Winter – 15 EXAMINATIONS

Subject Code: **17656** **Model Answer**

Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgment on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

1.a. Attempt any THREE of the following: 12 marks

i. Define the terms w.r.t. waveguide

1. Cutoff frequency of a waveguide 2. Guide wavelength

Ans: **(each correct definition – 2 marks)**

- **Cut off frequency of a waveguide:**

It is the frequency of the signal above which propagation of waves occur.

$$f_c = \frac{c}{2}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$$

Therefore lowest frequency which can propagate on the waveguide is f_{cTE10}

No energy can propagate in a rectangular waveguide at a frequency below f_{cTE10}. This is absolute cut off frequency of the waveguide.

- **Guide wavelength:**

It is defined as the distance travelled by the wave in order to undergo a phase shift of 2π radians.

$$\lambda_g = \frac{\lambda}{\sqrt{1 + \left(\frac{\lambda}{\lambda_c}\right)^2}}$$

where λ = wavelength of the signal, λc= cut off wavelength

ii. Draw labeled sketch of Reflex Klystron. State its applications.

Ans: **(diagram – 3 marks – any two correct applications – 1 marks)**

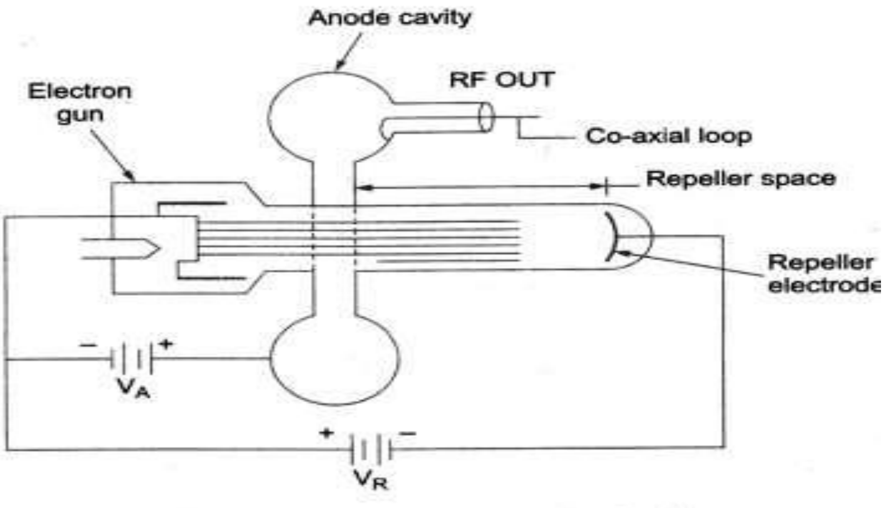


Fig. Constructional details of reflex klystron.

Applications: (any two)

This is the most widely used in applications where variable frequency is desired as

- In radar receivers.
- Local oscillator in microwave receivers.
- Signal source in microwave generator of variable frequency.
- Portable microwave links and
- Pump oscillator in parametric amplifier.

iii. Write RADAR range equation and state the factors affecting maximum range of RADAR.

Ans: **(Equation – 2 marks, factors affecting – 2 marks)**

$$R_{max} = \left(\frac{P_t A_0^2 S}{4 \pi \lambda^2 P_{min}} \right)^{1/4}$$

where R_{max} = maximum range
A_0 = Capture area of Antenna
P_t = Transmitter power
S = effective surface area of target
λ = signal wavelength
P_{min} = minimum receivable power.

- The factors influencing maximum range are as follows:
- Transmitted power (Pt): if the radar range is to be doubled we have to increase a transmitted power by 16 times.
- Frequency(f) : increase in frequency increase the range
- Target cross sectional area(S). Radar cross sectional area of the target is not a controllable factor.
- Minimum received signal (Pmin): A decrease in minimum receivable power will have the same effect has raising the transmuting power.

iv. Define geostationary orbit and geostationary satellite.

Ans: **(each correct definition – 2 marks)**

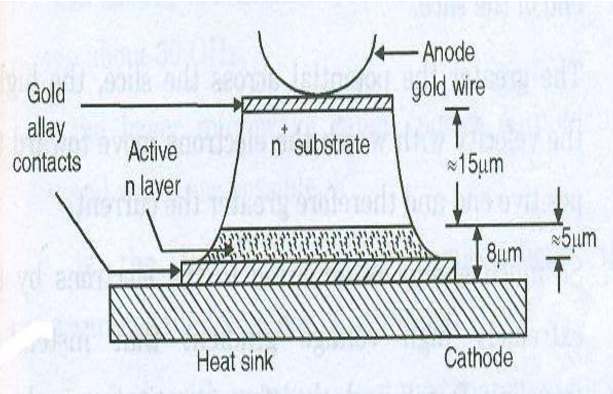
Geostationary orbit: the orbit in which the satellite completes one revolution around earth in 24 hours the orbit is called as geostationary orbit.

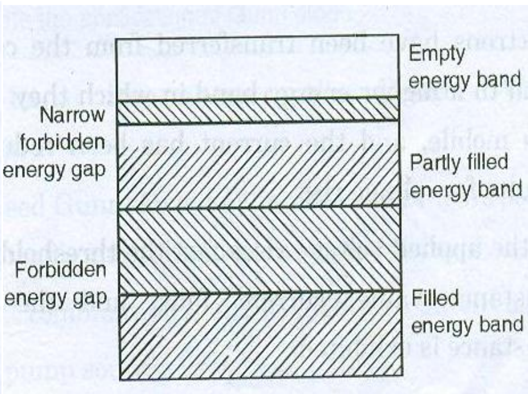
Geostationary satellite: the satellite that uses geostationary orbit is called as geostationary satellite.

b. Attempt any ONE of the following: 06 marks

i. Sketch the construction of Gunn diode and write its operation.

Ans: **(diagram - 3 marks, operation – 3 marks)**





OPERATION:

When a DC bias of value equal or more than threshold field (of about 3.3KV/cm) is applied to an n-type GaAs sample, the charge density and electric field within the sample become non- uniform creating domains that is electron in some region of the sample will be first to experience the inter valley transfer than the rest of the electrons in the sample. The EF inside the dip[ole domain will be greater than the fields on either side of the dipole so the electrons in that region or domain will move to upper- valley and hence with less mobility. This creates a slight deficiency of *e*-1 s in the region immediately ahead. This region of excess and efficient *e*-1 s form a dipole layer.

As the dipole drifts along more *e*-1 s in the vicinity will be transferred to the U-valley until the electric field outside the dipole region is depress below the threshold EF. This dipole continues towards the anode until it is collected upon collector, the EF in the sample jumps immediately to its original value and next domain formation begins as soon as the field values exceeds the threshold values and this process is repeated cyclically.

ii. What is waveguide? With neat sketch explain its operation.

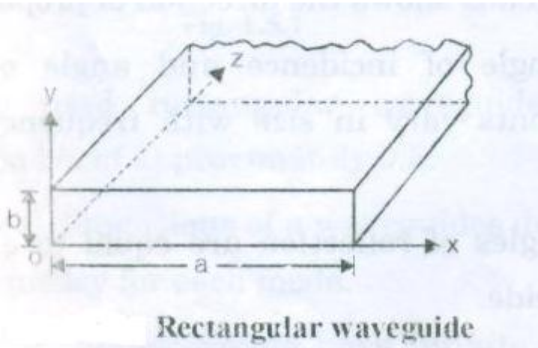
Ans ii. **(Definition of waveguide – 2 marks, explanation of any one type of waveguide – 2 marks, diagram – 2 marks)**

A waveguide is a hollow metal pipe designed to carry microwave energy from one place to another. Wave guide is a structure that guides electromagnetic energy.

Operation:

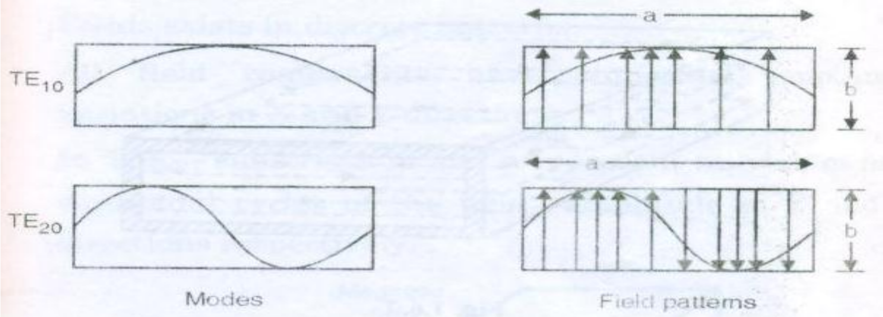
TE Mode:

- The TE_{mn} modes in a rectangular guide are characterized by $E_z = 0$ and $H_z \neq 0$.
- Z-component of magnetic field H_z exist to transmit energy in the guide.

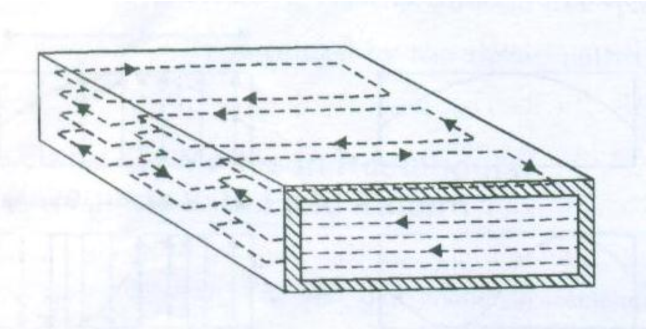


Rectangular waveguide

- For rectangular waveguide TE_{10} mode is dominant mode.
- It signifies all electric fields are transverse to the direction of propagation and not longitudinal electric field is present.
- There is longitudinal component of magnetic field and so TE_{mn} waves are also called H_{mn} waves.



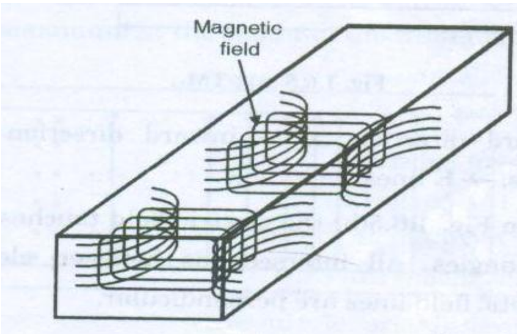
- Above Graph shows the field variations in a waveguide for TE_{10}, TE_{20}, mode.
- The electric field exists only at right angles to the direction of propagation.
- The electric field is maximum at the centre of the waveguide and drops off sinusoidal to zero intensity at the walls.
- TE_{mn} mode : m - indicates the number of half wave loops across the width of the guide, n – indicates the number of loops across the height of the guide or no E-field patterns across 'b' dimension. In above graphs value of n is 0.
- Choose the dimension of a guide in such a way that for a given input signal, only energy of the dominant mode can be transmitted through the guide.
- Figure shows magnetic field caused by half-sine E field.



- In figure, the magnetic field is in the form of (closed) loops. Which lie in planes normal to electric field i.e. parallel to the top and bottom of the guide.
- The magnitude of the magnetic field varies in a sine wave pattern down the center of the waveguide in 'time phase'with the electric field.
- Time phase means that the peak H lines and peak E lines occur at the same instant in time.
- Whenever two or more modes are having same cut-off frequency, they are said to be degenerate modes.
- In rectangular guide TE_{mn} and TM_{mn} are always degenerate modes.

