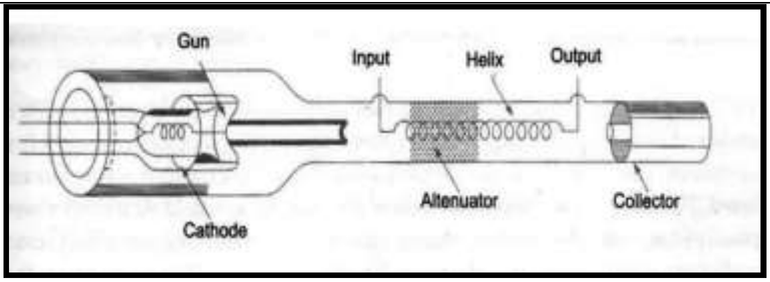
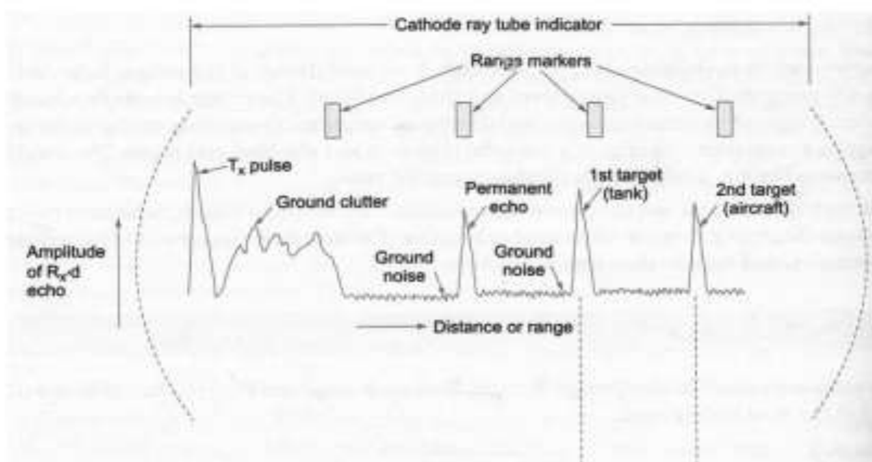
WINTER – 19EXAMINATION

Subject Name: Advanced Communication System **Model Answer** Subject Code: **17656**

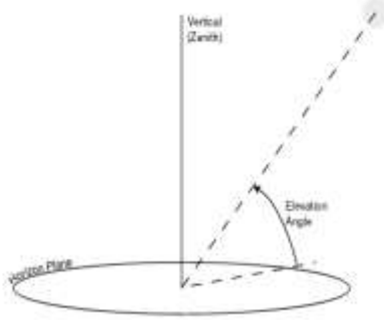
Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in themodel answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may tryto assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given moreImportance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in thefigure. The figures drawn by candidate and model answer may vary. The examiner may give credit for anyequivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constantvalues 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 judgement 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.

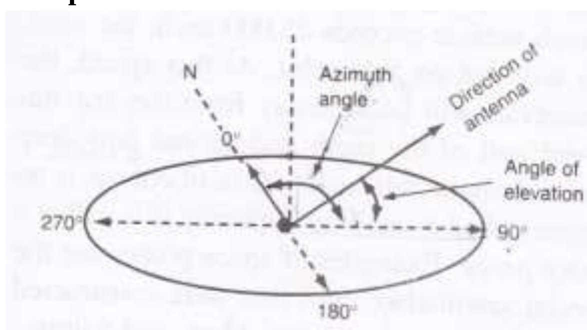
Q. No.	Sub Q. N.	Answer	Marking Scheme
Q.1	**(A)**	**Attempt any THREE of the following:**	**12Marks**
	(a)	**Define the term w.r.t. waveguide:** **(i) Cut-OFF frequency** **(ii) Group Velocity**	**4M**
	Ans:	**Group velocity:** It is defined as the rate at which the wave propagates through the waveguide and is given by $$v_g = v_c\sqrt{1-\left(\frac{\lambda}{\lambda_c}\right)^2}$$ **OR** $$v_g = v_c \sin\theta$$ The group velocity is also can be defined as the velocity of energy flow in the waveguide system. ***Note: When λ=λc, group velocity becomes zero, whereas phase velocity becomes infinite indicating that there is no propagation of energy along the Waveguide.*** **Cut off frequency:** 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 the lowest frequency which can propagate on the waveguide is fc $TE_{1,0}$. No energy can propagate in a rectangular waveguide at a frequency below fc $TE_{1,0}$. This is absolute cut off frequency of the waveguide.	**2M each definition**
	(b)	**Draw labelled sketch of TWT and give its two applications.**	**4M**
	Ans:	**(Note: Any other relevant diagram and applications can be considered.)**	**2M diagram,**

		 **Applications: (Any 2 Applications)** • Low noise RF amplifier in broadband microwave receivers. • Repeater amplifiers for long distance telephony. • Used as power output tube in communication satellites. • Continuous wave high power TWT"s are used in troposcatter links. • Airborne and ship borne pulsed high power radars, EM ground based radars.	**2M Application**
	(c)	**List different display methods used in Radar. Explain any one display method.**	**4M**
	Ans:	**Display methods used in RADAR are given below.** **1. A-Scope** **2. PPI** **3. Automatic target detection** **A scope: (ANY ONE)** **Diagram :**  • This is the most popular type of the deflection modulation type display system which indicates the range of the target. • The A-scope display, shown in figure, presents only the range to the target and the relative strength of the echo. Such a display is normally used in weapons control radar systems. • The bearing and elevation angles are presented as dial or digital readouts that correspond to the actual physical position of the antenna. • The A-scope normally uses an electrostatic-deflection crt. The sweep is produced by applying a sawtooth voltage to the horizontal deflection plates. The electrical length (time duration) of the sawtooth voltage determines the total amount of range displayed on the crt face. • The ranges of individual targets on an A-scope are usually determined by using a movable range gate or step that is superimposed on the sweep. • In addition to this there are various signals displayed on the screen corresponding to:	**1M Listing** **3M Explaintio n.**

		○ **Ground clutter** i.e. echoes from various fixed objects near the transmitter & from the ground. ○ **Grass noise** i.e. an almost constant amplitude & continuous receiver noise. ○ **Actual targets.** These signals are usually large. **OR** **PPI Display:**  • This is an intensity modulation type display system which indicates both range & azimuth angle of the target simultaneously in polar coordinates. The demodulated echo signals from the receiver are applied to the grid of the CRT which is biased slightly beyond cut-off. • The ppi scope shown in figure is by far the most used radar display. It is a polar coordinate display of the area surrounding the radar platform. • Own ship is represented as the origin of the sweep, which is normally located in the center of the scope, but may be offset from the center on some sets. • The PPI uses a radial sweep pivoting about the center of the presentation. This results in a map-like picture of the area covered by the radar beam. A long-persistence screen is used so that the display remains visible until the sweep passes again. • Bearing to the target is indicated by the target's angular position in relation to an imaginary line extending vertically from the sweep origin to the top of the scope. • The top of the scope is either true north(when the indicator is operated in the true bearing mode) or ship's heading (when the indicator is operated in the relative bearing mode)	
	(d)	**Define the following terms with respect to satellite:** **(i) Azimuth Angle** **(ii) Elevation Angle**	**4M**
	Ans:	**Angle of Elevation:** • It is the angle subtended between the line of sight joining the earth station antenna and the satellite and the horizontal plane. **Azimuth Angle:** • The angle measured clockwise from the true north to the projection of satellite (sub-satellite point) on the horizontal plane at the earth station is called as azimuth.	**2M each definition.**



1. It is also defined as the horizontal pointing angle of an antenna. **The angle measured clockwise from the true north to the projection of satellite (sub-satellite point) on the horizontal plane at the earth station is called as azimuth.**



	b)	**Attempt any ONE of the following:**	**6 Marks**
	(a)	**Describe rectangular waveguide in TE & TM mode.**	**6M**

Ans:

i. **Mode is defined as all possible configuration of electric and magnetic field which can exists in the waveguide.**

ii. Modes in rectangular waveguides are labeled $TE_{m,n}$ if they are transverse electric, and $TM_{m,n}$ if they are transverse magnetic. In each case *m* and *n* are integers denoting the number of half wavelengths of intensity between each pair of walls.

iii. *m* is measured along the *x* axis of the waveguide (dimension *a*), this being the direction along the broader wall of the waveguide; *n* is measured along the *y* axis (dimension *b*).

4M for explanation of each

$TE_{m,n}$ Modes: In TE modes, electric field is transverse only, and the has a component of the magnetic field in the direction of propagation.

