r_i = \left[\frac{\Delta V_{BE}}{\Delta I_B}\right]_{V_{CE}}$$

- ✶ The input resistance is high for a transistor in common emitter configuration.

(2) **<u>Output characteristics</u>** :

- ✶ The output characteristics give the relationship between the variation in the collector current (ΔI_C) with respect to the variation in collector-emitter voltage (ΔV_{CE}) at constant input current (I_B)



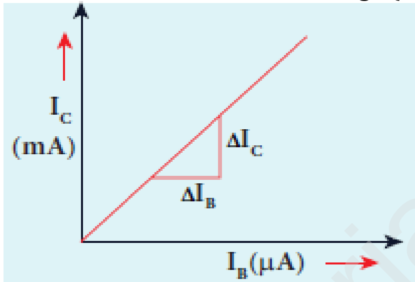
- ✶ There are four important regions in the curve
  - (i) Saturation region
  - (ii) Cut-off region
  - (iii) Active region
  - (iv) Break down region
- ✶ The ratio of the change in the collectoremitter voltage (ΔV_{CE}) to the corresponding change in the collector current (ΔI_C) at constant base current (I_B) is called output resistance (r_o).

$$r_o = \left[\frac{\Delta V_{CE}}{\Delta I_C}\right]_{I_B}$$

- ✶ The output resistance for transistor in common emitter configuration is very low.

(3) **<u>Current transfer characteristics</u>** :

- ✶ This gives the variation of collector current (I_C) with changes in base current (I_B) at constant collector-emitter voltage (V_{CE})



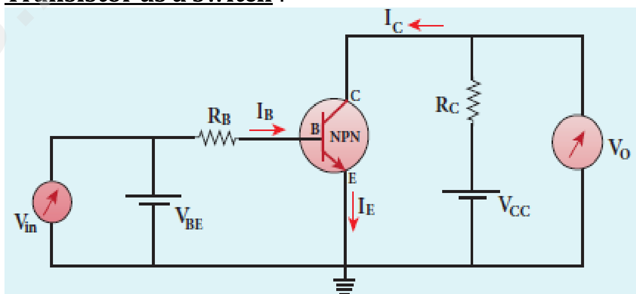
- ✶ It is seen that a small I_C flows even when I_B is zero.
- ✶ This current is called the common emitter leakage current (I_{CEO}), which is due to the flow of minority charge carriers.
- ✶ The ratio of the change in collector current (ΔI_C) to the change in base current (ΔI_B) at constant collector-emitter voltage (V_{CE}) is called forward current gain (β).

$$\beta = \left[\frac{\Delta I_C}{\Delta I_B}\right]_{V_{CE}}$$

- ✶ Its value is very high and it generally ranges from 50 to 200.

14. Transistor functions as a switch. Explain.

<u>Transistor as a switch</u> :



- ✶ The transistor in saturation and cut-off regions functions like an electronic switch that helps to turn ON or OFF a given circuit by a small control signal.

<u>Presence of dc source at the input (saturation region)</u> :

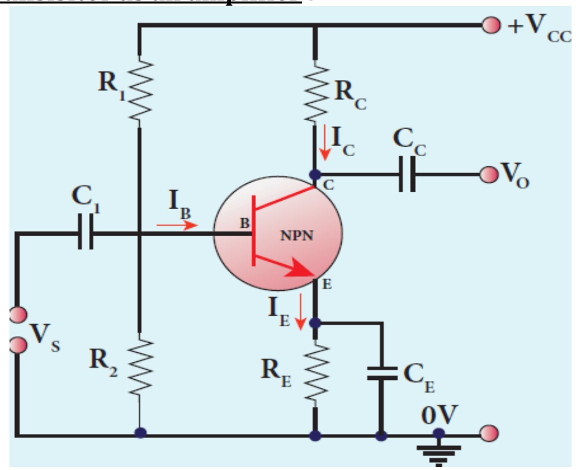
- ✶ When a high input voltage (V_{in} = +5 V) is applied, the base current (I_B) increases and in turn increases the collector current.
- ✶ The transistor will move into the saturation region (turned ON).
- ✶ The increase in collector current (I_C) increases the voltage drop across R_C, thereby lowering the output voltage, close to zero.
- ✶ The transistor acts like a closed switch and is equivalent to ON condition.