TM Mode in Rectangular Waveguide

- Transverse magnetic mode in rectangular waveguide is characterized by the Hz=0 and $E_z \neq 0$.
- Here z component of an electric field exists to transmit energy in the guide.
- Fields exists in discrete patterns.
- All field components have sinusoidal amplitude variations in X and Y directions.
- In TM_{mn}, subscripts m and n represent number of half sinusoidal cycles of the field amplitude in X and Y directions respectively.



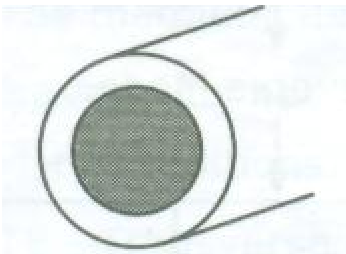
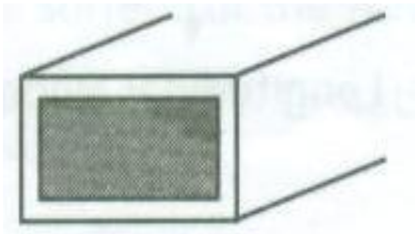
- For the existence of TM mode both indices M and N have to be non-zero.

- So TM_{mo} and TM_{on} modes cannot exist.
- On the waveguide walls the tangential components of the electric field is zero and the tangential component of the magnetic field is maximum.

2. Attempt any FOUR of the following: 16marks

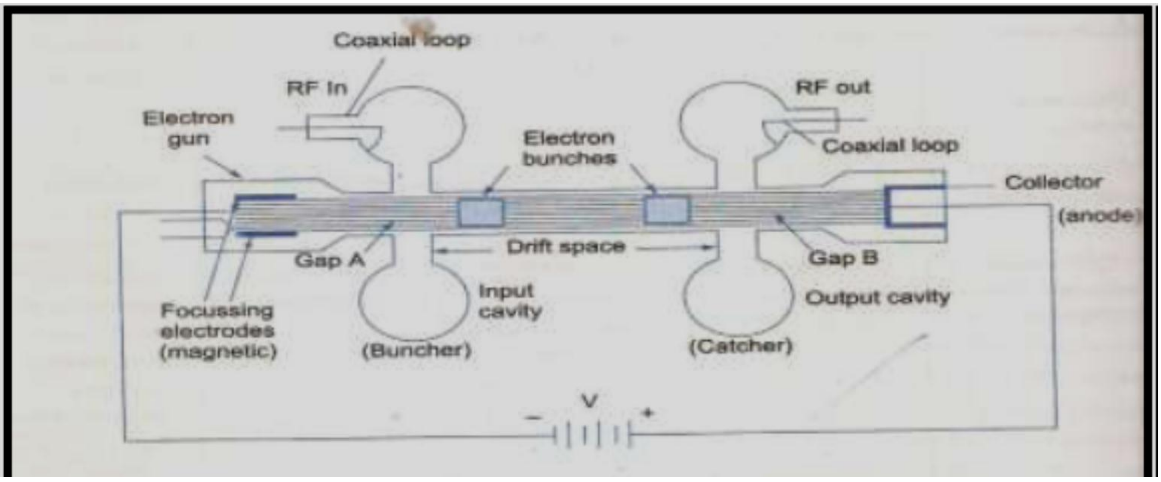
a. Differentiate between circular and rectangular waveguide.

Ans: **(any four correct points – 1 mark each)**

Sr. no	Parameter	Circular waveguide	Rectangular waveguide
1	Diagram		
2	Dominant mode	TE_{11}	TE_{10}
3	Manufacturing	Easy	Difficult compared to circular
4	Attenuation	Less	More
5	Cut off wavelength	Low	High
6	Power required	High	Low

b. Draw the construction of two cavity Klystron amplifier and describe its working principle.

Ans**: (diagram – 2 marks, principle – 2 marks)**



In the two-chamber klystron, the electron beam is injected into a resonant cavity. The electron beam, accelerated by a positive potential, is constrained to travel through a cylindrical drift tube in a straight path by an axial magnetic field. While passing through the first cavity, the electron beam is velocity modulated by the weak RF signal. In the moving frame of the electron beam, the velocity modulation is equivalent to a plasma oscillation. Plasma oscillations are rapid oscillations of the electron density in conducting media such as plasmas or metals.(The frequency only depends weakly on the wavelength). So in a quarter of one period of the plasma frequency, the velocity modulation is converted to density modulation, i.e. bunches of electrons. As the bunched electrons enter the second chamber they induce standing waves at the same frequency as the input signal. The signal induced in the second chamber is much stronger than that in the first. When the tube is energized, the cathode emits electrons which are focused into a beam by a low positive voltage on the control grid. The beam is then accelerated by a very high positive dc potential that is applied in equal amplitude to both the accelerator grid and the buncher grids. The buncher grids are connected to a cavity resonator that superimposes an ac potential on the dc voltage. Ac potentials are produced by oscillations within the cavity that begin spontaneously when the tube is energized. The initial oscillations are caused by random fields and circuit imbalances that are present when the circuit is energized. The oscillations within the cavity produce an oscillating electrostatic field between the buncher grids that is at the same frequency as the natural frequency of the cavity. The direction of the field changes with the frequency of the cavity. These changes alternately accelerate and decelerate the electrons of the beam passing through the grids. The area beyond the buncher grids is called the drift space. The electrons form bunches in this area when the accelerated electrons overtake the decelerated electrons.

The function of the catcher grids is to absorb energy from the electron beam. The catcher grids are placed along the beam at a point where the bunches are fully formed. The location is determined by the transit time of the bunches at the natural resonant frequency of the cavities (the resonant frequency of the catcher cavity is the same as the buncher cavity). The location is chosen because maximum energy transfer to the output (catcher) cavity occurs when the electrostatic field is of the correct polarity to slow down the electron bunches. The feedback path provides energy of the proper delay and phase relationship to sustain oscillations. A signal applied at the buncher grids will be amplified if the feedback path is removed.

c. How Doppler Effect can be used to measure speed?

Ans: **(relevant correct explanation – 4 marks)**

The frequency shift that occurs, when there is a relative motion between the transmitting station and a remote object is known as Doppler effect.

By measuring the amount of frequency, difference between the transmitted and the reflected signal, it is possible to determine the relative speed between the RADAR unit and the observed object

$\mathbf{V = 1.1\ f\ \ x\ \lambda}$

Where v = relative speed between the two objects (m/s)

F = frequency difference between the transmitted and reflected signals (Hz)

Λ = wavelength of transmitted signal (m)

d. State the reason for difference in uplink and downlink frequency in satellite communication.

Ans: **(any relevant correct reason – 4 marks)**

- Same antenna is used for transmission & reception.
- The uplink and downlink bands are separated in frequency to prevent oscillations within the satellite amplifier while simultaneously transmission and reception.
- Moreover low frequency band is used on the downlink to exploit the lower atmospheric losses thereby minimizing satellite power amplifier requirements.

e. Describe scattering and dispersion losses in optical fiber.

Ans: **(each loss correct explanation – 2 marks)**

SCATTERING. - Basically, scattering losses are caused by the interaction of light with density fluctuations within a fiber. Density changes are produced when optical fibers are manufactured.

- During manufacturing, regions of higher and lower molecular density areas, relative to the average density of the fiber, are created. Light traveling through the fiber interacts with the density area. Light is then partially scattered in all directions.
- Rayleigh scattering is the main loss mechanism between the ultraviolet and infrared regions. **Rayleigh scattering** occurs when the size of the density fluctuation (fiber defect) is less than one-tenth of the operating wavelength of light. Loss caused by Rayleigh scattering is proportional to the fourth power of the wavelength (1/λ^{4}). As the wavelength increases, the loss caused by Rayleigh scattering decreases.
- If the size of the defect is greater than one-tenth of the wavelength of light, the scattering mechanism is called **Mie scattering**. Mie scattering, caused by these large defects in the fiber core, scatters light out of the fiber core. However, in commercial fibers, the effects of Mie scattering are insignificant. Optical fibers are manufactured with very few large defects.

Dispersion loss:

1. <u>Intramodal dispersion</u>

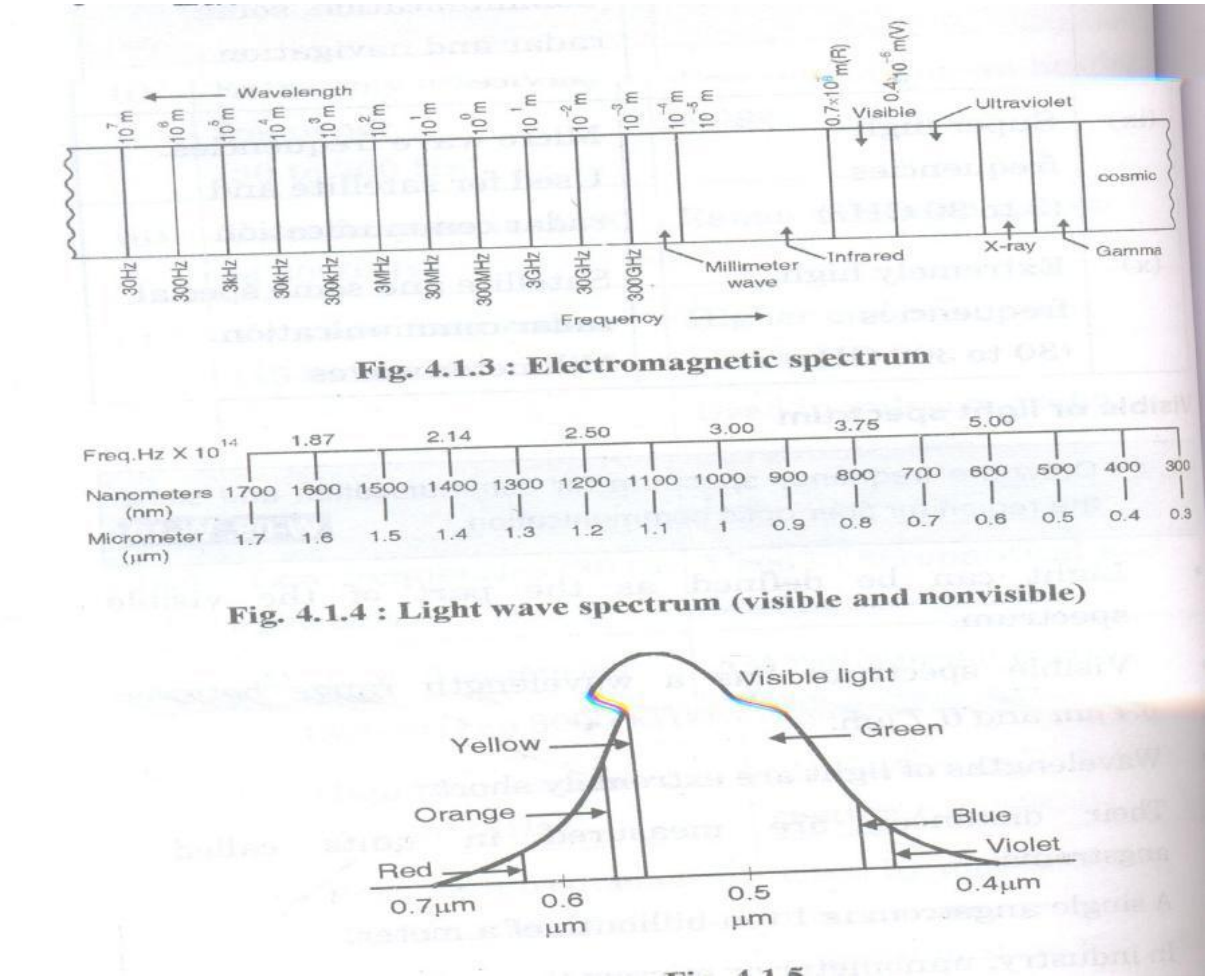
- Intramodal dispersion is also called chromatic dispersion.
- It occurs in all types of optical fibers.
- It results from the finite spectral line width of the optical source.
- Optical sources do not emit just a single frequency but band of frequencies.
- There may be propagation delay differences between the different spectral components of the transmitted signal.
- Delay in propagation causes broadening of each transmitted mode and so called intramodal dispersion.

