MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION
(Autonomous)
(ISO/IEC – 27001 – 2005 Certified)

SUMMER – 14 EXAMINATIONS

Model Answer

Subject Code : **12271** Page No: 1/

Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model 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.

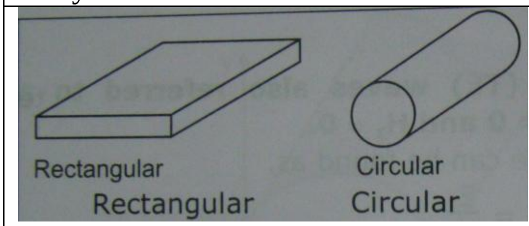
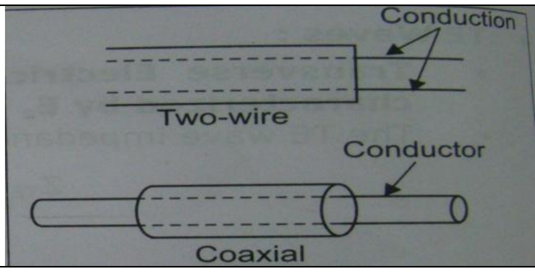
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.

6) In case of some questions credit may be given by 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.1 A) Attempt any three.

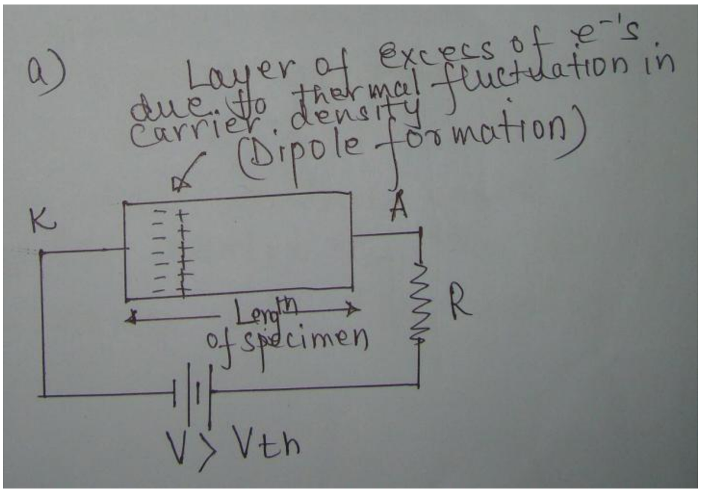
a) Compare waveguide with two wire transmission line(any four point)
(Each point 1Mark)

Wave guide	Two wire Transmission line
1. A wave guide is a hallow metallic pipe design to carry microwave energy from one place to another. Example radar.	1. Transmission on line is a conductor or wire designed to carry electrical energy below microwave range from one place to another
2. Used for Microwave frequency above 1 GHz	2. Used for RF up to 500 in GHz. Upto 18 GHz. For short distance.
3. For microwave freq range to connect transmitter to transmitting antenna and receiving antenna to receiver.	3. for low freq line for low freq range to connect transmitter to transmitting antenna and receiving antenna to receiver. Example TV.
4. Power handling capacity is high	4. Power handling capacity is low
5. Wave theory is consider in wave guide analysis	5. circuit theory
	

b) Explain working principle of Gunn diode.

Diagram-2M,working 2M

A Gunn diode is also called as transferred *e* - device where periodic fluctuation of current passes
through the N-type GaAs specimen when the applied voltage exceeds a certain critical value.



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

C) What is radar beacon? State its applications.
Explanation-2M, application-2M

RA-dar bea-CONS also called as radar responders or transponders. RACONS are receiver/transmitters. This device is used as navigation aid, identifying land marks. Racon responds to a received radar pulse by transmitting an identifiable mark back to radar set.
Racons are used for following purpose To identify aids to navigation both seaborne and land based.
To identify land full. To indicate navigable spans under the bridges. To identify offshore oil platforms. To identify and warn of environmentally sensitive areas.
To identify centers and turning points. To mark a uncharted hazards. All racons operate at frequency range of 9300 to 9500MHz and 2900-3100 Mhz Racons range is approximately line of site range Racon range depends upon a number of factors including mounting height, atmospheric conditions and racon receiver sensitivity setting.
Modern racon have wide band receiver that detects the incoming radar pulse, turns the transmitter and responds with 25µsecs long signal within 700nsec. Older racons operates in a slow sleep. It only responds only if the frequency of an incoming signal at moment it arrives tuned to it. RACON is a device that on receiving radar signal, transmits coded signals in response to help navigators determine their position.