The equation of characteristic wave impedance is given by –

$$Z_0 = \frac{377}{\sqrt{1-\left(\frac{\lambda}{\lambda_c}\right)^2}}$$

Where,

Z_0= characteristic wave impedance of the waveguide

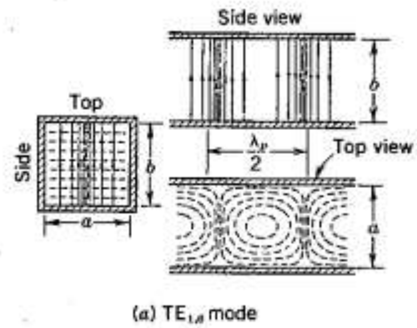
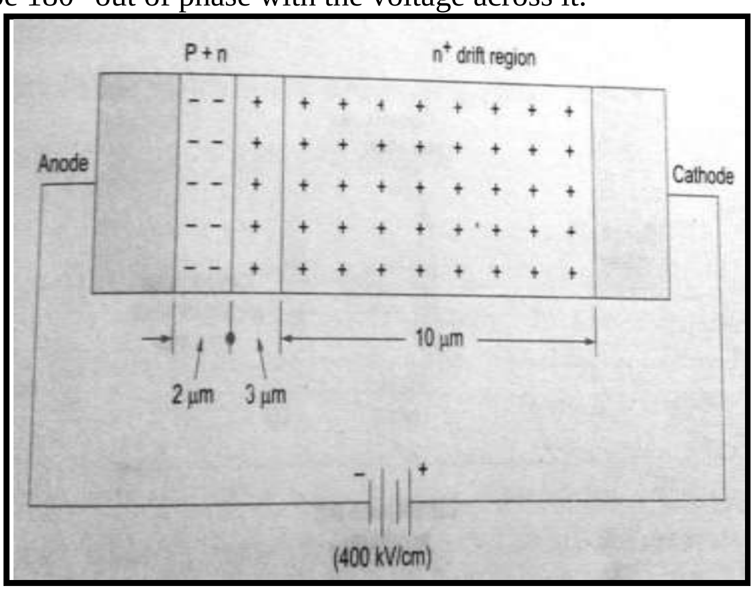
It is seen that the different $TE_{m,0}$ modes all have different cutoff wavelengths and therefore encounter different characteristic wave impedances.

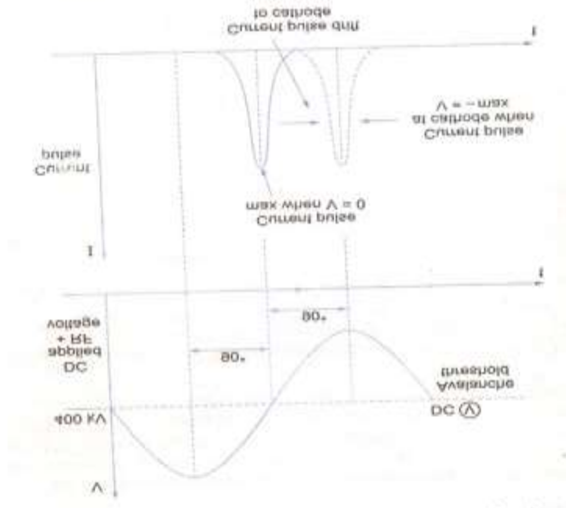
The cut-off wavelength for $TE_{m,n}$ mode is given by-

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

In the TEm,o mode, cut off wavelength is given by

$$\lambda_c = \frac{2a}{m}$$

		For $TE_{1,0}$ Mode m=1, $$\lambda_c = 2a$$ Which has the largest cutoff wavelength and hence $TE_{1,0}$ called as dominant mode  (a) $TE_{1,0}$ mode **$TM_{m,n}$ Modes:** In TM modes, the magnetic field is transverse only, and the electric field has a component in the direction of propagation. Since lines of magnetic force are closed loops, if a magnetic field exists and is changing in the *x* direction, it must also exist and be changing in the *y* direction. Hence $TM_{m,0}$ modes cannot exist in rectangular waveguides. The formula for characteristic wave impedance for TM modes is, $$Z_0 = 377\sqrt{1-\left(\frac{\lambda}{\lambda_c}\right)^2}$$	
	(b)	**With suitable sketch and explain the working of IMPATT diode.**	**6M**
	Ans:	• Any device which exhibits negative resistance for dc will also exhibit for ac i.e. if an ac voltage is applied current will rise when voltage falls at an ac rate. Hence negative resistance can also be defined as that property of a device which causes the current through it to be 180° out of phase with the voltage across it.  	**3 M Explanation** **3 M diagram**



		• This kind of negative resistance is exhibited by IMPATT diode. A combination of delay involved in generating avalanche current multiplication together with delay due to transit time through drift space provides the necessary 180° phase difference between applied voltage and resulting current in an IMPATT diode. • The cross section of the active region of this device is shown in figure above. It is a diode with the junction between the $p+$ and n layers. • An extremely high-voltage gradient is applied to the IMPATT diode, of the order of 400kV/cm, eventually resulting in a very high current. A normal diode would very quickly breakdown under such conditions, but the IMPATT diode is constructed so as to be able to withstand such conditions repeatedly. • Let us consider application of a RF ac voltage superimposed on top of the high dc voltage. Increased velocity of electrons and holes result in additional electrons and holes by knocking them out of the crystal structure by so called impact ionization. These additional carriers continue the process at the junction and it now snowballs into an avalanche. • If the original dc field was just at the threshold of allowing this situation to develop, his voltage will be exceeded during the whole of the RF positive cycle and the avalanche current multiplication will be taking place during this entire time. • Since it is a multiplication process avalanche is not instantaneous. This process in fact takes a time such that current pulse maximum at the junction occurs at the instant when RF voltage across the diode is zero and going negative. • A 90° phase shift or phase difference between voltage and current has then been achieved. • The current pulse as shown in figure below is situated at the junction. It does not stay there but moves towards the cathode due to applied reverse bias at a drift velocity dependent upon the presence of high dc field.	
Q.2		**Attempt any FOUR of the following:**	**16 Marks**
	(a)	**State the advantages of circular waveguide and list its applications.**	**4M**
	Ans:	**Advantages: (Any 2 Advantages)** • 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.	**2M for 2Advantages**

<table>
<tr><td></td><td></td><td>

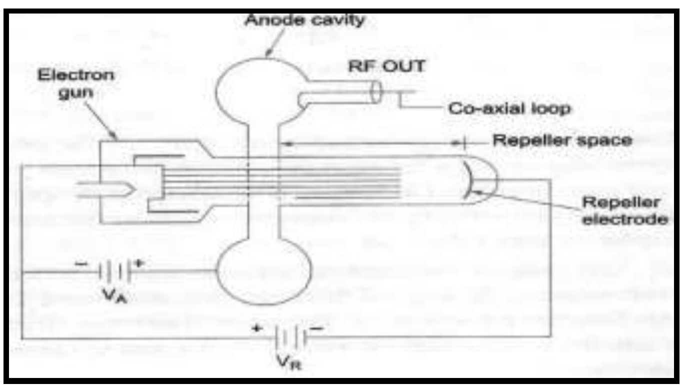
- $TE_{0,1}$ mode in circular for long distance waveguide transmission as it has the lowest attenuation per unit length.
- Lower attenuation for a given cutoff wavelength
- Greater power – handling capacity

Applications of Circular waveguide: (Any 2 application)

- 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.
- The circular waveguide is mostly used in the ground radar to transmit or receive the energy from antenna. This revolves in 360 degree bearing continuously.
- The waveguide is also used in communication system.
- It can also use in the devices of navigation aids.
- The circular waveguides are also used with the cavity resonators to carry the input and output signals.

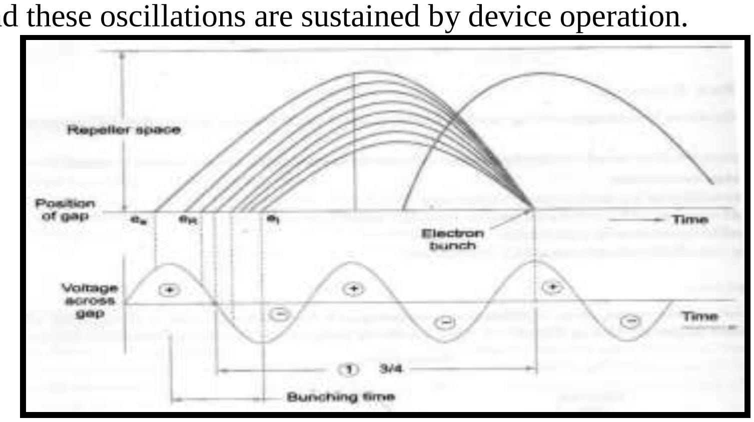
</td><td>**2M for 2 Application**</td></tr>
<tr><td></td><td>**(b)**</td><td>**Describe working of Reflex Klystron amplifier with a neat diagram.**</td><td>**4M**</td></tr>
<tr><td></td><td>**Ans:**</td><td>

(Note: If student is drawing any of the one diagram, can be given appropriate marks for diagram.)
Operation:



Reflex Klystron

- It is assumed that the oscillations are set up in the tube initially due to noise or switching transients and these oscillations are sustained by device operation.