2. <u>Intermodal dispersion</u> **:**

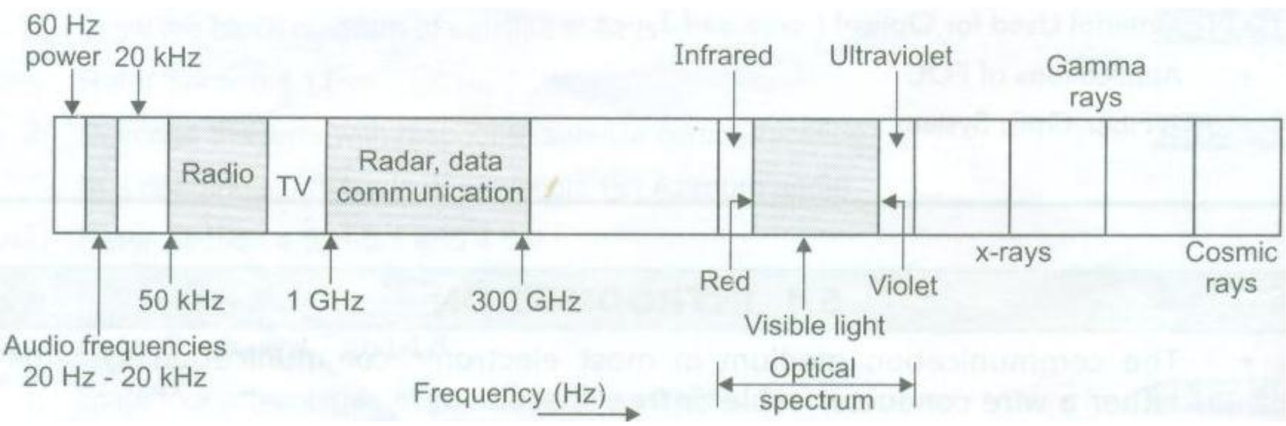
- It results from the propagation delay differences between modes within a multimode fiber travel along the channel with different group velocities.
- The pulse width at output is dependent upon the transmission times of the slowest and fastest modes.
- Multimode step index fibers exhibit a large amount of intermodal dispersion.
- It may be reduced by adapting an optimum refractive index profile.
- In pure single mode there is no intermodal dispersion.
- In multimode graded index fibers is far less than that obtained in multimode step index fibers.
- In multimode step index, the fastest and slowest modes propagating in it may be represented by axial ray and the extreme meridional ray respectively.
- The delay difference between these two rays when travelling in the fiber core allows estimation of the pulse broadening i.e. intermodal dispersion.

f. Draw frequency spectrum for optical communication with band name and its range.

Ans: **(any relevant correct diagram – 4 marks)**



(OR)



Frequency spectrum for optical communication

Q.3 Attempt any four of the following 16marks

a) State advantages and applications of circular waveguide.

Ans: <u>Advantages</u>: (any two) 2M

- The circular waveguide are easier to manufacture than rectangular waveguides and are easier to join.
- The TM01 modes are rotationally symmetrical and hence rotation of polarization can be overcome.
- TE01 mode in circular for long distance waveguide transmission.

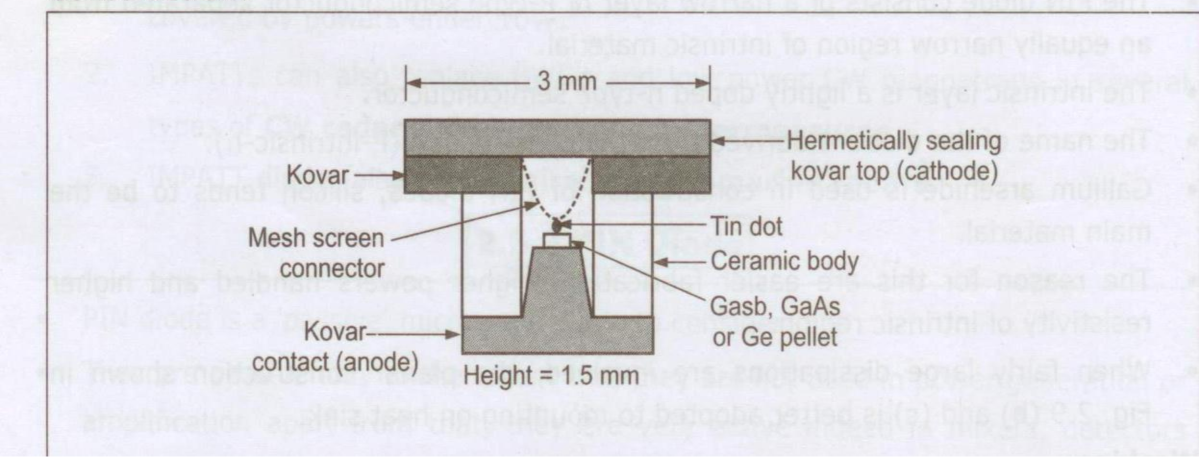
<u>Applications</u>: (any two) 2M

- Rotating joints in radars to connect the horn antenna feeding a paraboloid reflector (which must rotate for tracking).
- TE01 mode is suitable for long distance waveguide transmission above 10GHz.
- Short and medium distance broad band communication (cold replace/share coaxial and microwave links).
- It is used where the transmission or reception is in the range of microwave frequencies.
- It is also used for handling the high power of energy. □ It is mostly used in the airborne radar.

b) Sketch the construction of tunnel diode and write its operations.

Ans: **(Sketch 2M and operation 2M)**

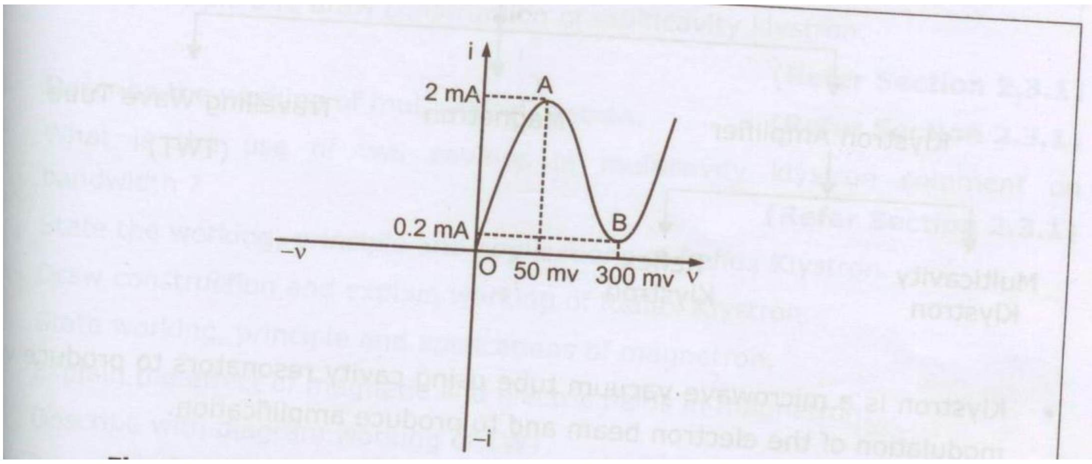
Construction:



Operation:

- Tunnel diode is a thin junction diode which under low forward bias conditions exhibits negative resistance useful for oscillation or amplification.
- The junction capacitance of the tunnel diode is highly dependent on the bias voltage and temperature.
- A very small tin dot about 50µm in diameter is soldered or alloyed to a heavily doped pellet of n- type Ge, GaSb or GaAs.
- The pellet is then soldered to a kovar pedestal, used for heat dissipation, which forms the anode contact.
- The cathode contact is also kovar being connected to the tin dot via a mesh screen used to reduce inductance.
- The diode has a ceramic body and hermetically sealing lid on top.

- In tunnel diode semiconductor material are very heavily doped, as much as 1000 times more than in ordinary diodes.
- This heavy doping results in a junction which has a depletion layer that is so thin (0.01μm) as to prevent tunneling to occur.
- In addition, the thinness of the junction allows microwave operation of the diode because it considerably shortens the time taken by the carriers to cross the junction.
- A current-voltage characteristics for a typical Germanium tunnel diode is shown in figure.
- Forward current rises sharply as voltage is applied.
- At point A, peak voltage occurs.
- As forward bias is increased past this point, the forward current drops and continues to drop until point B is reached, this is the valley voltage.
- At point B current starts to increase once again and does so very rapidly as bias is increases further.
- Diode exhibits dynamic negative resistance between A and B therefore, useful for oscillator applications.



c) Describe A scope display method of RADAR with its diagram

Ans: **(Diagram 2M and Explanation 2M)**

- A beam is made to scan the CRT screen horizontally by applying a linear saw tooth voltage to the horizontal deflection plates in synchronism with the transmitted pulses.
- The demodulated echo signals from the receiver is applied to the vertical deflection plates so as to cause vertical deflections from the horizontal lines.
- In the absence of any echo signal, the display is simply a horizontal line(as in a ordinary CRO)
- As indicated in the diagram, A-scope displays range v/s amplitude of the received echo signals.