Application:- **02M**
1) Used to identify itself
2) Used in airport traffic control
3) Military purposes
4) In ships

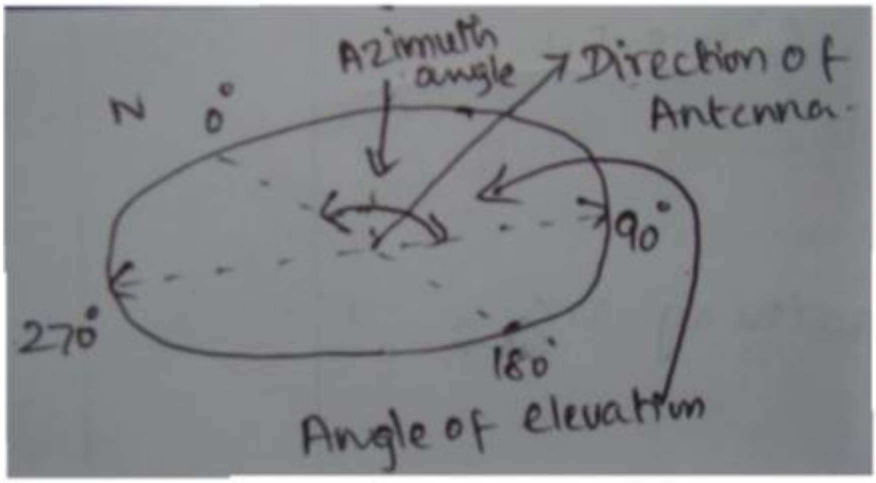
D) Define the following terms w. r.t. satellite

i. **Footprint**
ii. **Orbit**
iii. **Azimuth angle**
iv. **Elevation angle**

Foot print: (1 marks)
It is the area of the earth visible to the satellite. Since the ability to accurately view portions of the earth deteriorate as the edge of the footprint is reached, satellite footprints overlap providing coverage for these areas.

Orbit: (1 marks)
In space satellite moves, in aspecific path, this path is called as an orbit.

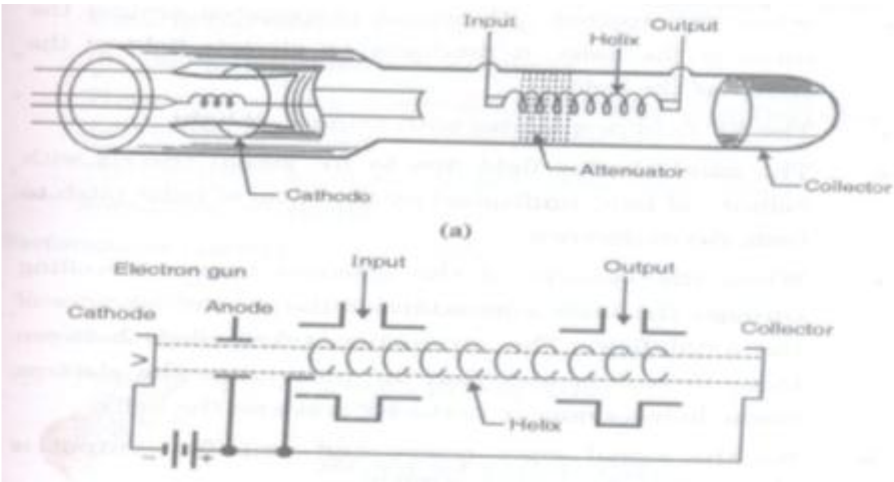
Azimuth angle:- (1 marks)
It refers to the angle made from the true north to the sub-satellite point on the horizontal plane.