<u>Absence of dc source at the input (cutoff region)</u> :

- ✶ A low input voltage (V_{in} = 0 V), decreases the base current (I_B) and in turn decreases the collector current (I_C).
- ✶ The transistor will move into the cut-off region (turned OFF).
- ✶ The decrease in collector current (I_C) decreases the drop across R_C, thereby increasing the output voltage, close to +5 V.
- ✶ The transistor acts as an open switch which is considered as the OFF condition.
- ✶ It is manifested that, a high input gives a low output and a low input gives a high output.
- ✶ Therefore, a transistor can be used as an inverter in computer logic circuitry.

15. Describe the function of a transistor as an amplifier with the neat circuit diagram. Sketch the input and output wave form.

<u>Transisitor as an amplifier</u> :



- Amplification is the process of increasing the signal strength (increase in the amplitude).
- If a large amplification is required, multistage amplifier is used.
- Here, the amplification of an electrical signal is explained with a single stage transistor amplifier
- Single stage indicates that the circuit consists of one transistor with the allied components.
- An NPN transistor is connected in the common emitter configuration.
- A load resistance, R_C is connected in series with the collector circuit to measure the output voltage.
- The capacitor C_1 allows only the ac signal to pass through.
- The emitter bypass capacitor C_E provides a low reactance path to the amplified ac signal.
- The coupling capacitor C_C is used to couple one stage of the amplifier with the next stage while constructing multistage amplifiers.
- V_S is the sinusoidal input signal source applied across the base-emitter.
- The output is taken across the collector-emitter.
- Collector current,

$$I_C = \beta\, I_B$$

- Applying Kirchhoff 's voltage law in the output loop, the collector-emitter voltage is

$$V_{CE} = V_{CC} - I_C R_C$$

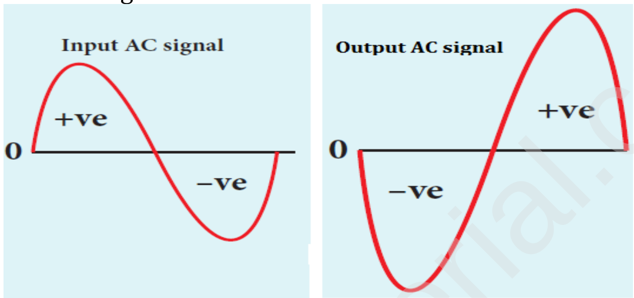
Working of the amplifier :

(1) **During the positive half cycle** :

- Input signal (Vs) increases the forward voltage across the emitter-base.
- As a result, the base current (I_B) increases.
- Consequently, the collector current (I_C) increases β times.
- This increases the voltage drop across R_C which in turn decreases the collector-emitter voltage (V_{CE}).
- Therefore, the input signal in the positive direction produces an amplified signal in the negative direction at the output. Hence, the output signal is reversed by 180°

(2) **During the negative half cycle** :

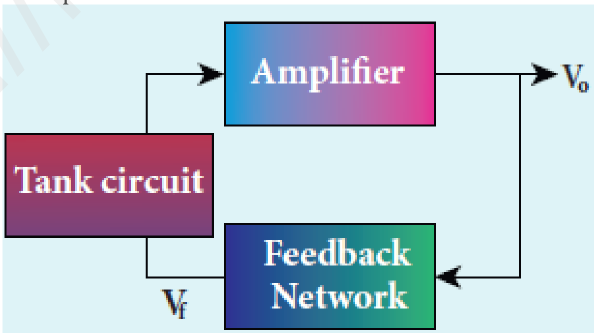
- Input signal (Vs) decreases the forward voltage across the emitter-base.
- As a result, base current (I_B) decreases and in turn increases the collector current (I_C).
- The increase in collector current (I_C) decreases the potential drop across R_C and increases the collector-emitter voltage (V_{CE}).
- Thus, the input signal in the negative direction produces an amplified signal in the positive direction at the output.
- Therefore, 180^0 phase reversal is observed during the negative half cycle of the input signal