Applegate Diagram

- The RF voltage that is produced across the gap by the cavity oscillations act on the electron beam to cause velocity modulation. The reference electron taken as the one that passes the gap on its way to the repeller at the time when the gap voltage is zero and

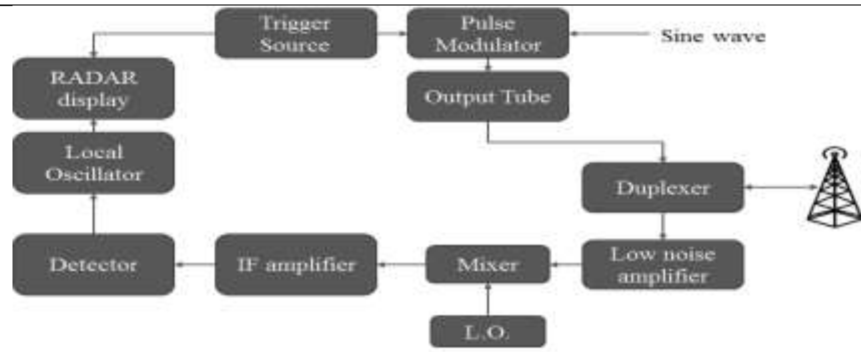
</td><td>**2M diagram, 2M explanation.**</td></tr>
</table>

going negative. This electron is unaffected, overshoots the gap and is ultimately returned to it having penetrated some distance into the repeller space.

- The early electron e_e that passes the gap before the reference electron, experiences a positive voltage at the gap. This electron is accelerated and moves with greater velocity and penetrates deep into repeller space. This electron will take slightly greater time than the reference electron to return to the gap.
- The late electron e_l that passes through the gap later than reference electron experiences negative voltage at the gap. This electron is retarded and shortens its stay in the repeller space and will return earlier to the gap as compared to the reference electron. So, the late electron will be able to catch up with $e_e$and e_r electrons forming the bunch.
- Bunches occur once per cycle centered on the reference electron. These bunch transfer maximum energy to the gap to get sustained oscillations.

(c) **Describe the operation for pulsed radar to detect the object.** **4M**

Ans:



2M Diagram

The Block diagram of high power Pulsed RADAR set is shown in fig. Above.

Trigger Source: It Provides pulses for the modulator.

Pulse Modulator: This Modulator provides rectangular voltage pulses which act as the supply voltage to the output tube, thus switching ON & OFF as required.

Output tube: It may be an oscillator tube such as a magnetron oscillator or an amplifier such as klystron, TWT or crossed field amplifier. If an amplifier is used, a source of microwave is also required.

The pulse modulated sine wave carrier then travels via duplexer to the antenna where it is radiated into space.

A single antenna is generally used for both transmission & reception. Usually parabolic reflectors with center feed arrangements is used.

Duplexer: The duplexer channelizes the returned echo signal to the receiver and not to the transmitter. The duplexer consists of gas-discharge tubes, one known as TR tube and other as ATR. The TR tube protects the receiver during transmission and the ATR helps in directing the received echo signals to the receiver.

Receiver: The receiver is usually of super heterodyne type whose function is to detect the desired echo signals in the presence of noise, interference & Clutter. The receiver in Pulsed RADAR consists of the RF amplifier, mixer, local oscillator, IF amplifier, Detector, Video Amplifier & RADAR display.

Low Noise RF amplifier: It is the first stage of the receiver. It is a low noise transmitter amplifier or parametric amplifier or TWT amplifier.

Mixer & Local Oscillator: These converts RF signal output from RF amplifier to comparatively lower frequency levels (IF). Thus, in a mixer stage, the Carrier frequency is reduced.

IF amplifier: This amplifier consists of a cascade of tuned amplifier & Provides the main receiver gain. It should be designed as a matched filter to get maximum peak signal to mean noise power ratio at the output.

2M Explanation

		Detector: The Detector is often is a schottky-barrier diode which extracts the pulse modulation from the IF amplifier output. The detector output is the amplified by the video amplifier to a level where it can be properly displayed usually on CRT directly or via computer processing and enhancing. Sync pulses are applied by the trigger source to the display devices or the display indicator.	
	(d)	**Explain absorption loss and scattering loss occurs in optical fiber.**	**4M**
	Ans:	**Scattering loss:-** 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. **Linear Scattering Losses:** Linear scattering occurs when optical energy is transferred from the dominant mode of operation to adjacent modes. It is proportional to the input optical power injected into the dominant mode. Linear scattering is divided into two categories: Mie scattering and Rayleigh scattering. **Non- Linear Scattering Losses:** Scattering loss in a fiber also occurs due to fiber non-linearity i.e. if the optical power at the output of the fiber does not changes proportionately with the power change at the input of the fiber, the optical fiber is said to be operating in the non-linear mode. Non-Linear scattering is divided into two categories: Stimulated Raman Scattering and Stimulated Brillouin Scattering. **Absorption loss:-** Absorption loss in optical fiber is analogous to power dissipation in copper cables. Impurities in the fiber absorb light and convert it to heat. Absorption losses in optical fibers are due to three different mechanisms – i. Absorption by atomic defects in the glass composition. ii. Extrinsic absorption by impurities in the glass material. iii. Intrinsic absorption by the basic constituent atoms of the fiber material.	**2M each loss**
	(e)	**Explain advantages of satellite communication system.**	**4M**
	Ans:	**(Note: Any other equivalent advantage can be considered)** **Broadcast property** – Wide coverage area. Satellites, by virtue of their very nature, are an ideal means of transmitting information over vast geographical areas. This broadcasting property of satellites is fully exploited in point-to-multipoint networks and multipoint interactive networks. The broadcasting property is one of the major plus points of satellites over terrestrial networks, which are not so well suited for broadcasting applications. **Wide bandwidth** – high transmission speeds and large transmission capacity. Over the years, satellites have offered greater transmission bandwidths and hence more transmission capacity and speeds as compared to terrestrial networks. However, with the introduction of fiber optic cables into terrestrial cable networks, they are now capable of providing transmission capabilities comparable to those of satellites. **Geographical flexibility** – independence of location. Unlike terrestrial networks, satellite networks are not restricted to any particular configuration. Within their coverage area, satellite networks offer an infinite choice of routes and hence they can reach remote location	**Any 4 advantages (1M each)**

shaving rudimentary or nonexistent terrestrial networks. This feature of satellite networks makes them particularly attractive to Third World countries and countries having difficult geographical terrains and unevenly distributed populations.

Easy installation of ground stations. Once the satellite has been launched, installation and maintenance of satellite Earth stations is much simpler than establishing a terrestrial infrastructure, which requires an extensive ground construction plan. This is particularly helpful in setting up temporary services. Moreover, one fault on the terrestrial communication link can put the entire link out of service, which is not the case with satellite networks.

Uniform service characteristics. Satellites provide a more or less uniform service within their coverage area, better known as a 'footprint'. This overcomes some of the problems related to the fragmentation of service that result from connecting network segments from various terrestrial telecommunication operators.

Immunity to natural disaster. Satellites are more immune to natural disaster such as floods, earthquakes, storms, etc., as compared to Earth-based terrestrial networks.

Independence from terrestrial infrastructure. Satellites can render services directly to the users, without requiring a terrestrial interface. Direct-to-home television services, mobile satellite services and certain configurations of VSAT networks are examples of such services. In general, C band satellites usually require terrestrial interfaces, whereas Ku and Ka band systems need little or no terrestrial links.

Cost aspects – low cost per added site and distance insensitive costs. Satellites do not require a complex infrastructure at the ground level; hence the cost of constructing a receiving station is quite modest – more so in case of DTH and mobile receivers. Also, the cost of satellite services is independent of the length of the transmission route, unlike the terrestrial networks where the cost of building and maintaining a communication facility is directly proportional to the distances involved.

(f) **Distinguish between LED & LASER. (Any four points)** **4M**

Ans: **1M each point**

Characteristics	**LEDs**	**Lasers**
Output Power	Linearly proportional to drive current	Proportional to current above the threshold
Current	Drive Current: 50 to 100 mA Peak	Threshold Current: 5 to 40 mA
Coupled Power	Moderate	High
Switching Speed	Slow	Fast
Beamwidth	Wide	Narrow
Bandwidth	Moderate	High
Wavelengths Available	0.66 to 1.65 μm	0.78 to 1.65 μm
Spectral Width	Wide	Narrow
Fiber Type	Multimode Only	SM, MM
Ease of Use	Easy	Difficult
Lifetime	Long	Short as compared to LED

Cost	Low	High

Q.3		**Attempt any FOUR of the following :**	**16 Marks**

a) **Compare between waveguide and two wire transmission line (any four points)** — **4M**

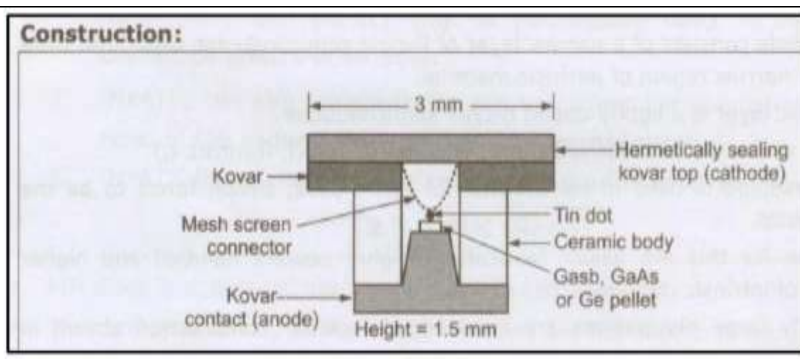
Ans:

SR. NO.	WAVEGUIDES	TRANSMISSION LINES
1.	It acts as a High Pass Filter	All frequencies can pass through.
2.	It is one conductor transmission system. The whole body of the waveguide acts as ground. The wave propagates through multiple reflections from the walls of waveguide (WG).	It consists of two conductors. One or both conductors are used to carry the wave.
3.	The system of propagation in waveguide is in accordance with field theory.	The system of propagation in transmission line (TL) is in accordance with circuit theory.
4.	TE and TM modes exist in WG.	TEM mode exists in TL.
5.	Wave impedance (characteristic impedance) is a function of frequency.	Characteristic impedance in TL depends on the physical parameters of TL.
6.	The velocity of propagation of wave in WG is less than the free space velocity.	The velocity of propagation of waves is equal to free space velocity.
7.	WG handles greater power and possesses less resistance.	TL handles less power as compared to WG.
8.	Lower signal attenuation at high frequencies than TL.	Significant signal attenuation at high frequencies due to conductor and dielectric losses.