Elevation angle:- (1 mark)
It is the angle between horizontal plane & the line of sight between the earth station antenna and the satellite.

B) Attempt any one.

a) Draw construction sketch of TWT and explain its working. State its application
Constructional diagram:3M for diagram 3M for explanation application 2 M



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.

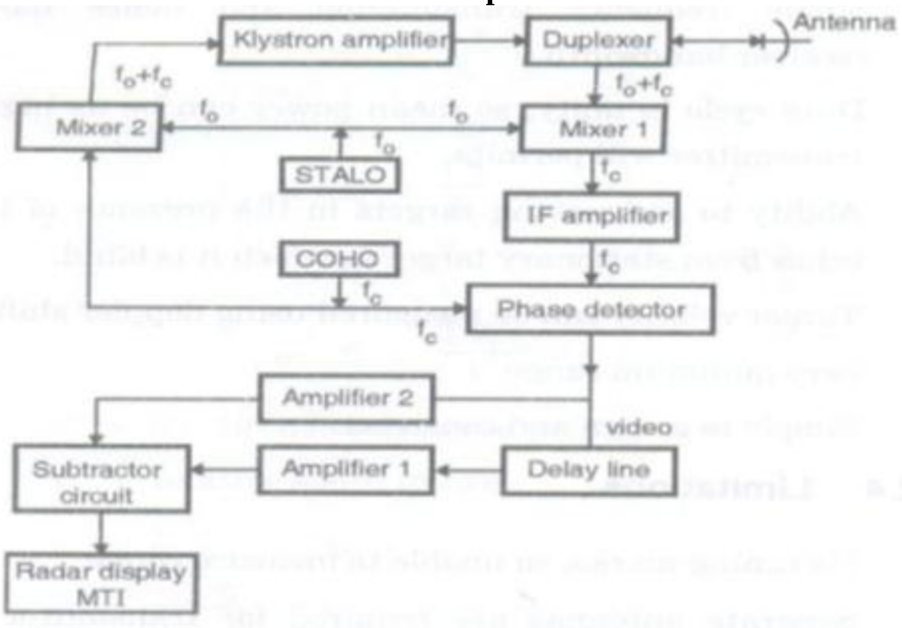
- The electron in bunch encounter retarding field and deliver energy to way on helix.

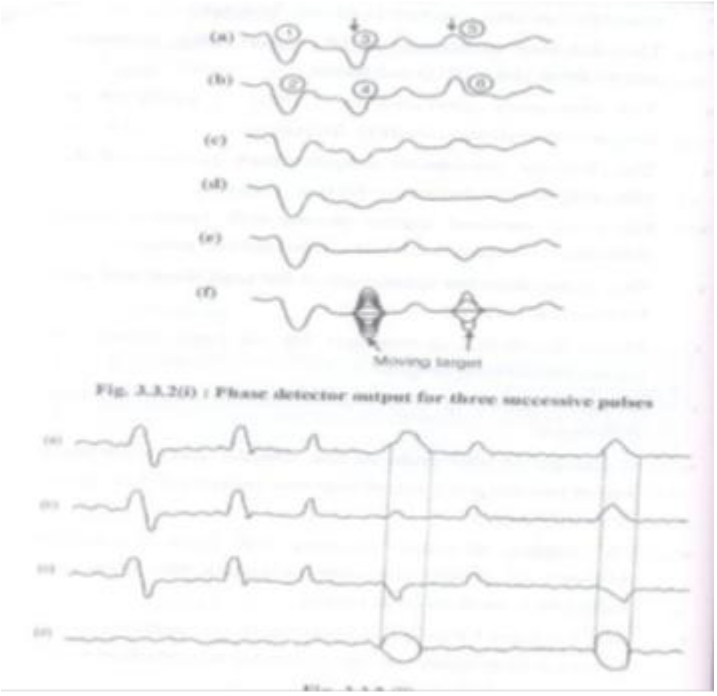
- The output becomes larger than the input and then amplification results.