16. Explain the action transistor as an oscillator.

Transistor as an oscillator :

- An electronic oscillator basically converts dc energy into ac energy of high frequency ranging from a few Hz to several MHz.
- Hence, it is a source of alternating current or voltage.
- Unlike an amplifier, oscillator does not require any external signal source.
- Basically, there are two types of oscillators: Sinusoidal and non-sinusoidal.
- An oscillator circuit consists of a tank circuit, an amplifier and a feedback circuit as shown



Amplifier :

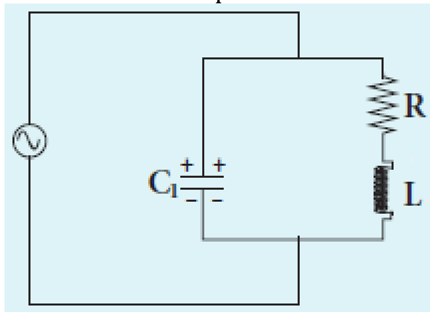
- Amplification is the process of increasing amplitude of weak signals (i.e) Amplifier amplifies the input ac signal

Feedback network :

- The circuit used to feedback a portion of the output to the input is called the feedback network.
- If the portion of the output fed to the input is in phase with the input, then the magnitude of the input signal increases.
- It is necessary for sustained oscillations.

Tank circuit :

- The LC tank circuit consists of an inductance and a capacitor connected in parallel



- Whenever energy is supplied to the tank circuit from a DC source, the energy is stored in inductor and capacitor alternatively.
- This produces electrical oscillations of definite frequency.
- But in practical oscillator circuits there will be loss of energy across resistors, inductor coils and capacitors.
- Due to this, the amplitude of the oscillations decreases gradually.
- Hence, the tank circuit produces damped electrical oscillations.
- Therefore, in order to produce undamped oscillations, a positive feedback is provided from the output circuit to the input circuit.
- The frequency of oscillations is determined by the values of L and C using the equation.

$$f = \frac{1}{2\,\pi\,\sqrt{L\,C}}$$

17. State and prove De Morgan's First and Second theorems.

De Morgan's First Theorem :

✶ The complement of the sum of two logical inputs is equal to the product of its complements.

$$\overline{A+B} = \bar{A}\,.\,\bar{B}$$

Proof :

✶ The Boolean equation for NOR gate is

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

✶ The Boolean equation for a bubbled AND gate is

$$Y = \bar{A}\,.\,\bar{B}$$

A	B	A+B	$\overline{A+B}$	$\bar{A}$	$\bar{B}$	$\bar{A}\,.\,\bar{B}$
0	0	0	1	1	1	1
0	1	1	0	1	0	0
1	0	1	0	0	1	0
1	1	1	0	0	0	0

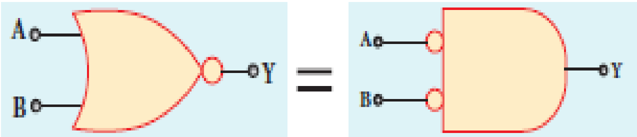
✶ From the above truth table, we can conclude

$$\overline{A+B} = \bar{A}\,.\,\bar{B}$$

✶ Thus De Morgan's First Theorem is proved.

✶ It also says that a NOR gate is equal to a bubbled AND gate.

✶ The corresponding logic circuit diagram



De Morgan's First Theorem :

✶ The complement of the products of two logical inputs is equal to the sum of its complements.

$$\overline{A\,.\,B} = \bar{A} + \bar{B}$$

Proof :

✶ The Boolean equation for NAwD gate is

$$Y = \overline{A\,.\,B}$$

✶ The Boolean equation for a bubbled OR gate is

$$Y = \bar{A} + \bar{B}$$

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

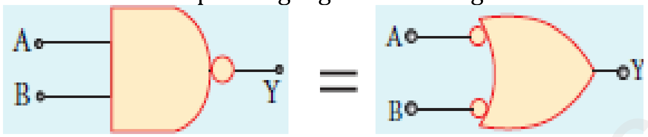
✶ From the above truth table, we can conclude

$$\overline{A\,.\,B} = \bar{A} + \bar{B}$$

✶ Thus De Morgan's second Theorem is proved.