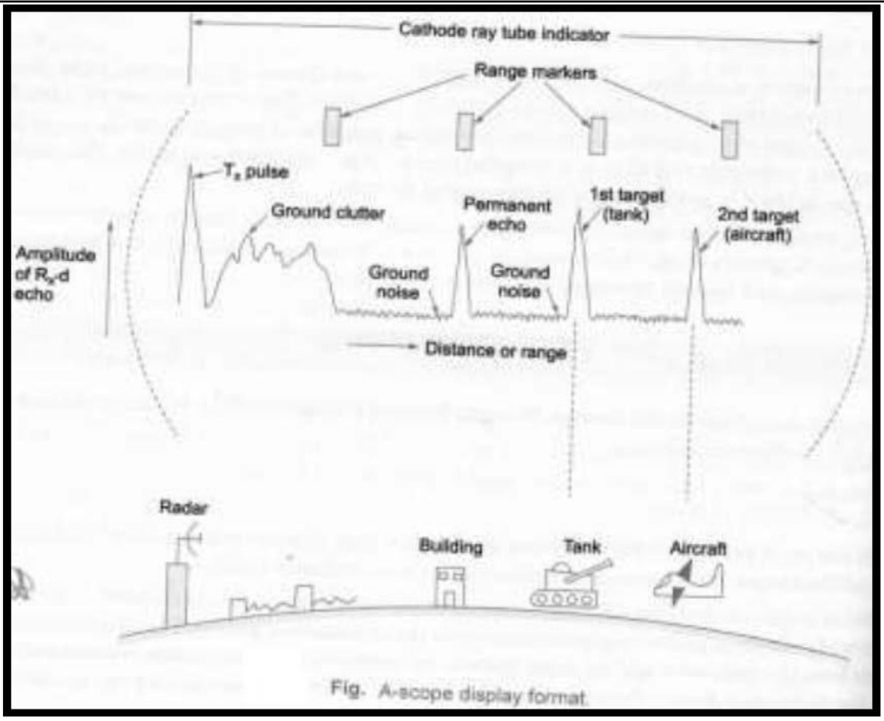
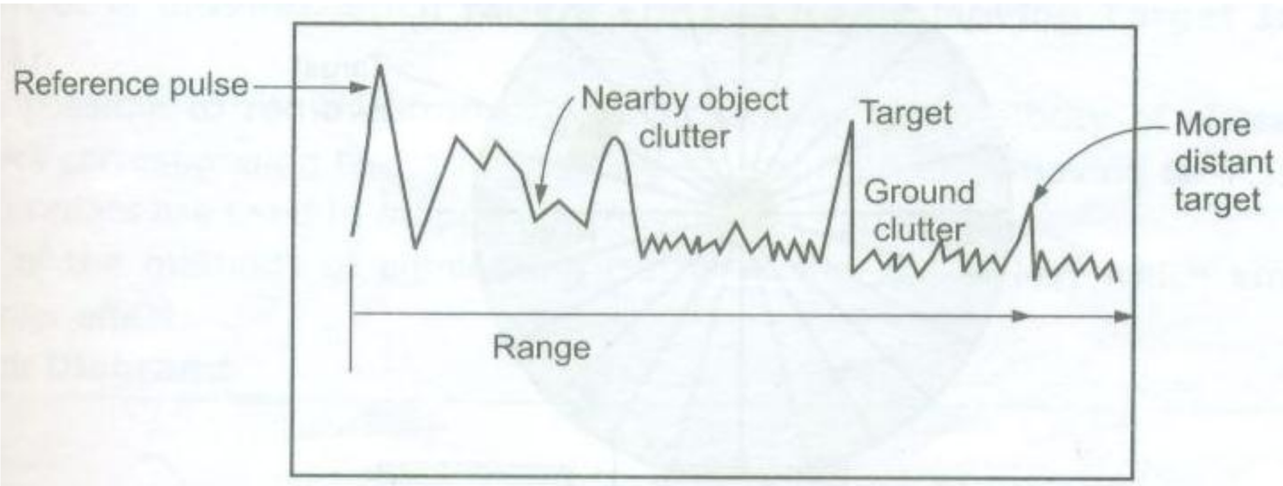


Fig. A-scope display format

(OR)



- The first 'blip' is due to the transmitted pulse, part of which is deliberately applied to the CRT for reference. In addition to this there are blips corresponding to:

  i. Ground clutter i.e., echoes from various fixed objects near the transmitter and from the ground.

  ii.Grass noise i.e., an almost constant amplitude and continuous receiver noise.

  iii. Actual target,the blips are usually large.

d) State advantages and disadvantages of fiber optic communications**.**

Ans: **Advantages: (any two) 2M, Disadvantages (any two) 2M**

1. Extremely wide system bandwidth: Fiber systems have greater capacity due to the inherently larger BWs available with optical frequencies. Metallic cables exhibit capacitance between and inductance along their conductors. These properties cause them to act as low pass filters which limit their transmission frequencies and hence bandwidths.

2. Immunity to electromagnetic interference: Fiber cables are immune to static interference caused by lightning, electric motors, fluorescent light and other external electrical noise sources.

This immunity is due to the fact that optical fibers are non-conductors of electricity. Also fiber cables do not radiate RF energy and therefore cannot cause interference with other communication system.

3. Virtual elimination of crosstalk: The light on one glass fiber does not interfere with light on an adjacent fiber. Fiber systems are immune to cross talk between cables caused by magnetic induction. Glass or plastic fibers are non-conductors of electricity and therefore do not have a magnetic field associated with them. In metallic cables, the primary cause of cross talk is magnetic induction between conductors located near each other.

4. Lower signal attenuation than other propagation systems: Typically attenuation figure of a 1GHz BW signal for optical fibers are 0.03dB per 100 feet compared to 4dB for both coax and an X band waveguide. So, fewer repeater stations are needed as a result of glass fiber.

5. Substantially lighter weight and smaller size: Fibers are smaller and much lighter in weight than their metallic counterparts. Fiber cables require less storage space and are cheaper to transport.

6. More resistive to environmental extremes and non-corrosiveness:

Fiber cables operate over a larger temperature variation than their metallic counterparts and fiber cable are affected less by corrosive liquids and gases. Fibers are used around volatile liquids and gases without worrying about their causing explosions.

7. Lower cost: The long term cost of fiber optics system is projected to be less than that of its metallic counterpart as the cost of copper is increasing.

8. Conservation of the earth's resources:

The supply of copper and other good electrical conductors is limited whereas the principal ingredient of glass is sand and it is cheap and in unlimited supply

9. Security:

Fiber cables are more secure than their metallic counterparts. It is virtually impossible to tap into a fiber cable without the user knowing about it.

10. Safety:

In many wired systems, the potential hazard of short circuits requires precautionary designs. Additionally, the dielectric nature of optical fiber eliminates the spark hazard.

Disadvantage:-

1 Brittleness and small size makes it difficult to work with.
2 Difficult to manufacture.
3 Expensive tools and techniques are required.
4 It is difficult to lay fiber to cover large area.
5 Broadcasting not possible.

e) Define w.r.t. satellite communication (i) orbit (ii) footprint.

Ans: **(Each 2 M)**

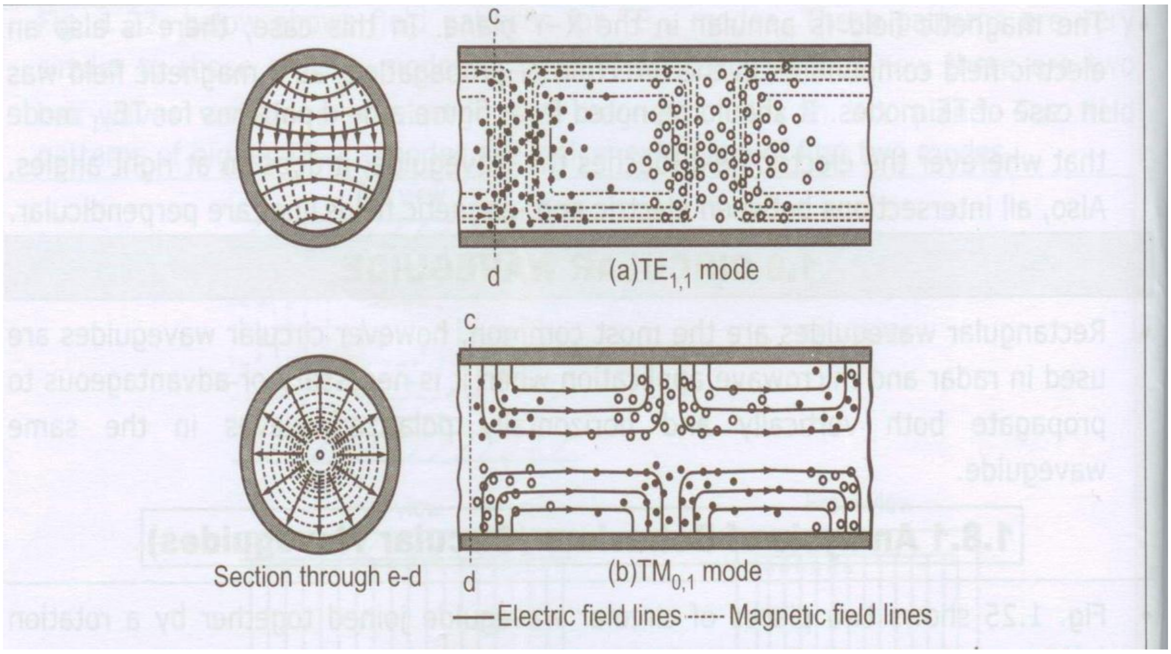
i) **Orbit:** An orbit is a trajectory that is periodically repeated. While the path followed by the motion of an artificial satellite around Earth is an orbit Or Satellites travel around the earth along predetermined/predefined repetitive paths called orbits.

ii) **Foot print**: The geographical representation of a satellite antenna radiation pattern is called foot print. The foot print of a satellite is the earth area that the satellite can receive from and transmitted to.

Q 4) a) Attempt any Three of the following 12 marks

i. Draw field pattern of circular wave guide. State its applications.

Ans: (Field pattern 3 M Application 1M)



Applications: Circular waveguide are used in radar and microwave applications when it necessary or advantages to propagate both vertically and horizontally polarized waves in same waveguide.

ii) Draw construction diagram of PIN diode and describe its working.

Ans: **Any one constructional diagram 2 marks, Description 2 marks)**

Working:

The PIN diode has following modes of operation:

1. Forward biased:

When the diode is forward biased, it behaves as if it possesses a variable resistance controlled by the applied current. When a PIN diode is forward biased, holes and electrons are injected from the P and N regions into the I-region. This results in the carrier concentration in the I layer becoming raised above equilibrium levels and the resistivity drops as forward bias is increased. Thu low resistance is offered in the forward direction. . The high-frequency resistance is inversely proportional to the DC bias voltage applied to the diode. A PIN diode, suitably biased, therefore acts as a variable resistor. This high-frequency resistance may vary over a wide

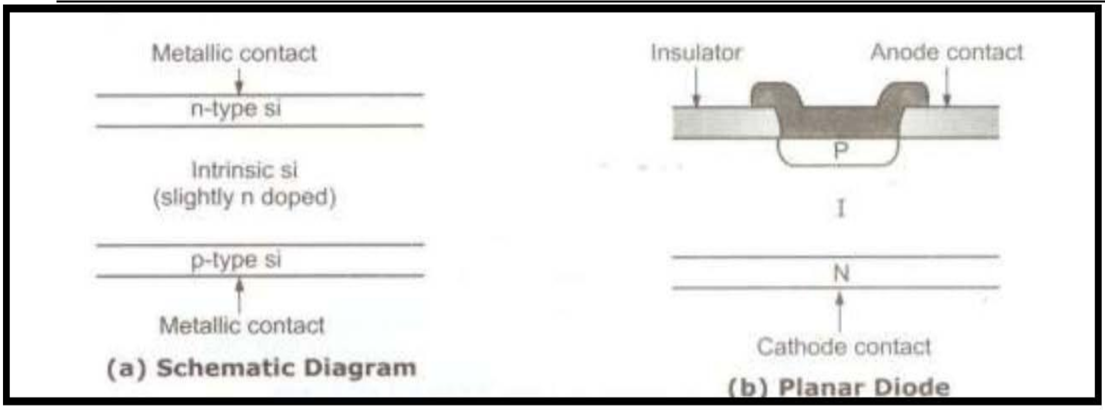
range from 0.1Ω to 10 kΩ.