Application of TWT: (any two 2 M)

1. In broadband microwave receiver as low noise RF amplifier.
2. As repeater amplifier in wideband communication cables and co-axial cable.
3. Used as a power output in communication satellite due to long tube life
4. Airborne and shipborne pulsed high power radars, ground based radars use a TWT.

b) Draw block diagram of MTI radar and explain its working
3M for diagram 2 M for waveform and 3 M for explanation





Working principle:

- The echo pulse from the target is received by MTI radar antenna.
- 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.

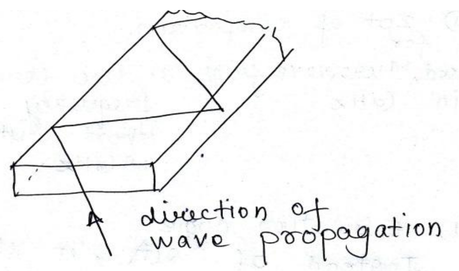
- Phase difference is constant for all fixed targets but varies for moving targets.
- Doppler frequency shift causes this variation in the phase difference.
- A change of half cycle in Doppler shift would cause an output of opposite polarity in the phase detector output.
- The output of phase detector will have an output different in magnitude and polarity fro

  Successive pulse in case of moving targets.
- And for fixed target magnitude and polarity of output will remain the same as shown in figure.

Q.2 Attempt any four.

a) Explain wave propagation in rectangular waveguide. What is dominant mode?
Wave propagation in rectangular waveguide : (2M)

- Rectangular waveguide is a hollow metallic tube with a rectangular cross section.
- TEM wave cannot exists in rectangular waveguide .
- The wave propagates down the wave guide in a zig – zag manner with the Electric field maximum at the center of the guide and zero at the walls.



Dominant mode: (2)

- It is the mode for which the cut off wavelength is maximum.
- Cut of wavelength is given by

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

For $TE_{1,0}$.
$m = 1 \quad n = 0$
$\therefore \lambda_c = 2a$

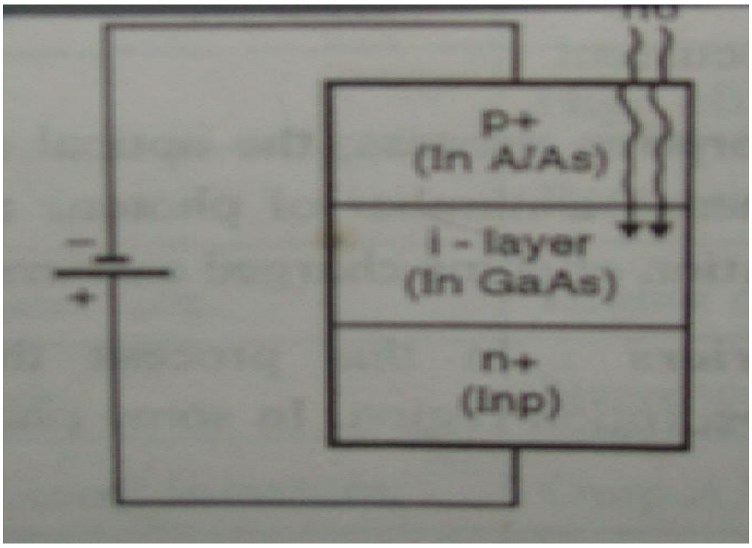
For $TE_{0,1}$
$m = 0 \quad n = 1$
$\therefore \lambda_c = 2b$

For $TE_{1,1}$, $m = 1$; $n = 1$
$\lambda_c = \frac{2ab}{\sqrt{a^2+b^2}}$

Form the above modes $TE_{1,0}$ has highest cut off wave length since a>b. hence $TE_{1,0}$ is the dominant mode.

b**) Explain working principle of PIN diode.**
(Diagram-2M, working-2M)

- PIN photo diode is a depletion layer photo diode an is probably most common device used as a light detector an FOC
- Principal of PIN diode reverse that of LED.