✶ It also says that a NAND gate is equal to a bubbled OR gate.

✶ The corresponding logic circuit diagram



18. State Boolean laws. Elucidate how they are used to simplify Boolean expressions with suitable example.

Boolean laws :

(1) Complement law :

(i) $\bar{\bar{A}} = A$

(2) OR –Laws:

(i) $A + 0 = A$
(ii) $A + 1 = 1$
(iii) $A + A = A$
(iv) $A + \bar{A} = 1$

(3) AND –Laws:

(i) $A\,.0 = 0$
(ii) $A\,.1 = A$
(iii) $A\,.\,A = A$
(iv) $A\,.\,\bar{A} = 0$

(4) Commutative Laws :

(i) $A + B = B + A$
(ii) $A\,.\,B = B\,.\,A$

(5) Associative Laws :

(i) $A + (B + C) = (A + B) + C$
(ii) $A\,.\,(B.\,C) = (A\,.\,B).\,C$

(6) Distributive Laws :

(i) $A\,(B + C) = A\,B + A\,C$
(ii) $A + (B\,C) = (A + B)(A + C)$

Example :

Simplify the following Boolean expression.

$$AC + ABC$$

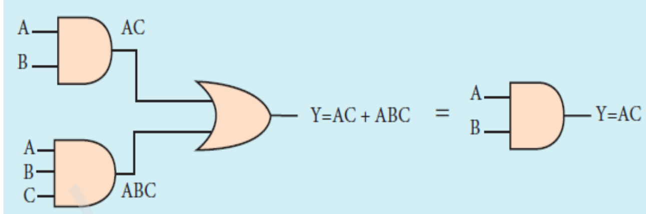
Solution :

$AC + ABC = AC\,(1 + B)$

$AC + ABC = AC\,.1$ [OR –law (2)]

$AC + ABC = AC$ [AND –law (2)]

Circuit description



19. What is called modulation? Explain the types of modulation with help of necessary diagrams.

Modulation :

♦ For long distance transmission, the low frequency baseband signal (input signal) is superimposed onto a high frequency radio signal by a process called modulation.

♦ In the modulation process, a very high frequency signal called carrier signal (radio signal) is used to carry the baseband signal.

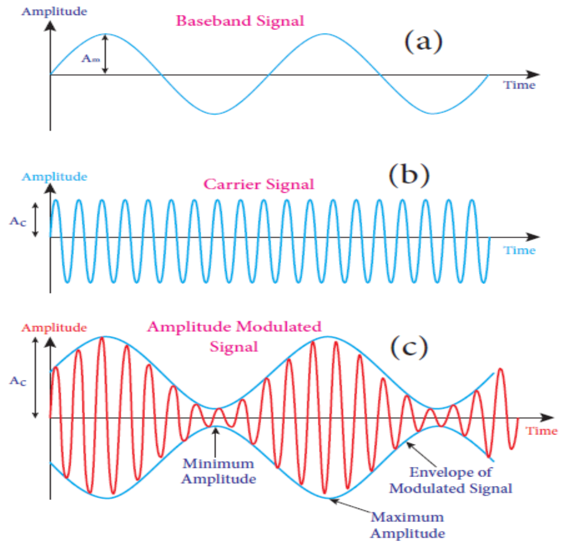
Types of modulation :

(1) Amplitude modulation (AM)
(2) Frequency modulation (FM)
(3) Phase modulation (PM)

Amplitude modulation (AM) :

♦ If the amplitude of the carrier signal is modified according to the instantaneous amplitude of the baseband signal, then it is called amplitude modulation.

♦ Here the frequency and the phase of the carrier signal remain constant.



- We can see clearly that the carrier wave is modified in proportion to the amplitude of the baseband signal.
- Amplitude modulation is used in radio and TV broadcasting.