Any correct 4 points 4M

b) **Sketch the construction of tunnel diode and write its operation.** — **4M**

Ans:



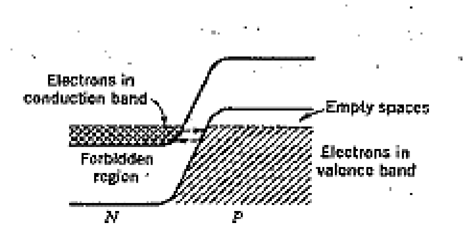
Tunnel diode

2M diagram & 2M working

Operation:

We can explain the diode theory with the help of three biasing levels:

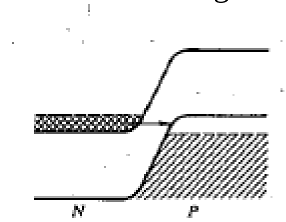
i. When the bias voltage is zero energy state in the CB and VB are at the same height as shown in fig below



(a)

Electrons can now tunnel from one side of junction to the other because of its thickness. But the tunneling currents in the two directions are the same. Hence overall current flow is zero.

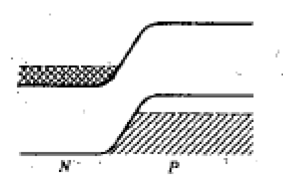
ii. When the small forward bias is applied across the junction, the energy level of the p side is lowered as compared with the n side as shown in fig below



(b)

Thus the electrons are able to tunnel through from the n side as the electrons in the conduction band find themselves opposite vacant states on the p side. Tunneling in the other direction is not possible.

iii. When the forward bias is increased beyond this point, tunneling will decrease as shown in the fig below



(c)

The energy level on the p side is now depressed further, with the result that fewer n side free electrons are opposite unoccupied p side energy levels. As the bias is raised, the forward current drops and this corresponds to negative resistance region of the diode characteristic.

iv. As a forward bias is reached at which there are no conduction band electrons opposite valence band states and tunneling stops altogether. When the forward is increased even further normal forward current flows and tunnel diode acts as the normal diode.

	c)	**State two advantages and two applications of continuous wave radar.**	**4M**
	Ans:	**Advantages of CW RADAR.** (1) Capable of giving accurate measurement of relative velocity. (2) Low transmitting powers. (3) Compact hence can be used for mobile applications like police radar. (4) Single frequency transmission and hence narrow receiver bandwidth. (5) Zero minimum range. (6) Ability to see moving targets in the presence of large echos from stationary target to	**2 Marks for 2 Advantage**

which it is blind.
(7) Simple in design and construction.

Applications:

(1) Police radar used to measure vehicle speed.
(2) In aircraft navigation for speed measurement.
(3) Rate climber meter for vertical takeoff planes.
(4) Traffic control radar.
(5) Doppler radar motion sensor.
(6) Measurement of the relative velocity of a moving target.
(7) Human Gait Recognition
(8) In Doppler Radar

2 Marks for 2 application

d) **Define geo-stationary orbit and the geo-stationary satellite.** **4M**

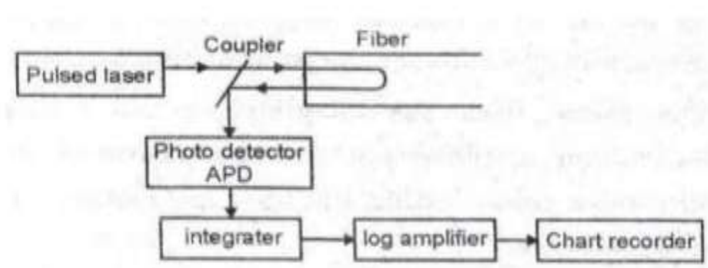
Ans: Geostationary Orbit:
A geostationary orbit, geostationary Earth orbit is a circular geosynchronous orbit 35,786 kilometers (22,236 mi) above the Earth's equator.
Geostationary satellite:
A geostationary satellite is an earth-orbiting satellite, placed at an altitude of approximately 35,800 kilometers (22,300 miles) directly over the equator, that revolves in the same direction the earth rotates .At this altitude, one orbit takes 24 hours, the same length of time as the earth requires to rotate once on its axis. The term geostationary comes from the fact that such a satellite appears nearly stationary in the sky as seen by a ground-based observer

Each definition 2M each

e) **Draw block diagram of OTDR and explain its working.** **4M**

Ans: **Block diagram of OTDR**

2M diagram



Working principle of OTDR:

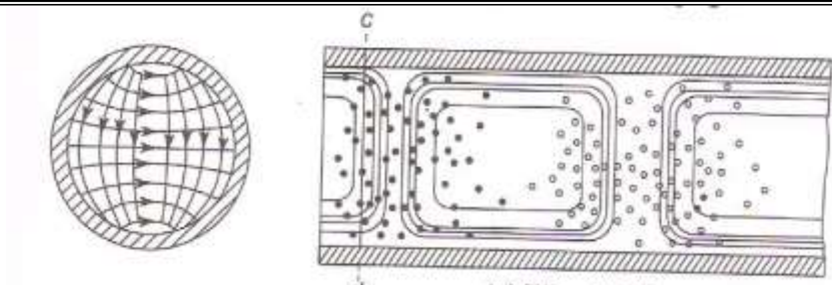
• A light pulse is launched into the fiber in the forward direction from an injection laser using either a directional coupler or a beam splitter
• Beam splitter or coupler makes possible to couple the optical power impulse into the tested fiber and simultaneously to deviate the backscattered power to the optical receiver.
• The backscattered light is detected using avalanche photodiode receiver. Output of photodiode receiver drivers an integrator.

2M working

Q.4 **(A)** **Attempt any THREE of the following:** **12 Marks**

(a) **Draw the field pattern of circular waveguide for its dominant mode.** **4M**

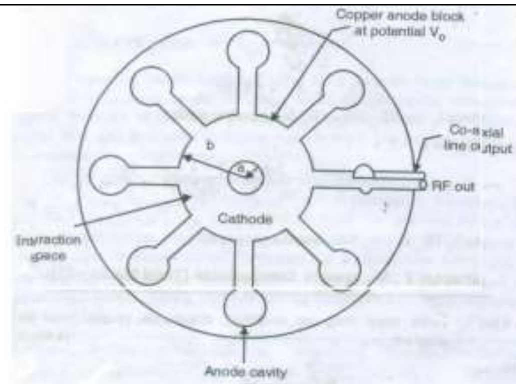
Ans: $TE_{1,1}$ Mode is the dominant mode in circular waveguides. In $TE_{m,n}$/ $TM_{m,n}$ the letter *m* denotes the number of full-wave intensity variations around the circumference and *n* represents the number of half-wave intensity changes radially out from the center to the wall. (Cylindrical co-ordinates are used). **4M**



(a) $TE_{1,1}$ mode

	(b)	**Draw the construction of magnetron and describe it's working.**	**4M**

Ans: (**1M for Diagram &3 M for working**)



Constructional diagram of magnetron

Working/Operation:

1. Now assume RF oscillations are initiated due to some noise transient within the magnetron, the oscillations will be sustained by device operation.