2.Reverse biased:

When the diode is reversed biased the space charge regions in the p and n layers will become thicker. The reverse resistance will be very high and almost constant.

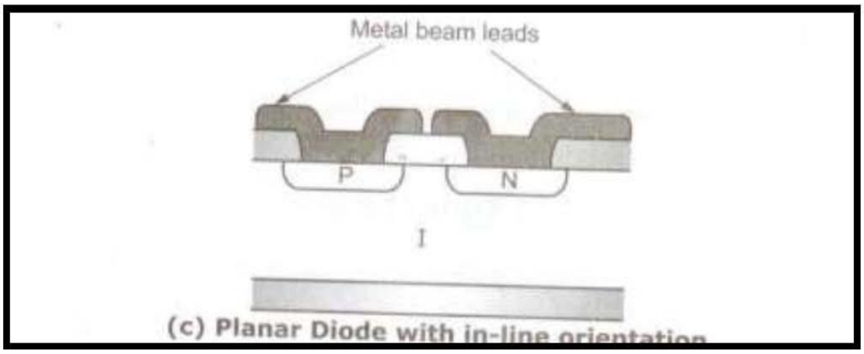
3. Zero Bias:

At zero bias, the diffusion of the holes and electrons across the junction causes space charge region of thickness inversely proportional to the impurity concentration. The diode has high impedance.



(a) Schematic Diagram

(b) Planar Diode



(c) Planar Diode with in-line orientation

iii) State two advantages and two applications of CW RADAR

Ans: **(Each 2 M)**

Advantages:

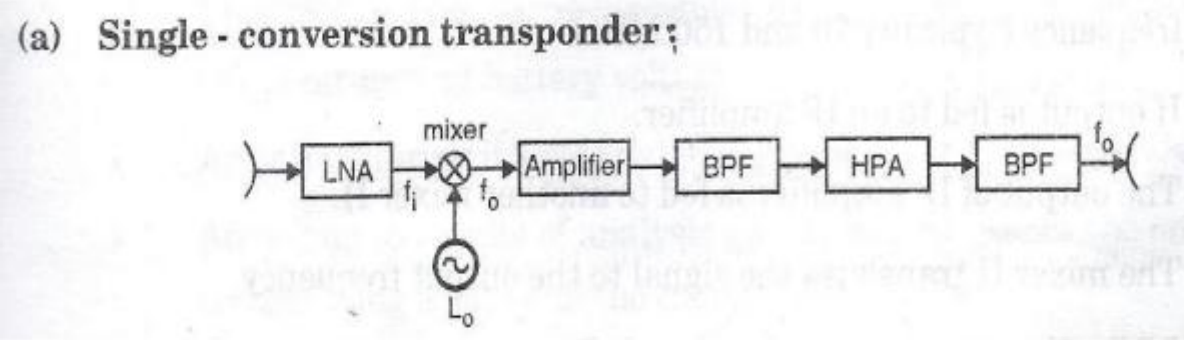
1. CW Doppler radar has no blind speed.
2. CW Doppler radar is capable of giving accurate measurements of relative velocities.
3. CW Doppler radars are always on, they need low power and are compact in size.

Applications:

1. It is used to give Doppler information contained in echo signal.
2. It is used to measurement of relative velocity to distinguish moving target from stationary objects.

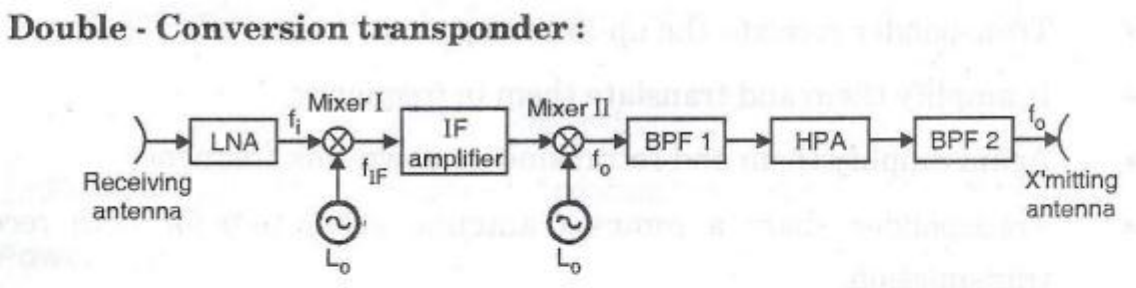
iv) Illustrate the block diagram of communication channel sub system used in satellite communication

Ans: **(Diagram 2M , explanation – 2M)**



1. In this transponder only a single-frequency translation process takes place
2. First uplink frequency signal is picked up by the receiving antenna and is routed to LNA (Low Noise Amplifier)
3. The signal is very weak at this point, so LNA amplifies the signal
4. Once the signal is amplified, it is translated in correct frequency by mixer.
5. The output of mixer is then amplified again and fed to band pass filter (BPF1)
6. BPF1 allows only a desired down-link signal of 4 GHz
7. At last, the down-link signal is amplified by high power amplifier (HPA) usually TWT (Travelling wave tube)
8. Again output of BPF2 is fed to the down-link antenna
9. If common antenna is used for transmission or reception then diplexer is used to share the antenna.

OR



1. First uplink signal is received by the receiving antenna.
2. LNA amplified the received signal.
3. Amplified signal first fed to first mixer (1).
4. The mixer 1 translates the received signal frequency into intermediate frequency (typically 70 and 150 MHz). If output is fed to an IF amplifier.
5. The output of IF amplifier is fed to another mixer 2.
6. The mixer 2 translates the signal to the output frequency.
7. BPF1 filters the output signal and eliminates the unwanted output.

8. HPA increases the output signal level.

9. Again output signal is passed through BPF2 to filter out the harmonics etc.

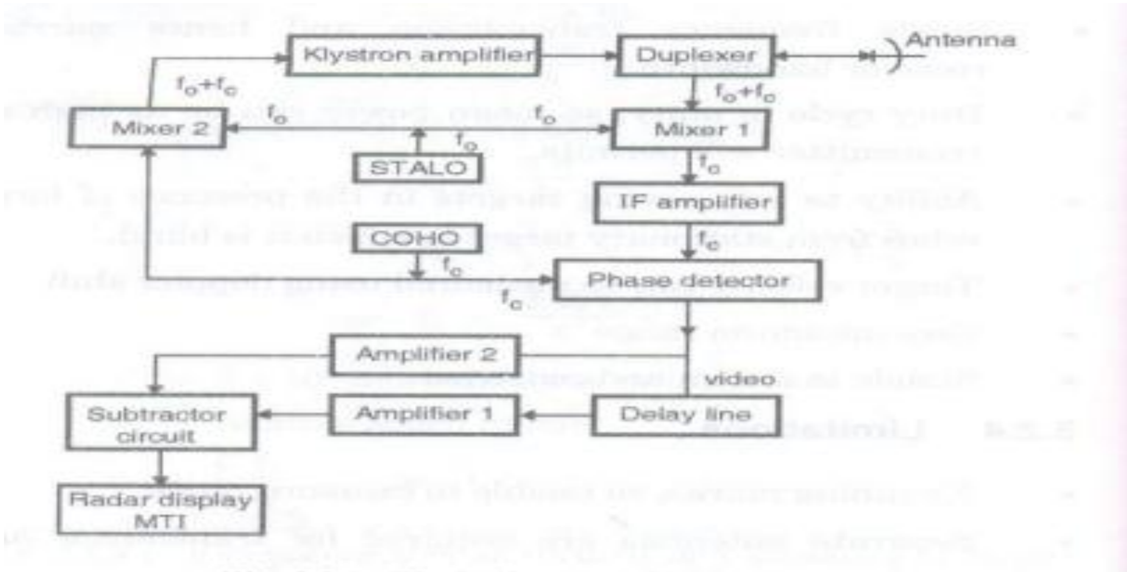
10. At last, transmitting antenna sends the signal over the down link.

11. This transponder provides greater flexibility in filtering and amplification.

Q. 4 b) Attempt any one of the following 6 marks

i) Explain the working of MTI radar with the help of block diagram and with suitable waveform

Ans: **(Block diagram 2M, Explanation 2M and Waveform 2M)**



Working principle:

It compares the present echo with the previous one. If the present and previous echo are same the target is stationary, where as if the present and previous echo are not same the target is moving target.If echo is due to moving target, the echo pulse under goes a Doppler frequency. The received echo pulses than pass through mixer 1 of the receiver. Mixer 1 heterodynes the received signal of frequency (Fo+Fc) with the output of the stalo at Fo. Mixer 1 produces a difference frequency Fc at its output. This difference frequency signal is amplified by an IF amplifier.

Amplifies output is given to phase detector. The detector compares to IF amplifier with reference signal from the COHO oscillator. The frequency produced by COHO is same as IF frequency so called coherent frequency. The detector provides an output which depends upon the phase difference between the two signals. Since all received signal pulses will have a phase difference compared with the transmitted pulse. The phase detector gives output for both fixed and also moving targets. Phase difference is constant for all fixed targets but varies for moving targets. Doppler frequency shift causes this variation in the phase difference. A change of half cycle in Doppler shift would cause an output of opposite polarity in the phase detector output.

The output of phase detector will have an output different in magnitude and polarity fro successive pulse in case of moving targets. And fro fixed target magnitude and polarity of output will remain the same as shown in figure