Advantages of AM :

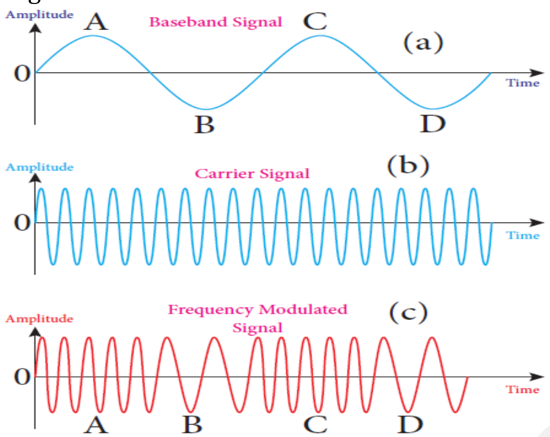
- Easy transmission and reception
- Lesser bandwidth requirements
- Low cost

Limitations of AM :

- Noise level is high
- Low efficiency
- Small operating range

Frequency modulation (FM) :

- If the frequency of the carrier signal is modified according to the instantaneous amplitude of the baseband signal, then it is called frequency modulation.
- Here the amplitude and the phase of the carrier signal remain constant.



- When the amplitude of the baseband signal is zero, the frequency of the modulated signal is the same as the carrier signal.
- The frequency of the modulated wave increases when the amplitude of the baseband signal increases in the positive direction (A, C).
- The increase in amplitude in the negative half cycle (B, D) reduces the frequency of the modulated wave
- When the frequency of the baseband signal is zero (no input signal), there is no change in the frequency of the carrier wave.
- It is at its normal frequency and is called as ***centre frequency*** or ***resting frequency***.
- Practically **75 kHz** is the allotted frequency of the FM transmitter.

Advantages of FM :

- Large decrease in noise. This leads to an increase in signal-noise ratio.
- The operating range is quite large.
- The transmission efficiency is very high as all the transmitted power is useful.
- FM bandwidth covers the entire frequency range which humans can hear. Due to this, FM radio has better quality compared to AM radio.

Limitations of FM :

- FM requires a much wider channel.
- FM transmitters and receivers are more complex and costly.
- In FM reception, less area is covered compared to AM.

Phase modulation (PM) :

- The instantaneous amplitude of the baseband signal modifies the phase of the carrier signal keeping the amplitude and frequency constant is called phase modulation
- This modulation is used to generate frequency modulated signals.

20. Elaborate on the basic elements of communication system with the necessary block diagram.

Communication system :

- Electronic communication is nothing but the transmission of sound, text, pictures, or data through a medium.

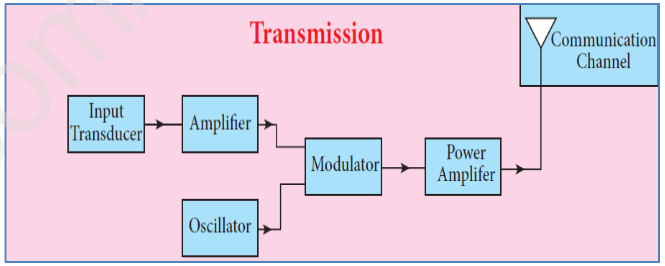
Basic elements of communication system :

(1) **Input transducer** :

- A transducer is a device that converts variations in a physical quantity (pressure, temperature, sound) into an equivalent electrical signal or vice versa.
- In communication system, the transducer converts the information which is in the form of sound, music, pictures or computer data into corresponding electrical signals.
- The electrical equivalent of the original information is called the **baseband signal**. (e.g.) microphone

(2) **Transmitter** :

- It feeds the electrical signal from the transducer to the communication channel.
- The transmitter is located at the broadcasting station.



- It consists,

  (i) **Amplifier** : The transducer output is very weak and is amplified by the amplifier.

  (ii) **Oscillator** : It generates high-frequency carrier wave (a sinusoidal wave) for long distance transmission into space.

  (iii) **Modulator** : It superimposes the baseband signal onto the carrier signal and generates the modulated signal.

  (iv) **Power amplifier** : It increases the power level of the electrical signal in order to cover a large distance.