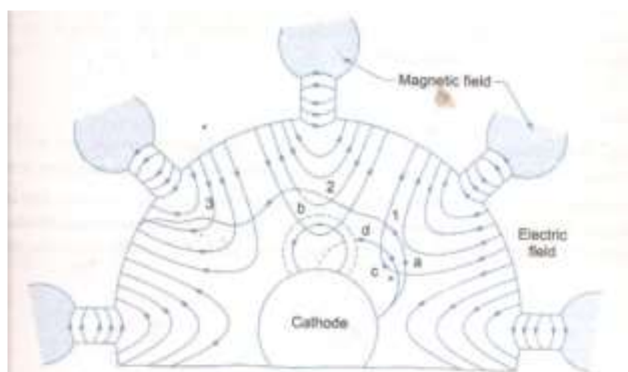
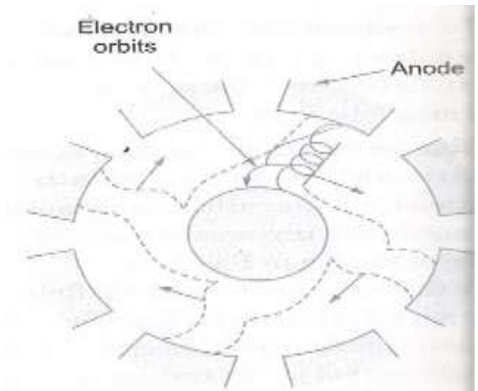


Fig. 8.33 π-mode of magnetron

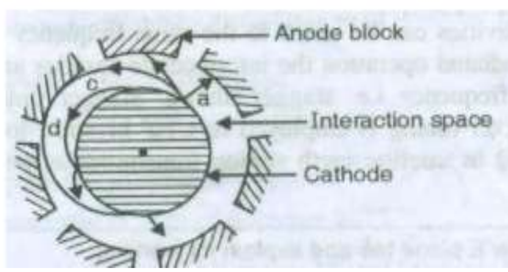
2. Self-oscillations will be obtained if the phase difference between adjacent anode poles is $n\pi/4$ (N=8), where n is an integer. n=4 results in π mode. Here the anode poles are π radians apart.
3. The dotted lines refer to the path of electrons in case of static field. The solid lines refer to the electron trajectories in the presence of RF oscillations in the interaction space.
4. The electron 'a' is seen to be slowed down in the presence of oscillations thus transferring energy to the oscillations during its longer journey from cathode to anode. Such electrons which participate in transferring energy to the RF field are called as favored electrons and these electrons are responsible for bunching effect.
5. An electron 'b' is accelerated by the RF field. Instead of imparting energy to the

oscillations, it takes energy from the oscillations resulting in increased velocity. Hence bends more sharply, spends very little time in the interaction space and is returned back to the cathode. Such electrons are called un-favored electrons which do not participate in the bunching process; rather they are harmful as they cause back heating.

6. Similarly electron ‘c’ which is emitted little later to be in correct position moves faster and tries to catch up with electron ‘a’ and an electron emitted at d will be slowed down to fall back in step with the electron ‘a’.
7. This result in all favored electrons like a, c, d to form a bunch and are confined to electron clouds or spokes as shown in fig below. This process is called **phase focusing effect** corresponding to the bunch of favored electrons around the reference electron ‘a’. The spokes so formed in the π-mode rotate with an angular velocity corresponding to 2 poles/cycle.



8. The phase focusing effect of these favored electrons imparts enough energy to the RF oscillations so that they are sustained.



(c)	**Write radar range equation and state the factor affecting maximum range of radar.**	**4M**

Ans: The Radar range equation is given by

equation 2M,

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

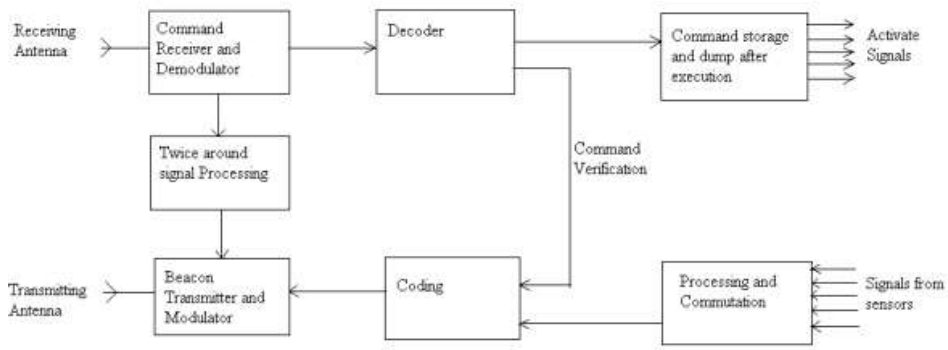
where
R_{max} = maximum range
A_0 = Capture area of Antenna
P_t = Transmitter power
S = effective surface area of target
λ = signal wavelength
P_{min} = minimum receivable power.

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.	**Factors 2M**
	(d)	**Illustrate how telemetry tracking and command system used in satellite communication.**	**4M**
	Ans:	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. Telemetry System: 1. The telemetry system is used to transmit information like temperature, pressure, voltage, etc. or data regarding the status of the on board subsystems to the ground station at all times. The telemetry system consists of various electronic sensors for the measurement of quantities as voltage, current, temperature, pressure, radiation level, power supply, status of switches and solenoids 2. The telemetry measurements can run into hundreds thus necessitating time division multiplexing to combine different data into a single stream for downlink transmission. In all modern satellites, pulse code modulation is used. After modulation, the transmitter sends the telemetry data back to the earth station where the processing equipment in the TT&C earth station recovers this telemetry information and monitors it. 3. With this information the ground station is then able to determine the operational status of the satellite at all time Tracking: 1. Another important function of the TT&C system is measurement of satellite position. 2. Beacon transmitters are usually provided on the spacecraft for tracking during the launch and operation. This transmitter can also carry telemetry signals and range signal, turn around and command verifications. 3. Angular measurements are done by conventional terrestrial methods using large antennas and mono pulse or conical scanning system is used. 4. Ranging is done by sending uplink frequency which is modulated by a tone frequency by the earth station to the satellite. The received uplink frequency is demodulated in the command receiver, the tone re-modulated and transmitted back to the earth station on the telemetry carrier (downlink frequency). The precise range is obtained by measuring at TT&C station the time delay between the transmitted and received pulses 5. In this way the orbital parameters are obtained by tracking the communication satellite from the ground and measuring angular position and range of the satellite Command: 1. The computers on the ground station generate the command signals which are sent to the satellite on the command uplink. The TT&C receiver accepts the commands and decodes these signals and sends verification signal back to the earth station. 2. On reception of the verification signal, the ground station sends back an execute pulse to	**Diagram 1M ,function of command, telemetry &tracking 1M each**

the satellite. Then the satellite executes these commands.

BLOCK DIAGRAM OF TT&C system



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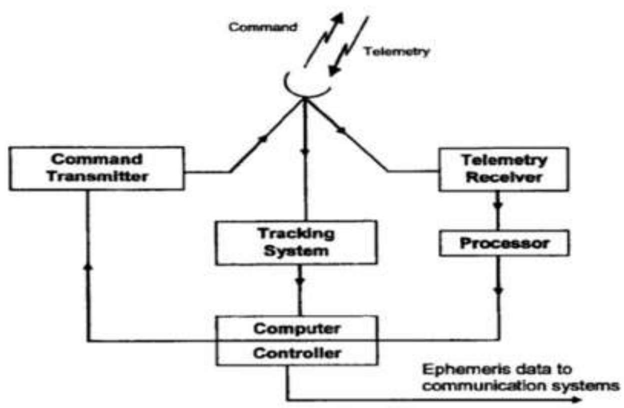
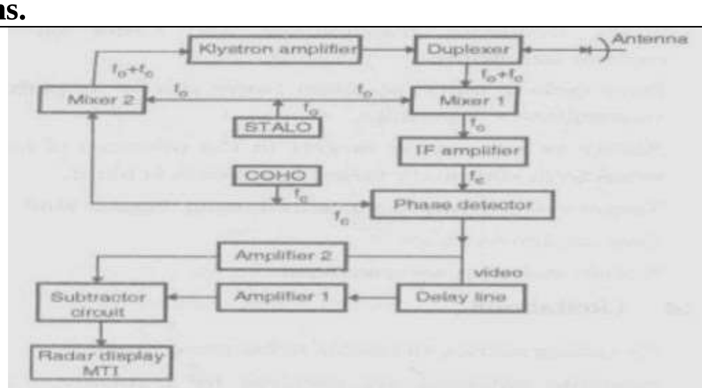


	(B)	**Attempt any ONE of the following:**	**6 Marks**
	a)	**Explain the working of MTI radar with the help of block diagram and with suitable waveforms.**	**6M**

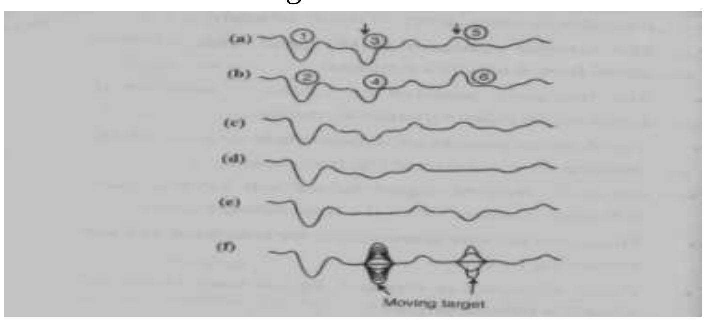
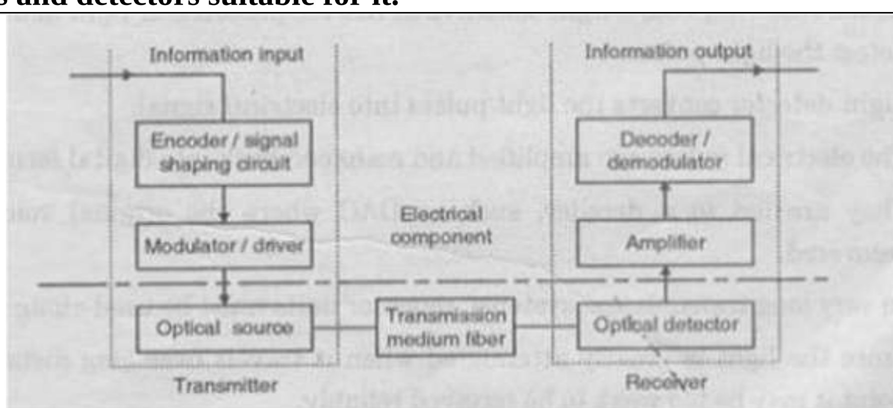
Ans:

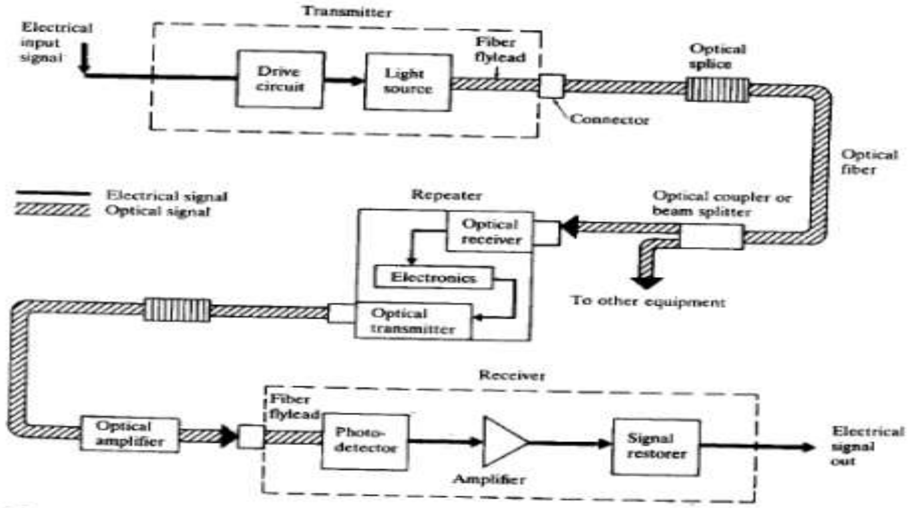


3 Marks Diagram 2 Marks Explanation 1 Marks Waveform

Explanation :

- The echo pulse from the target is received by MTI radar antenna. If echo is due to moving target, the echo pulse undergoes a Doppler frequency.
- The received echo pulses then 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 from Successive pulse in case of moving targets. And for fixed target magnitude and polarity of output will remain the same as shown in figure. 	
	b)	**Explain with neat sketch block diagram of optical fiber communication system and list out sources and detectors suitable for it.**	**6M**
	Ans:	 **OR**	**2MDiagram &2M Explanation source & detector 1M each**



1. The light source is normally an infrared LED or LASER device which is driven by the current value from the V to I convertor. It emits light which is proportional to the drive current. Thus light which is proportional to the input voltage value is generated and given as input to fiber
2. A source to fiber interface is used for coupling the light source to the fiber optic cable. The light emitted from the source is inserted into the fiber such that maximum light emitted from it is coupled to the fiber.

Optical Splice:

1. For creating long haul communication link, it is necessary to join one fiber to other fibers permanently. For this purpose, optical splicing techniques are used to join different fibers.

Optical Coupler/ Beam splitter:

1. Optical couplers are used to couple the light output from the fiber end to the device which can be receiver or regenerator.

2. Beam splitters are used to split the light beam which can be given to other equipment.

Regenerator/ Repeater:

1. After an optical signal is launched in to a fiber, it will become progressively attenuated and distorted with increasing distance because of scattering, absorption and dispersion mechanisms in the glass material.

2. Therefore repeaters are placed in between to reconstruct the original signal and again retransmit it.

3. The signal is processed in electronics domain and hence optical to electrical conversion and electrical to optical conversions are performed in the repeater.

Optical Amplifier:

1. After an optical signal has travelled a certain distance along a fiber, it becomes greatly weakened due to power loss along the fiber.

2. Therefore, when setting up an optical link, engineers formulate a power loss budget and add amplifiers or repeaters when the path loss exceeds the available power margin.

3. The periodically placed amplifiers merely give the optical signal a power boost, whereas a repeater attempts to restore the signal to its original shape.

Receiver:

1. At the destination of an optical fiber transmission line there is a coupling device (connector) which couples the light signal to the detector.
2. Inside the receiver is a photodiode that detects the weakened and distorted optical signal emerging from the end of an optical fiber and converts it to an electrical signal. (Referred to as photo current).
3. I to V convertor produce an output voltage proportional to the current generated by the light detector. Thus, we obtain output value which was given to the system as data input.

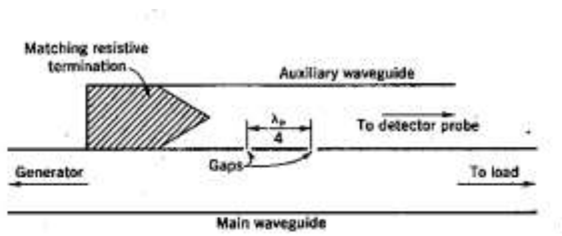
Optical source: Light source at the transmitter end which converts electrical current into optical signal. Light sources which are used are **LED and LASER.**

Detector: light detector at the receiver end which converts optical energy electrical signal. The light detectors which are used as **PIN photodiode and avalanche photo diode.**

Q.5		**Attempt any FOUR of the following:**	**16 Marks**
	(a)	**Describe the working of directional coupler with neat diagram.**	**4M**
	Ans:	(see below)	**2M Explanation** **2M Diagram**

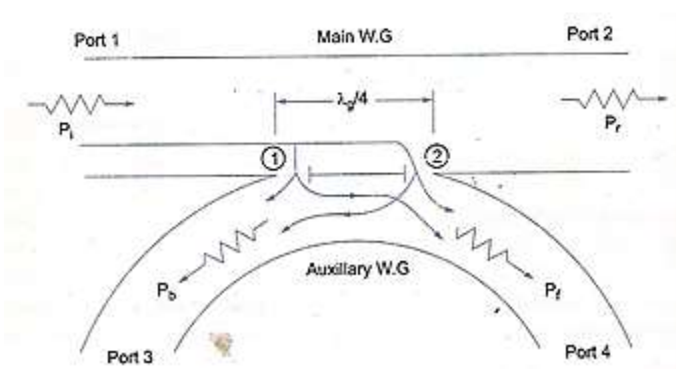
- Directional couplers are devices that will pass signal across one path while passing a much smaller signal along another path.
- One of the most common uses of the directional coupler is to sample a RF power signal either for controlling transmitter output power level or for measurement.

Two Hole Directional Couplers:



Two-hole directional coupler.

OR



i. The principle of operation of a two-hole directional coupler is shown in figure above. It consists of two guides; the main and the auxiliary with two tiny holes common between them as shown.

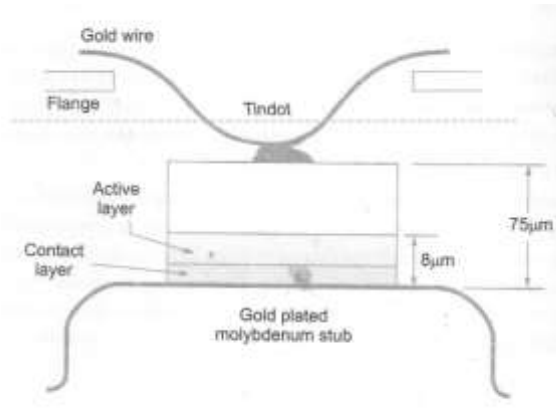
ii. The two holes are at a distance of $\frac{\lambda_g}{4}$ where λ_g is the guide wavelength.

iii. The two leakages out of holes 1 and 2 both in phase at position of 2nd hole and hence they add up contributing to P_f. But the two leakages are out of phase by 180° at the position of the 1st hole and therefore they cancel each other making $P_b = 0$(ideally).

iv. The magnitude of power coming out of the two holes depends on the dimension of the holes.

v. Although a high degree of directivity can be achieved at a fixed frequency, it is quite difficult over a band of frequencies. The frequency determines the separation of the two holes as a fraction of the wavelength.