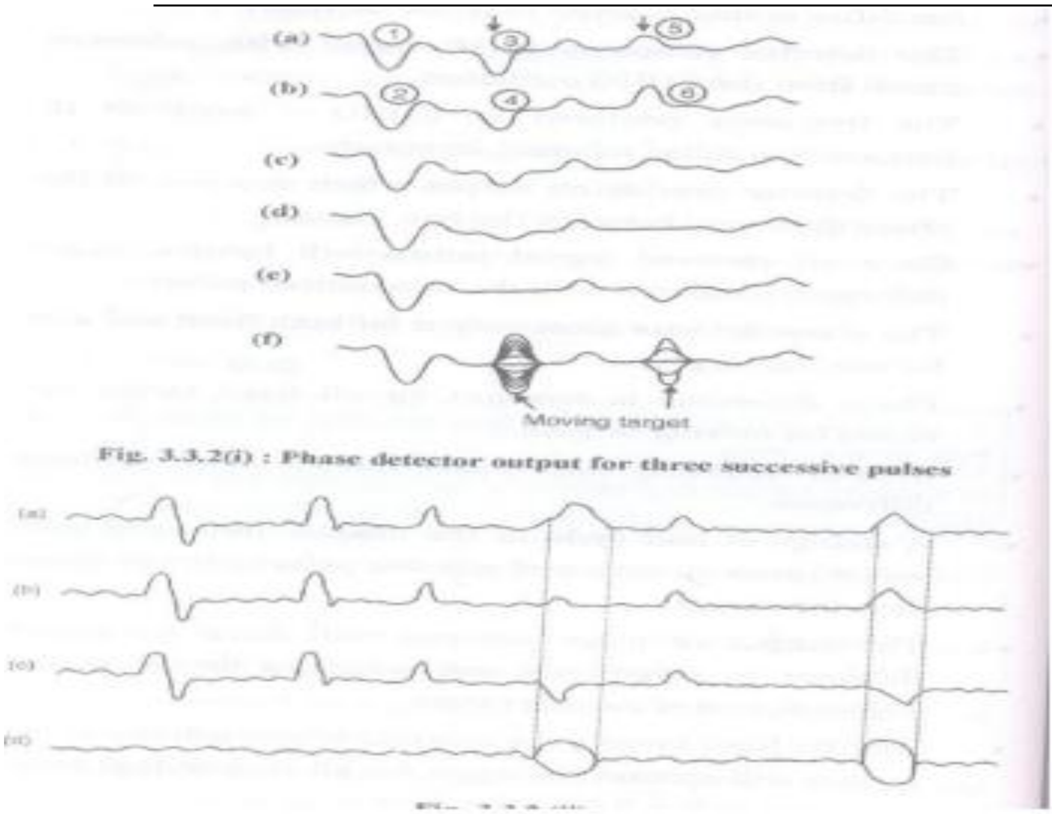
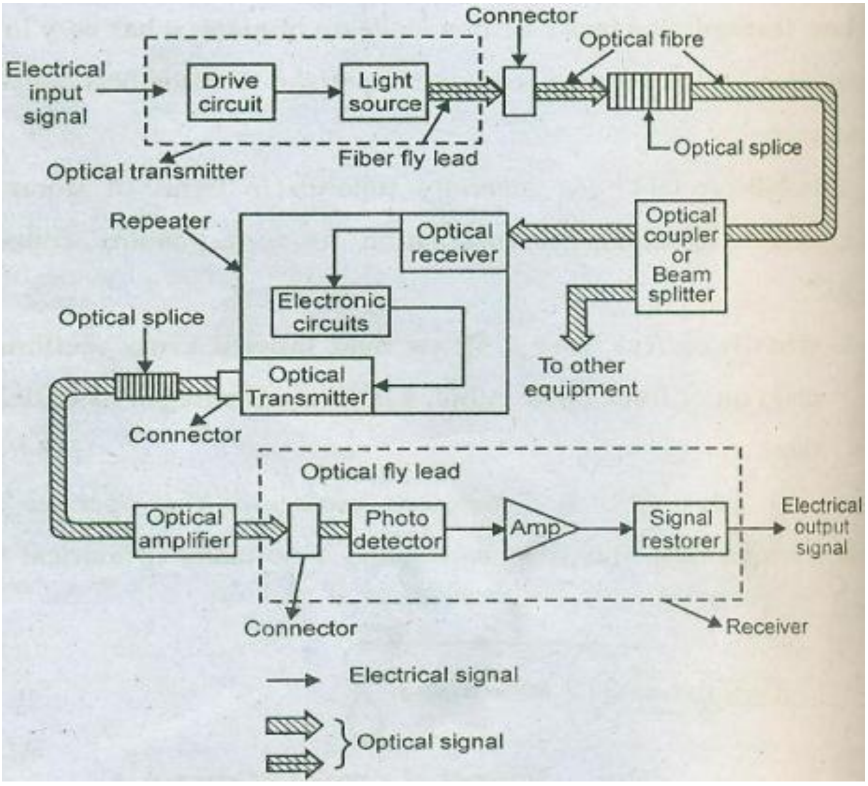


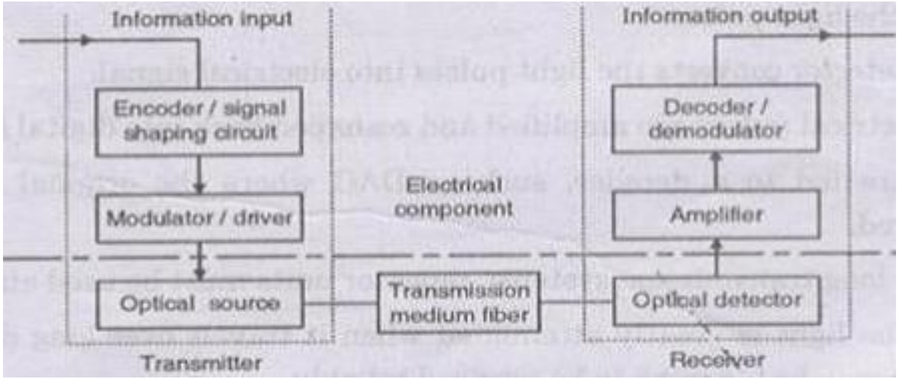
Fig. 3.3.2(i) : Phase detector output for three successive pulses

ii) Draw the block diagram of fiber optic communication system and list out the detector and light source.

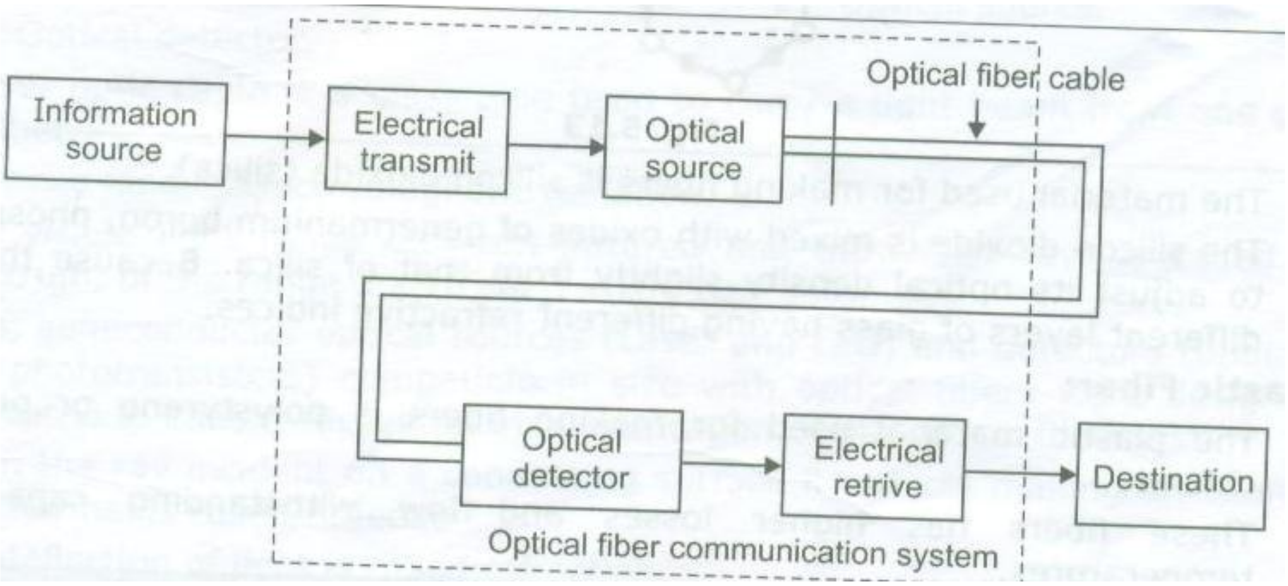
Ans: **(Block diagram 4M, detector 1M and light source 1M)**



OR



OR



Detector used are: i) Avalanche Photo Diode, ii) PIN Photo Diode

Light source used are: i) LED , ii) LASER

Q.5 Attempt any FOUR of the following 16 marks

a) Distinguish microwave circulator and isolator with the following parameters.

i) Function

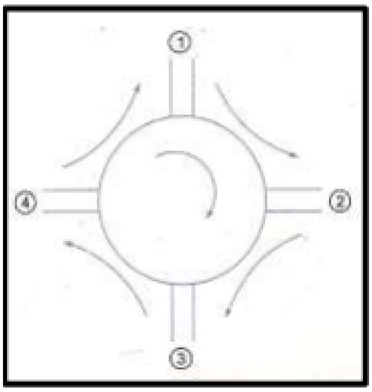
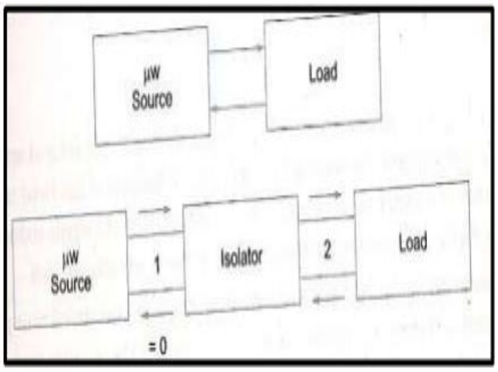
ii) Construction

iii) Application

iv) Number of ports

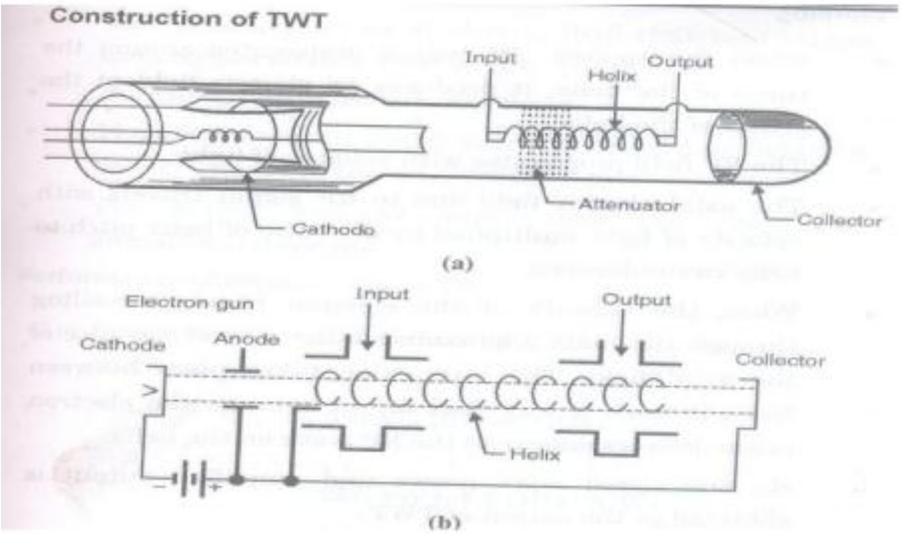
Ans: **(1M for each point)**

Sr. No.	Parameter	Circulator	Isolator
1	Function	It has peculiar property that each terminal is connected to next clockwise terminals. That means port 1 is connected to port 2 only and not to port 3 and port4.	It uses property of faradays rotation in the ferrite material. It provides very small attenuation for transmission from port 1 to 2. But provides very high attenuation for transmission from port 2 to 1.

2	Construction		
3	Application	Circulators are used in parametric amplifiers, tunnel diode amplifiers and duplexers in radars.	Isolators are used in the output of an amplifier that is sensitive to its load conditions. In UHF or VHF transmitters. In Radio Transmitters.
4	Number of ports	Circulator is usually(more than 2) 4 port microwave device.	Isolator is a 2 port microwave device.

b) Show how TWT can be used as an amplifier.

Ans: **2M - diagram and 2M -explanation**



Working principle:

When the applied RF signal propagates around the turn of helix it produces electric field at the centre of helix. The RF field propagates with velocity of light. The axial electric field due to the RF signal travels with velocity of light multiplied by the ratio of helix pitch to helix circumference. When the velocity of electron beams, travelling through the helix approximates the rate of advance of axial field. The interaction takes place between them in such a way that on average the electron beam delivers energy to the RF field in helix. So the signal wave grows and amplified output is obtained at output of TWT. At a point where axial field is zero electron velocity is unaffected. A point where the axial field is positive, the electron coming against it is accelerated and tries to catch up with later electrons which encounter the RF axial field.