Working –

- The PIN diode does not provide any gain so maximum internal quantum efficiency is 100 %
- Now since the resistance of I layer is very high all the reverse bias is applied across this layer
- When the light is incident on this photodiode , the electron hole pair are generated in I layer
- These changed carrier point are generated in I layer these changed carriers are attached forwards the respective battery terminal.

- Now this reverse biased PIV junction will act as a capacitor, here a layer is the depletion region which acts as a dielectric material for the optimum design the transit time should be equal to RC time constant of such capacitor.

c) Give RADAR range equation .Discuss the factors influencing maximum range.
Equation -2M, factors-2M
Ans:

The Radar range equation is given by

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

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 (P_t): 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 (P_{min}): A decrease in minimum receivable power will have the same effect has raising the transmuting power.

d) State four Advantage of fiber optic communication: (four points gives 4mark)

Advantage of fiber optic communication:

1) Greater information capacity/ higher bandwidth OFC's are capable of transmitting several gigabits per second over hundreds of miles allowing millions of individual voice and data channel over optical fibers cables.

2) Immunity to crosstalk: glass and fiber are non-conductor of electricity

3) Optical fibers have less attenuation of signal strength then copper wire and coaxial cables

4) Security:- fiber have high level of information security to extreme environmental condition

5) Immune to electromagnetic interference

6) Safety.

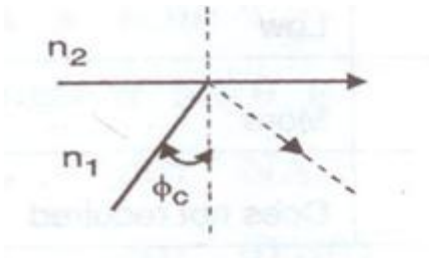
e) Define the following terms

i. **Critical angle**
ii. **Acceptance angle.**

Critical angle: (2M)

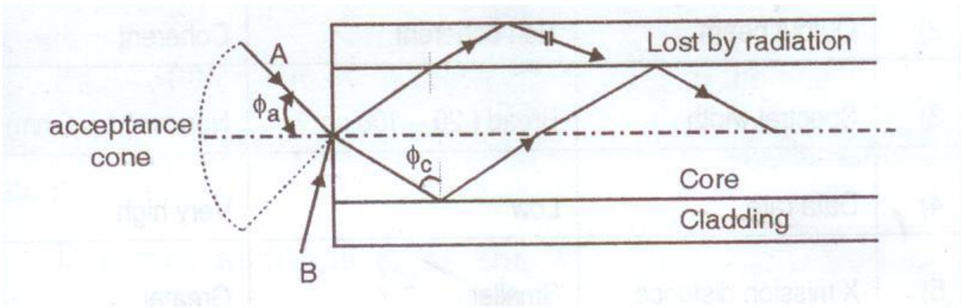
It is an angle of incident at which the reflected ray emerges parallel to the interface between two different dielectrics**.**

Critical angle (Øc) = Sin -1n2/n1



Acceptance angle: (2M)
It is the maximum angle to the axis at which light may enter the fiber in order to be propagated**.**

Acceptance angle (θa)= Sin -1 NA



Q3. Attempt any four. (16 Marks)

a) State two advantages and two applications of CW Radar.

Ans :

Advantages : **(2M)**

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 : **(2M)**

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 object.

b) With brief explanation state any four application of fiber optic communication system.

Ans : (Any four 4M)

1. Optical fiber communication is used within military mobiles such as aircraft, ships and tanks due to small size and weight of fiber. Because of advantages of fiber such as immunity to electromagnetic interference, immunity to lightning and electromagnetic pulses, optical fiber communication is safe and reliable.
2. In flight control system, optical fibers are employed for an airship.
3. To provide monitoring function, optical sensor systems are used in mobiles.