	(b)	**Draw the constructions of Gunn diode and explain its working.**	**4M**
	Ans:	**Construction:**	**2M Diagram**



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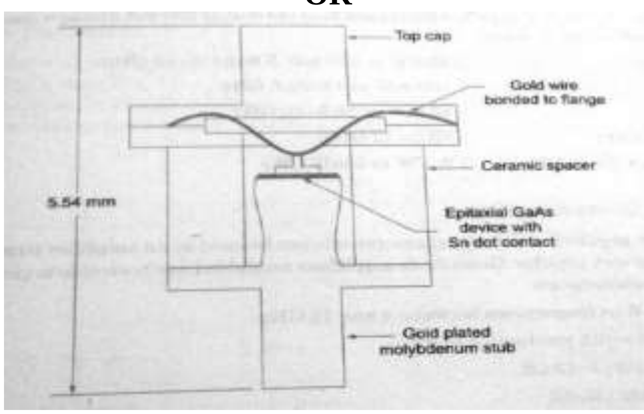


Working: Formation of Gunn Domain: **2M Explanation**

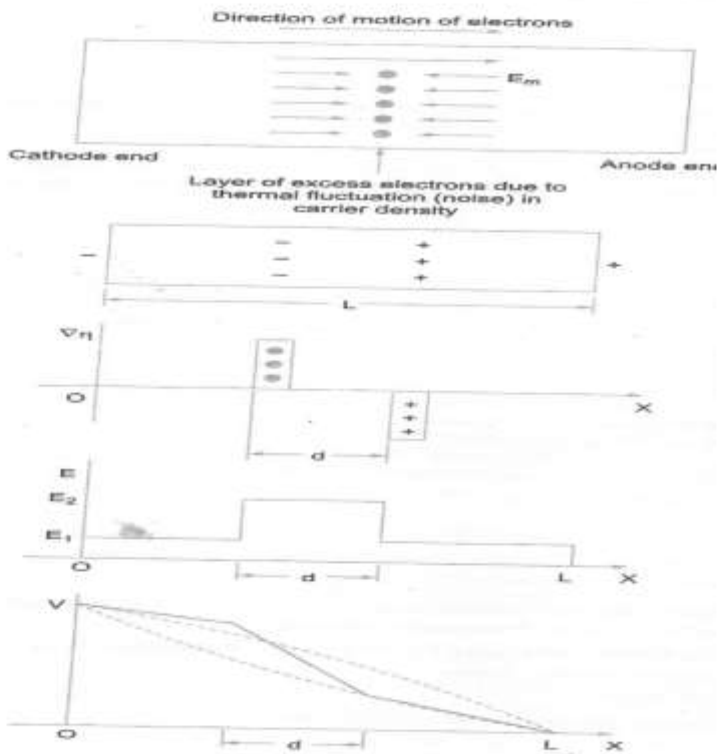


Fig. 9.44 Dipole domain formation

- When a dc bias of value equal or more than the threshold field (of about 3.3kV/cm) is applied to an n-type GaAs sample, the charge densities and electric field within the sample become non-uniform creating domains i.e. electrons in some region of the sample will be first to experience the valley transfer than the rest of the sample.
- The electric field inside the dipole domain will be greater than the fields on either side of the dipole. So the electrons in that region or domain will move to U – valley and hence will have reduced mobility.
- This creates a slight deficiency of electrons in the region immediately ahead. This region of excess and deficient electrons forms a dipole layer.
- As the dipole drifts along, more electrons in the vicinity will get transferred to the U – valley until the electric field outside the dipole region is depressed below the threshold electric field.
- This dipole continues towards the anode until it is collected. Upon collection, the field in the sample jumps immediately to its original value and the next domain formation begins as soon as the field value exceeds the threshold value and this process is repeated cyclically.
- The time taken by the dipole domain to travel from cathode to anode is the transit time of the device. The fundamental frequency in MHz is given by: $f = \frac{V_d}{L}$; where V_d = drift velocity and L=device length in µm.

(c) Write up-link and down-link frequency for c-band, x-band, ka-band &ku-band. **4M**

Ans: **1M each**

Band	Uplink (GHz)	Downlink (GHz)	Bandwidth
C – Commercial	5.925 – 6.425	3.7 – 4.2	500 MHz
X – Military	7.9 – 8.4	7.25 – 7.75	500 MHz
Ku - Commercial	14 – 14.5	11.7 – 12.2	500 MHz
Ka – Commercial	27.5 – 30	17.7 – 21.2	3500 MHz
Ka – Military	43.5 – 45.5	20.2 – 21.2	-

(d) Calculate critical angle of incidence between two substances with different refractive indices $n_1 = 1.5$ and $n_2 = 1.46$. **4M**

Ans: **4M**

Given:

$n_1 = 1.5$

$n_2 = 1.46$

formula:

$\theta_c = \sin^{-1}\left(\frac{n_2}{n_1}\right)$

$\theta_c = \sin^{-1}\left(\frac{1.46}{1.5}\right)$

$\theta_c = 76.74^\circ$

$= 1.339$ radians.

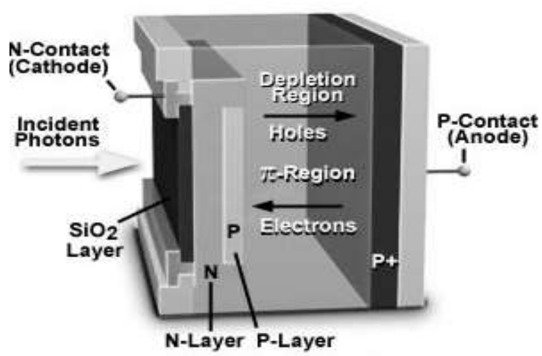
(e) Draw the construction of Avalanche photodiode. State its working principle. **4M**

Ans: **2M Diagram 2M Explanation**

Avalanche photodiode are used to obtain the large gain, i.e. large output because Conventional photodiodes and PIN photodiodes obtain the limited gain.

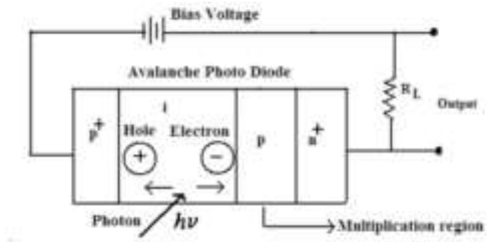
CONSTRUCTION:

- APD's are usually variation of PIN diodes. The materials used and thus the spectral ranges are the same.
- One form of APD, a reach through diode, is shown in figure.



- It consists of p^+-π-p-n^+ layers. The p^+ and n^+ layers are highly doped, low resistance regions having a very small voltage drop. The π region is lightly doped nearly intrinsic. Most of the photons are absorbed in this layer creating electron hole pairs.
- When the APD is reverse biased, most of the voltage appears across the p-n^+ junction because of negligibly small photocurrent.

OPERATION:



- The RAPD is operated in the fully depleted mode. Photons enter the device through the p^+region and are mostly absorbed by the high resistivity intrinsic p type layer where electron hole pairs are created.
- The relatively weak electric field in this region forces or separates the carriers causing the electrons and holes to drift into the high electric field region.
- The electrons are drifted towards the $p\text{-}n^+$ layer. Because of the high field intensity, electrons are imparted with high kinetic energy.
- The kinetic energy of electrons is greater than band gap energy of the valence electrons, so the collision can free a bound electron.
- The free electron and hole so created acquire enough kinetic energy to cause further ionization. It results in avalanche with the number of carriers growing exponentially as the process continues.

(f)	**Define w.r.t. Optical fiber cable:** **(i) Numerical Aperture** **(ii) Acceptance Angle**	**4M**
Ans:	**(i)**NUMERICAL APERTURE:	**2M each**

It is defined as the light gathering ability of an optical fiber and is given by the sine of the maximum angle a ray entering the fiber can have with the axis of the fiber and still propagate by internal reflection.

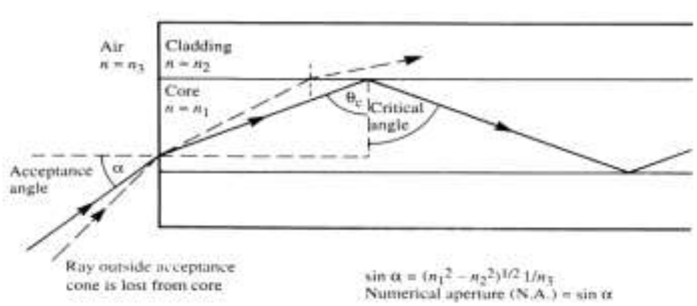
For step index; $= sin\theta_{in} = \sqrt{\eta_1^2 - \eta_2^2}$; θ_{in} = *acceptance cone half angle*

For graded index; $= sin\theta_c$; θ_c = *critical angle*

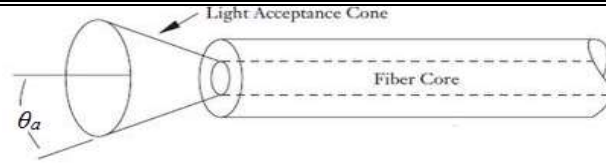
(ii) ANGLE OF ACCEPTANCE / ACCEPTANCE CONE HALF ANGLE:

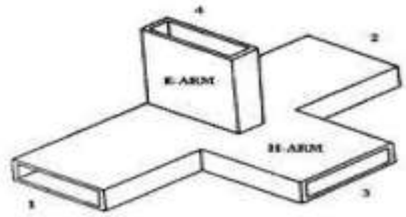
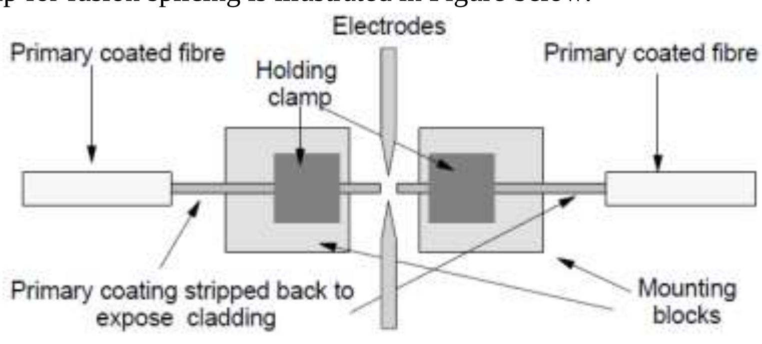
1. It defines the maximum angle in which external light rays may strike the air fiber interface and still propagate down the fiber.