A point where axial field is negative the electrons get velocity modulated. And the energy transfer from electron to RF field at axial and second wave is induced on helix. This produces an axial electric field that lags behind original electric field by $\lambda/4$. Bunching continues to take place. The electron in bunch encounter retarding field and deliver energy to way on helix. The output becomes larger than the input and then amplification results.

c) A step index fiber has a numerical aperture of 0.16, a core refractive index of 1.45 and core diameter of 90mm.Calculate:

i) The acceptance angle

ii) The refractive index of cladding.

Ans: **1M –each formula, 1M-each answer**

Given : n1= 1.45

NA= 0.16

Find: n2, θa

Acceptance angle (θa) = $\sin^{-1}$ NA

$\theta a = \sin^{-1} 0.16$

$\theta a = 9.20°$

ii) The refractive index of cladding(n2)

$NA = (n_1^2 - n_2^2)^{1/2}$

$NA = (1.45^2 - n_2^2)^{1/2}$

$n_2^2 = 1.45^2 - 0.16^2$

$n_2 = 1.44$

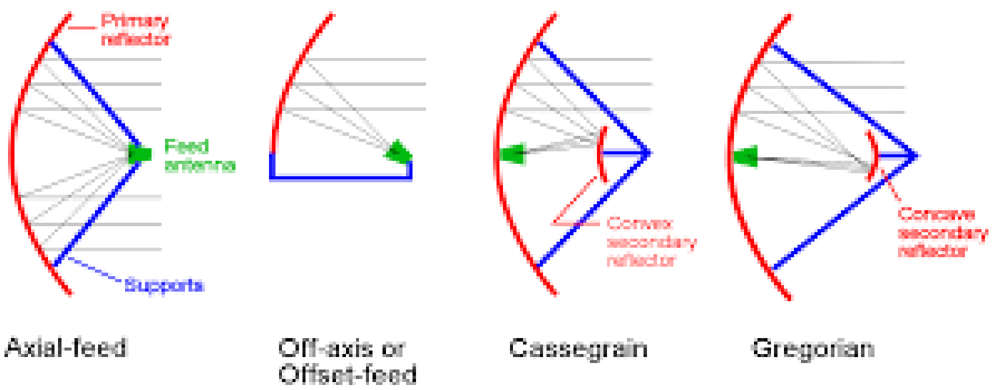
d) Describe the antenna used in Satellite.

Ans: **2M – diagram and 2M –explanation** **Note: any one should be considered**

Antennas receive the uplink signal and transmit to downlink signals. In addition they provide single link for the satellite telemetry, command and ranging systems which in conjunction with attitude control subsystem provides beacon tracking signals for precise pointing of the antenna towards the Earth coverage areas. The design of satellite antenna is conditioned by the required coverage. It should be remembered that antennas are the one of the key elements in a satellite communication system since their gain values directly determine the amount of received power.

Types of antenna system use in satellite communication

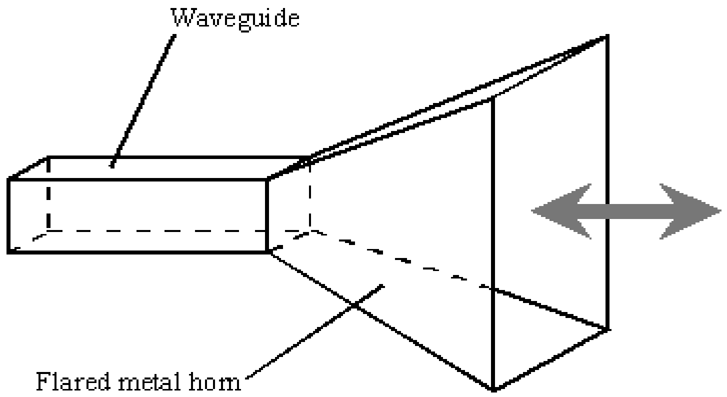
Parabolic antenna



A parabolic antenna is a high-gain reflector antenna used for radio, television and data communications, and also for radiolocation (RADAR), on the UHF and SHF parts of the electromagnetic spectrum. The relatively short wavelength of electromagnetic (radio) energy at these frequencies allows reasonably sized reflectors to exhibit the very desirable highly directional response for both receiving and transmitting. A typical parabolic antenna consists of a parabolic reflector illuminated by a small feed antenna. The reflector is a metallic surface formed into a paraboloid of revolution and (usually) truncated in a circular rim that forms the diameter of the antenna. This paraboloid possesses a distinct focal point by virtue of having the reflective property of parabolas in that a point light source at this focus produces a parallel light beam aligned with the axis of revolution. The feed antenna is placed at the reflector focus. This antenna is typically a low-gain type such as a half-wave dipole or a small waveguide horn. In more complex designs, such as the Cassegrain antenna, a sub-reflector is used to direct the energy into the parabolic reflector from a feed antenna located away from the primary focal point. The feed antenna is connected to the associated radio-frequency (RF) transmitting or receiving equipment by means of a coaxial cable

(OR)

Horn Antenna

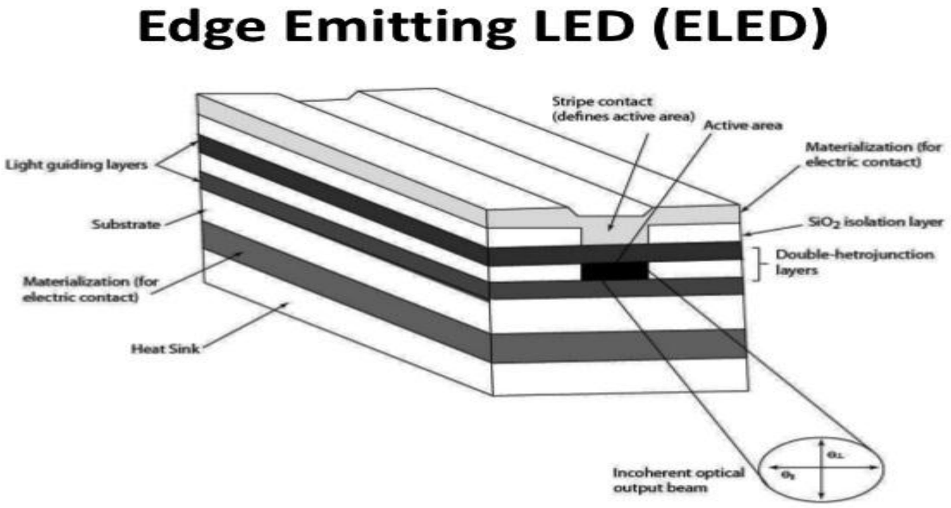


A horn antenna or microwave horn is an antenna that consists of a flaring metal waveguide shaped like a horn to direct radio waves in a beam. Horns are widely used as antennas at UHF and microwave frequencies, above 300 MHz. They are used as feeders (called feed horns) for larger antenna structures such as parabolic antennas, as standard calibration antennas to measure the gain of other antennas, and as directive antennas for such devices as radar guns, automatic door openers, and microwave radiometers. Their advantages are moderate directivity, low standing wave ratio (SWR), broad bandwidth, and simple construction and adjustment. In order to function properly, a horn antenna must be a certain minimum size relative to the wavelength of the incoming or outgoing electromagnetic field. If the horn is too small or the wavelength is too large (the frequency is too low), the antenna will not work efficiently.

Horn antennas are commonly used as the active element in a dish antenna. The horn is pointed toward the center of the dish reflector. The use of a horn, rather than a dipole antenna or any other type of antenna, at the focal point of the dish minimizes loss of energy (leakage) around the edges of the dish reflector. It also minimizes the response of the antenna to unwanted signals not in the favored direction of the dish.

e)Describe Edge emitter LED construction and working principle.

Ans: **2M – diagram and 2M –explanation**



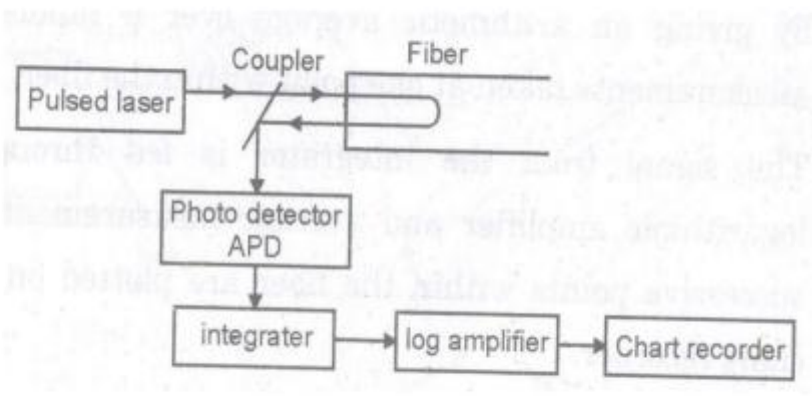
Currently used, high radiance structure is the edge emitter LED. It have transparent guiding layers with a very thin active layer (50 to 100 um) as shown in above figure.

The light produced in the active layer spreads into the transparent guiding layers, reducing self-absorption in the active layer. Most of the propagating light is emitted at one end face only due to a reflector on the other end faced and antireflection coating on the emitting end face. It is modified injection laser structure. It has very thick active region with significant difference that a waveguide around the active region channels radiation to the emitting face of the device. Here light is generated in the active layer and guided to the emitting face. The light is coupled to the lowest order guided mode parallel to the junction .Most of the light propagating in this mode is transmitted to the end facets and emitted with a half power beam width of about 25-30◦ in plane of a junction . The beam emitted perpendicularly to the junction where there is no waveguiding effect. Although the optical power obtained from such a structure is 2 to 6 times smaller than that of a SLED but more efficient coupling due to narrow band width.

f) Draw and explain the block diagram of OTDR.

Ans: **2M - diagram and 2M -explanation**

An optical time domain reflector is used in fiber optics to measure the time and intensity of light reflected on an optical fiber. It is used as trouble shooting device to find faults, splices and bends in fiber optic cables with an eye towards identifying light loss. Light loss is important in fiber optic cables because it can interface with the transmission of data. An OTDR can detect such light loss and pinpoint trouble areas making repair easy. The more quickly trouble areas are identifies and addressed the less fiber optic network will suffer from data transfer problems. An OTDR test can anywhere along the length of fiber from ten seconds to three minutes. It emits a high power pulse that hits the fiber and bounces back. What comes back is measured, factoring in time and distance and results in “trouble spots” which radiate and can be targeted for repair. Some OTDR systems are equipped with PC-linking capabilities that the data recorded during testing can be downloaded to a computer for analysis and storage.



The above figure is the block diagram. The main blocks of the reflectometer are the generator of the testing impulse and detection system of the backscattered light. The remaining blocks provide the suitable timing of signals and the interpretation of the measured data(display) .