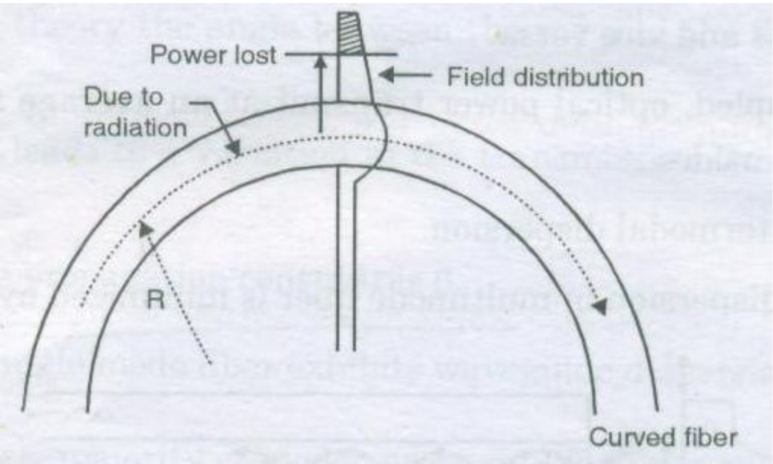
4. In military sphere that includes short and long distance communication links to connect electronic equipment's, for missile guidance.
5. Optical fiber systems with high performance are readily available at reasonable cost so these systems offer reliable telemetry and control communication for industrial environment where EMI is main problem for metallic cable links.
6. Optical fiber system are safer than conventional electrical monitoring where explosive or corrosive gases are abundant. So extensively used in problematical environment to provide reliable and safe communication.
7. Optical fiber systems are used in nuclear testing applications.
8. Recently Optical fiber systems are used in LAN for data communication.
9. Optical fibers are used for mains isolators and digital data buses within both digital telephone exchanges and computers.
10. Optical fibers are suitable for video transmission so is used in commercial television transmission.
11. Optical fiber is used for short distance link between studio and outside broadcast vans, links between studios and broadcast or receiving aerials and close circuit television links for security and traffic surveillance.
12. Optical fibers are used to transmit both narrow-band and broadband communication services such as telephone, ISDN, video conferencing and ultrafast data on a single subscriber line.

c) Explain bending losses in optical fiber.

Ans :

Macrobending losses : **(2M)**

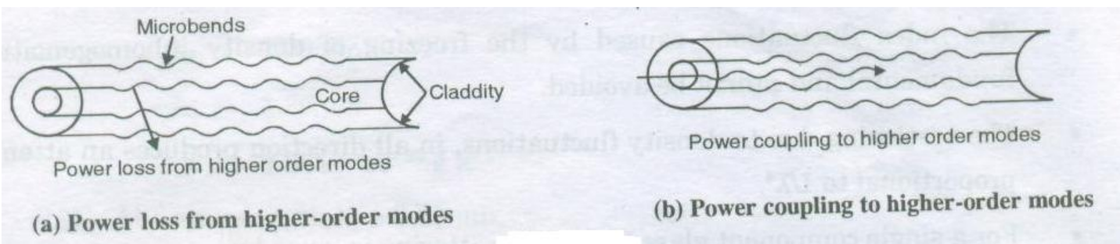
- Macroscopic bends have radii large compared to fiber diameter e.g. it occurs when fiber turns a corner.
- For slight bends the excess loss is extremely small.
- As the radius of curvature decreases, the loss increases exponentially.



- At a certain critical radius curvature loss becomes observable.
- Figure shows relationship between radiation form a bent and field strength.
- Any bound core mode has field tail in the cladding which decays exponentially as a function of distance from the core.
- This fields tail moves long with the field in the core, part of the energy of a propagating mode travels in the fiber cladding.
- When a fiber is bent, the field fail on the far side of the center of curvature must move faster to keep up with the field in the core, for lowest order fiber mode.
- The amount of optical radiation from a bent fiber depends on the field strength and on the radius of curvature.
- Higher-order modes are bound less tightly to the fiber core than lower-order modes, the higher order modes will radiate out of the fiber first.

Microbend loss : (2M)

- Microbends are repetitive small-scale fluctuations in the radius of curvature of the fiber axis as shown in figure.
- They are caused either by nonuniformities in the manufacturing of the fiber, or by nonuniform lateral pressures created during cabling of the fiber.