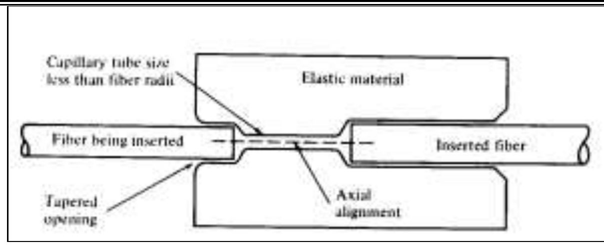
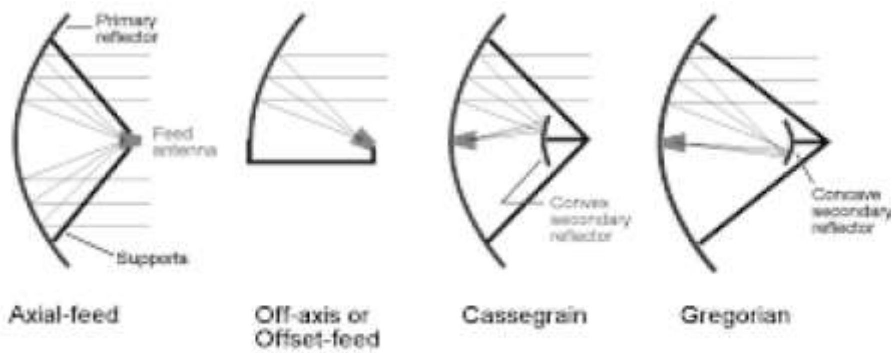
$$\theta_a = sin^{-1}(Numerical\ Aperture)$$

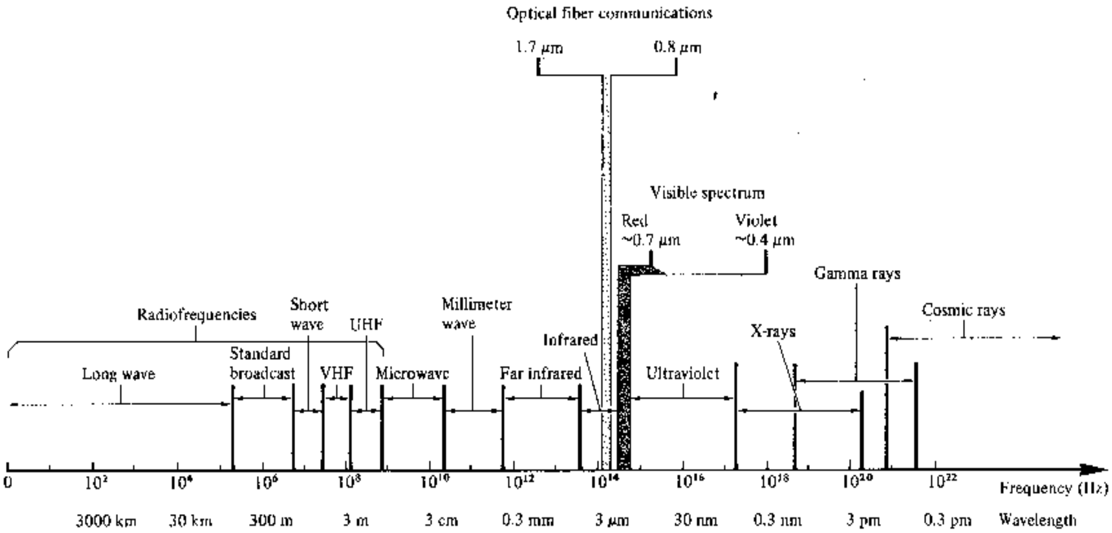


2. Rotating the acceptance angle around the fiber axis describes the acceptance cone of the fiber input. This is shown in above figure.



Q.6		**Attempt any FOUR of the following:**	**16 Marks**
	(a)	**Describe with the neat sketch of hybrid junction and illustrate its properties.**	**4M**
	Ans:	 The magic tee is a combination of E and H plane tees. Arm 3 forms an H-plane tee with arms 1 and 2. Arm 4 forms an E-plane tee with arms 1 and 2. Arms 1 and 2 are sometimes called the side or collinear arms. Port 3 is called the H-plane port, and is also called the Σ port, sum port or the P-port (for "parallel"). Port 4 is the E-plane port, and is also called the Δ port, difference port, or S-port (for "series"). A signal injected into the H-plane port will be divided equally between ports 1 and 2, and will be in phase. A signal injected into the E-plane port will also be divided equally between ports 1 and 2, but will be 180 degrees out of phase. If signals are fed in through ports 1 and 2, they are added at the H-plane port and subtracted at the E-plane port.	**2M Diagram** **2M Explanation**
	(b)	**Draw the diagram of Fusion Splice and rigid alignment tube splice.**	**4M**
	Ans:	Different types of splicing are: 1. Fusion splicing or welding 2. Mechanical splicing 3. Elastic tube splicing FUSION SPLICING: A fiber join is a type of wield. The fiber ends are cut, polished, butted up to one another and fused by heat. A device setup for fusion splicing is illustrated in Figure below.  ELASTIC TUBE SPLICE: The elastic tube splice shown cross sectionally in the figure below is a unique device that automatically performs lateral, longitudinal and angular alignment.	**2 M for each diagram**

		 Schematic of an Elastic Tube Splice.	
	(c)	**Describe the antenna subsystem of satellite.**	**4M**
	Ans:	➢ Antennas on the satellite serve as an interface between the earth stations on the ground and various satellite subsystems during operations ➢ Antennas receive the uplink signals and transmit the 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. ➢ Most of the antennas are highly directional gain antennas that must be accurately pointed. ➢ The design of a satellite antenna is conditioned by the required coverage area. ➢ The antennas in antenna subsystem can be linear,dipole,helix,horn,antenna array and the parabolic reflector. ➢ The parabolic reflector is the most commonly used one as it gives a highly directional symmetrical pattern. ➢ In the satellite antenna it is essential that the antenna main lobe should be such that the energy is concentrated towards the earth station and hence maximizing the EIRP ➢ 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** 	**3M Explanation** **1 M Diagram**
	(d)	**Classify the optical fiber based on bands and specify their operating frequency ranges.**	**4M**
	Ans:		**4M**



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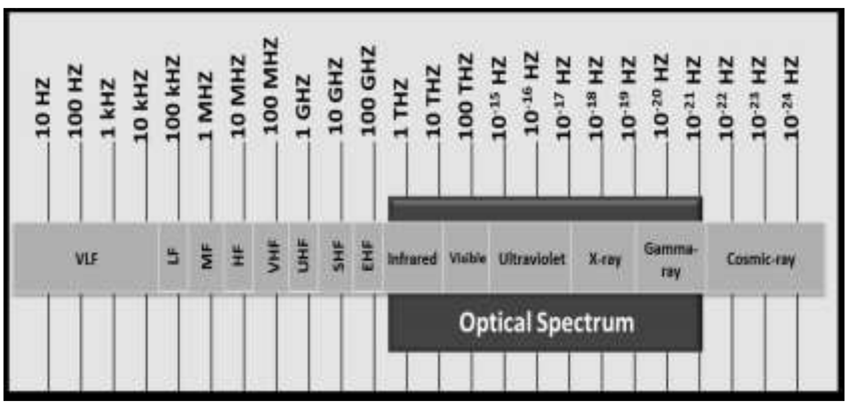

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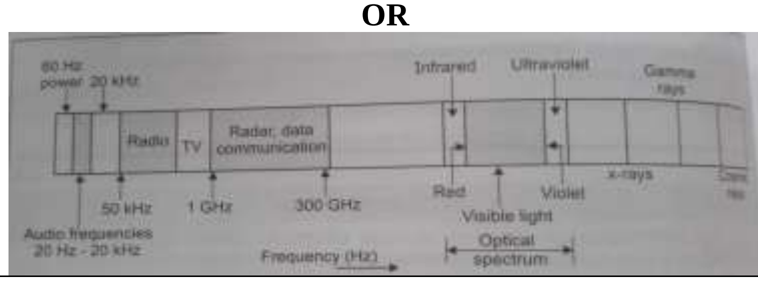

	(e)	**Differentiate between single mode and multimode fiber. (Four points)**	**4M**

Ans:

Single mode fiber	Multi mode fiber
Core radius is small.	Core radius is large.
Supports one mode of propagation.	Supports hundreds of modes.
Optical source- LASER.	Optical source- LED.
The launching of optical power into fiber is difficult as the core radius is small.	The launching of optical power into fiber is easier as the core radius is large.
Supports larger bandwidth.	Supports lesser bandwidth.
Intermodal dispersion is absent.	These fiber suffer from Intermodal dispersion.
Used for long distance communication	Used for short distance communication.

1M each