(3) **Transmitting antenna** :

- It radiates the radio signal into space in all directions.
- It travels in the form of electromagnetic waves with the velocity of light (3×10^8 m s^{-1})

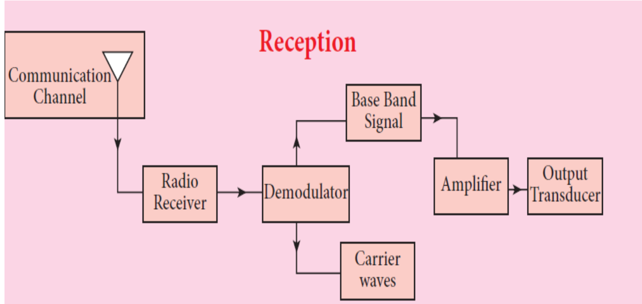
(4) **Communication channel** :

- Communication channel is used to carry the electrical signal from transmitter to receiver with less noise or distortion.
- The communication medium is basically of two types: wireline communication and wireless communication.

(5) **Receiver** :

- The signals that are transmitted through the communication medium are received with the help of a receiving antenna and are fed into the receiver.

- The receiver consists of electronic circuits like demodulator, amplifier, detector etc.



- The demodulator extracts the baseband signal from the carrier signal.
- Then the baseband signal is detected and amplified using amplifiers. Finally, it is fed to the output transducer.

(6) **Output transducer** :

- It converts the electrical signal back to its original form such as sound, music, pictures or data. (e.g.) loudspeakers, picture tubes, computer monitor, etc.

21. Explain the three modes of propagation of electromagnetic waves through space.

Modes of propagation of electromagnetic waves :

- The electromagnetic wave transmitted by :
  (1) Ground wave propagation (or) surface wave propagation (2 kHz to 2 MHz)
  (2) Sky wave propagation (or) ionospheric propagation (3 MHz to 30 MHz)
  (3) Space wave propagation (30 MHz to 400 GHz)

Ground wave propagation :

- If the electromagnetic waves transmitted by the transmitter glide over the surface of the earth to reach the receiver, then the propagation is called ground wave propagation.
- The corresponding waves are called ground waves or surface waves.
- Both transmitting and receiving antennas must be close to the earth.
- The size of the antenna plays a major role in deciding the efficiency of the radiation of signals.
- During transmission, the electrical signals are attenuated over a distance.
- Some reasons for attenuation are as follows:
  - Increasing distance
  - Absorption of energy by the Earth
  - Tilting of the wave
- It is mainly used in local broadcasting, radio navigation, for ship-to-ship, shipto- shore communication and mobile communication.

Sky wave propagation :

- The mode of propagation in which the electromagnetic waves radiated from an antenna, directed upwards at large angles gets reflected by the ionosphere back to earth is called sky wave propagation or ionospheric propagation.
- Extremely long distance communication is possible as the radio waves can undergo multiple reflections between the earth and the ionosphere.
- The phenomenon of bending the radio waves back to earth is due to the ***total internal reflection***.
- This is the reason why the EM waves are transmitted at a critical angle to ensure that the waves undergo total reflection and reaches the ground without escaping into space.
- The shortest distance between the transmitter and the point of reception of the sky wave along the surface is called as the ***skip distance***
- There is a zone in between where there is no reception of electromagnetic waves neither ground nor sky, called as ***skip zone or skip area***.

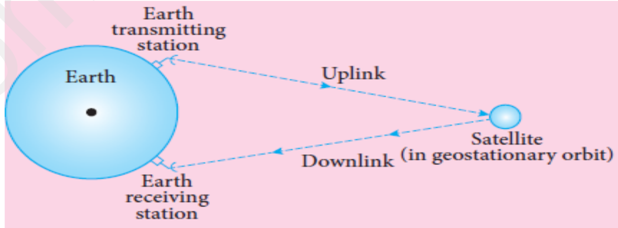
Space wave propagation :