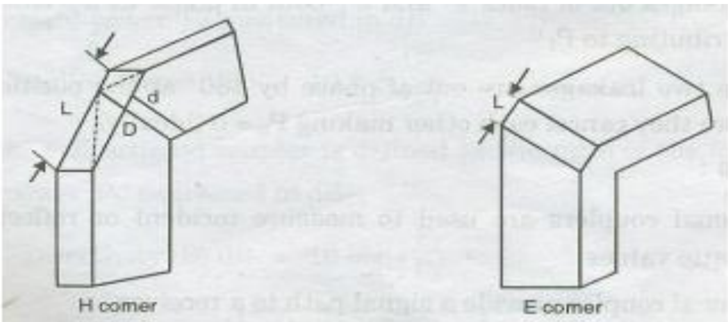
A light pulse is launched into the fiber in the forward direction from an injection laser using either a directional coupler or a beam splitter. Beam splitter or coupler makes possible to couple the optical power impulse into the tested fiber and simultaneously to deviate the backscattered power to the optical receiver. The backscattered light is detected using avalanche photodiode receiver. Output of photodiode receiver drivers an integrator. Integrator improves the received signal to noise ratio by giving an arithmetic receiver over a number of measurements taken at one point within the fiber. The signal from the integrator is fed through a log amplifier and average measurements for successive points within the fiber are plotted on as a chart recorder.

Q.6 Attempt any FOUR of the following 16marks

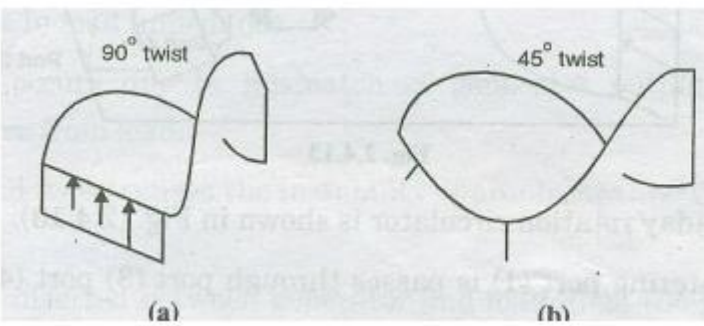
a) Draw diagram of Twists and corners. State its applications

Ans: **(Diagram – 2 Marks, Any two Applications – 2 Marks)**

i) Corners: Corners are used change the direction of the wave propagating through waveguide.



ii) Twists: Twists are used to convert vertical to horizontal polarization and vice – versa.



Applications (Any two relevant applications) (2 Marks)

ii) RADAR system.

iii) Terrestrial microwave system

iv) Satellite communication system

b) Describe the Intrinsic and Extrinsic absorption losses in optical fiber.

Ans: **(each explanation – 2 marks)**

Absorption loss is related to the material composition and fabrication process of fiber. Absorption loss results in dissipation of some optical power as hear in the fiber cable. Although glass fibers are extremely pure, some impurities still remain as residue after purification. The amount of absorption by these impurities depends on their concentration and light wavelength.

1. Intrinsic absorption

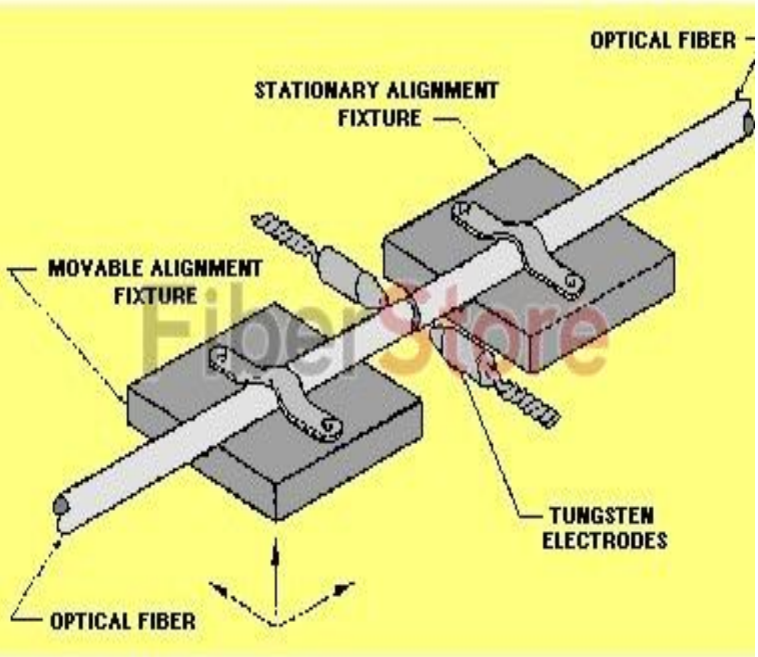
Intrinsic absorption in the ultraviolet region is caused by electronic absorption bands. Basically, absorption occurs when a light particle (photon) interacts with an electron and excites it to a higher energy level. The main cause of intrinsic absorption in the infrared region is the characteristic vibration frequency of atomic bonds. In silica glass, absorption is caused by the vibration of silicon-oxygen (Si-O) bonds. The interaction between the vibrating bond and the electromagnetic field of the optical signal causes intrinsic absorption. Light energy is transferred from the electromagnetic field to the bond.

2. Extrinsic absorption

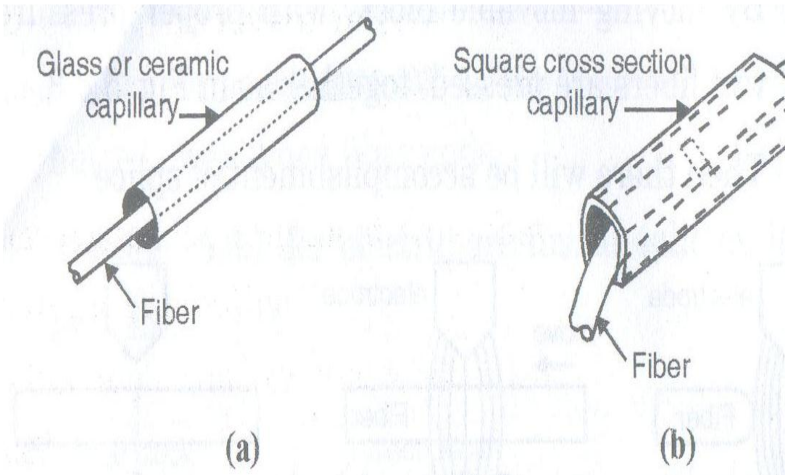
Extrinsic absorption is much more significant than intrinsic Caused by impurities introduced into the fiber material during manufacture – Iron, nickel, and chromium Caused by transition of metal ions to higher energy level Modern fabrication techniques can reduce impurity levels below 1 part in 1010. For some of the more common metallic impurities in silica fibre the table shows the peak attenuation wavelength and the attenuation caused by an impurity concentration of 1 in 10^9

c) Draw the diagram of fusion splicing and rigid alignment tube splice.

Ans: **2M- each diagram**



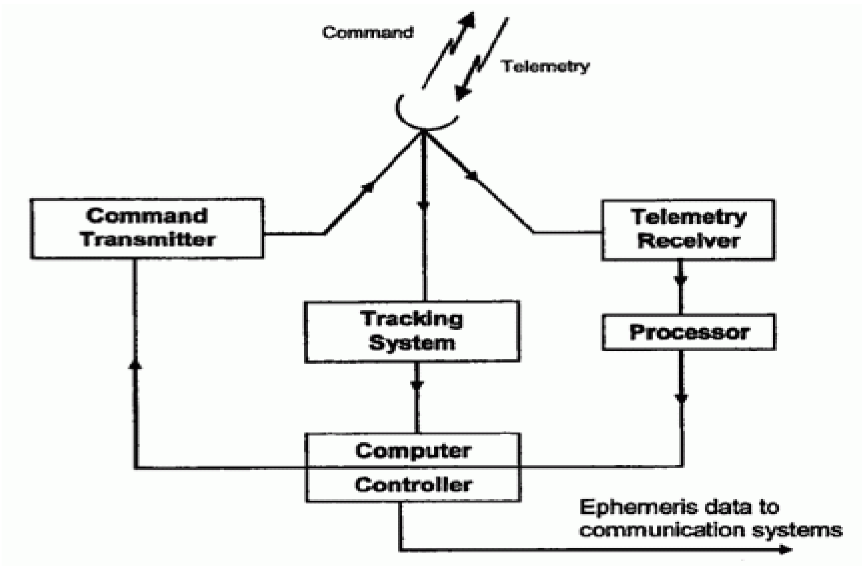
a. Fusion splicing



b. Tube splicing

d) Illustrate how Telemetry tracking and command system is used in satellite.

Ans: **2M - diagram and 2M -explanation**



Telemetry, Tracking and Command (TT&C) Subsystem

These systems are partly on the satellite and partly at the control earth station. They support the functions of the spacecraft management. The main functions of a TTC system are

- To monitor the performance of all satellite subsystems and transmit the monitored data to the satellite control center via a separate Telemetry link.
- To support the determination of orbital parameters.
- To provide a source to earth station for tracking.
- To receive commands from the control center for performing various functions of the satellite.

Typical functions include:

- To correct the position and attitude of the satellite.
- To control the antenna pointing and communication system configuration to suit current traffic requirements.
- To operate switches on the spacecraft.

TELEMETRY:

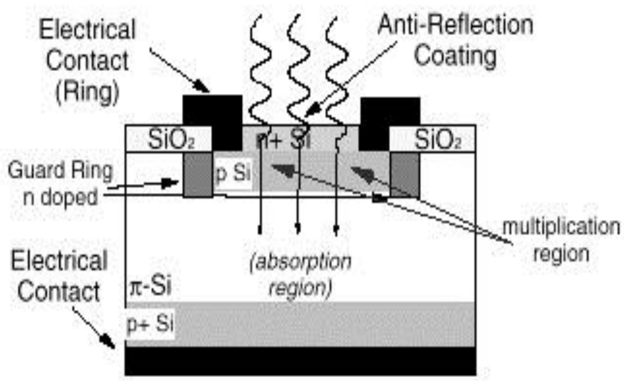
- It collects data from all sensors on the satellite and send to the controlling earth station.
- The sighting device is used to maintain space craft altitudes are also monitored by telemetry.
- At a controlling earth station using computer telemetry data can be monitored and decode.
- And status of any system on satellite can be determined and can be controlled from earth station

TRACKING:

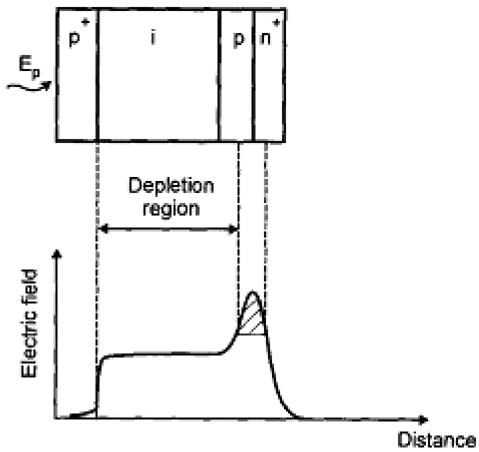
- By using velocity and acceleration sensors, on spacecraft the orbital position of satellite can be detect from earth station.
- For accurate and precise result number of earth stations can be used.

e) Draw structure of avalanche photodiode and describe its working principle.

Ans: **2M - diagram and 2M -explanation**



(OR)



Avalanche photodiode is a major type of optical communication detector. The structure of it such that to create an extremely high electric field region. The depletion region where most of the photons are absorbed and the primary carrier pair generated there is a high field region in which holes and electrons can acquire sufficient energy to excite new electron hole pairs i.e. process of impact ionization that leads to avalanche breakdown.

It requires high reverse bias voltage in order that the new carriers created by impact ionization can produce additional carriers by same mechanism.