- The process of sending and receiving information signal through space is called space wave communication
- The electromagnetic waves of very high frequencies above 30 MHz are called as space waves.
- These waves travel in a straight line from the transmitter to the receiver. Hence, it is used for a ***line of sight communication*** (LOS).
- For high frequencies, the transmission towers must be high enough so that the transmitted and received signals (direct waves) will not encounter the curvature of the earth and hence travel with less attenuation and loss of signal strength.
- Certain waves reach the receiver after getting reflected from the ground.
- The communication systems like television broadcast, satellite communication, and RADAR are based on space wave propagation.
- The range or distance (d) of coverage of the propagation depends on the height (h) of the antenna given by the equation, $\boldsymbol{h} = \sqrt{2\,R\,h}$

  where, $R \rightarrow$ Radius of earth (6400 km)

22. Explain satellite communication.

Satellite communication :



- The satellite communication is a mode of communication of signal between transmitter and receiver via satellite.
- The message signal from the Earth station is transmitted to the satellite on board via an uplink (frequency band 6 GHz), amplified by a transponder and then retransmitted to another earth station via a downlink (frequency band 4 GHz)
- The high-frequency radio wave signals travel in a straight line (line of sight) may come across tall buildings or mountains or even encounter the curvature of the earth.
- A communication satellite relays and amplifies such radio signals via transponder to reach distant and far off places using uplinks and downlinks.
- It is also called as a ***radio repeater*** in sky.

Applications :

(1) **Weather Satellites**:

- They are used to monitor the weather and climate of Earth.
- By measuring cloud mass, these satellites enable us to predict rain and dangerous storms like hurricanes, cyclones etc.

(2) **Communication satellites**:

- They are used to transmit television, radio, internet signals etc. Multiple satellites are used for long distances.

(3) **Navigation satellites**:

- These are employed to determine the geographic location of ships, aircrafts or any other object.

23. **Explain the function of RADAR. Give its applications.**

RADAR :

- Radar basically stands for RAdioDetection And Ranging System.
- It is one of the important applications of communication systems and is mainly used to sense, detect, and locate distant objects like aircraft, ships, spacecraft, etc.
- The angle, range, or velocity of the objects that are invisible to the human eye can be determined.
- Radar uses electromagnetic waves for communication.
- The electromagnetic signal is initially radiated into space by an antenna in all directions.
- When this signal strikes the targeted object, it gets reflected or reradiated in many directions.
- This reflected (echo) signal is received by the radar antenna which in turn is delivered to the receiver.
- Then, it is processed and amplified to determine the geographical statistics of the object.
- The range is determined by calculating the time taken by the signal to travel from RADAR to the target and back.

Applications :

- In military, it is used for locating and detecting the targets.
- It is used in navigation systems such as ship borne surface search, air search and weapons guidance systems.
- To measure precipitation rate and wind speed in meteorological observations, Radars are used.
- It is employed to locate and rescue people in emergency situations.

24. **Fiber optic communication is gaining popularity among the various transmission media -justify.**

Fiber optic communication :

- The method of transmitting information from one place to another in terms of light pulses through an optical fiber is called fiber optic communication.
- It is in the process of replacing wire transmission in communication systems.
- Light has very high frequency (400THz –790 THz) than microwave radio systems.
- The fibers are made up of silica glass or silicon dioxide which is highly abundant on Earth.
- Now it has been replaced with materials such as chalcogenide glasses, fluoroaluminate crystalline materials because they provide larger infrared wavelength and better transmission capability.
- As fibers are not electrically conductive, it is preferred in places where multiple channels are to be laid and isolation is required from electrical and electromagnetic interference.

Applications :

- Optical fiber system has a number of applications namely, international communication, inter-city communication, data links, plant and traffic control and defense applications.

Merits :

- Fiber cables are very thin and weigh lesser than copper cables.
- This system has much larger band width. This means that its information carrying capacity is larger.
- Fiber optic system is immune to electrical interferences.
- Fiber optic cables are cheaper than copper cables.

Demerits :

- Fiber optic cables are more fragile when compared to copper wires.
- It is an expensive technology.

Importance :

- Fiber optic cables provide the fastest transmission rate compared to any other form of transmission.
- It can provide data speed of ***1 Gbps*** for homes and business.
- Multimode fibers operate at the speed of ***10 Mbps***.
- Recent developments in optical communication provide the data speed at the rate of ***25 Gbps***