- In microbending the fiber curvature causes modes and leaky or non guided modes in the fiber.
- To minimize this loss, extrude a compressible jacket over the fiber.
- When external forces are applied, the jacket will be deformed but the fiber will tend to stay straight.

d) Compare LED and Laser (any four points).

Ans : (Any four points 4M).

Sr. No.	Parameter	LED	LASER
1	Principle operation	Spontaneous emission	Stimulated emission
2	Output beam	Non-coherent	Coherent
3	Spectral width	Broad (20 – 100 mm)	Narrow (1 – 5 mm)
4	Data rate	Low	Very high
5	X'mission distance	Smaller	Greater
6	Temperature sensitivity	Less sensitive	More sensitive
7	Coupling efficiency	Very low	High
8	Compatible fibers	Multimode step index	Single mode step index
9	Circuitary	Simple	Complex
10	Lifetime	10^4 hours	10^5 hours
11	Cost	Low	High
12	Noise	More	Less
13	Heating	Does not required	Required initially

e) A rectangular waveguide of breadth 10 cm operates in dominant mode and 2.5 GHz signal propagates through it,

Find i) Guide wavelength ii) Phase velocity

Ans :

1. **Guide wavelength (2M)**

f = 2.5 GHz

$\lambda_g = \lambda / \sqrt{1 - (\lambda / \lambda_c)^2}$

But $\lambda = c/f = 3 \times 10^{10} / 2.5 \times 10^9 = 12$ cm

Therefore, $\lambda_g = 12/\sqrt{1 - (12/20)^2} = 12/0.8 = 15$ cm

1. **Phase velocity (2M)**

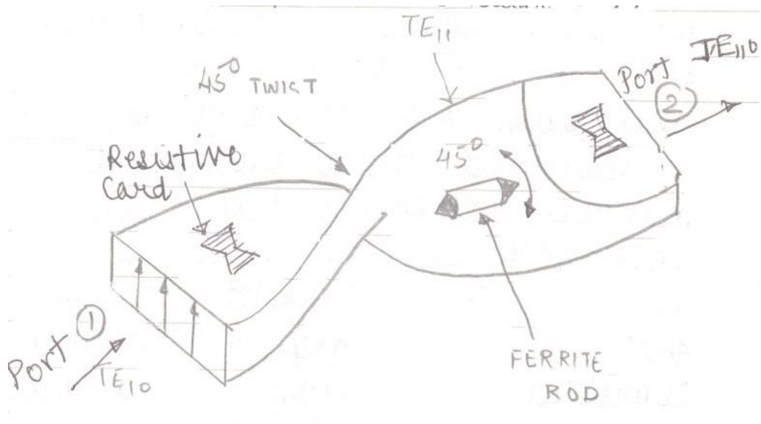
$V_p = c / \sqrt{1 - (\lambda / \lambda_c)^2}$

$= 3 \times 10^{10} / 0.8 = 3.75 \times 10^{10}$ cm/sec

Q4. A) Attempt any two : (8 Marks)

a) Draw constructional diagram of isolator and state its use.

Ans : (4M)



ISOLATOR

Uses : (4M)

1. It provides very small attenuation for transmission.
2. Isolator makes use of 45° twisted rectangular waveguide.
3. It is a two port device.
4. It provides very small attenuation for transmission from port (1) to port (2).
5. But it provides maximum attenuation for transmission from port (2) to port (1).
6. In most microwave generator, the output amplitude and frequency tend to fluctuate with changes in load impedance.
7. Fluctuation occurs due to mismatch of generator output to load that results reflected wave from load.
8. That reflected wave causes the instability of amplitude and frequency of microwave generator.
9. If isolator is inserted between generator and load, then the generator is coupled to load with zero attenuation and reflections.
10. If any reflections generated from load side then those are completely absorbed by isolator without affecting generator output.

b) List different display methods used in Radar. Explain any one.

Ans: <u>Display Methods are:</u> **(2M)**

1. A-scope or A-Scan method.
2. PPI (Plan Position Indicator) method

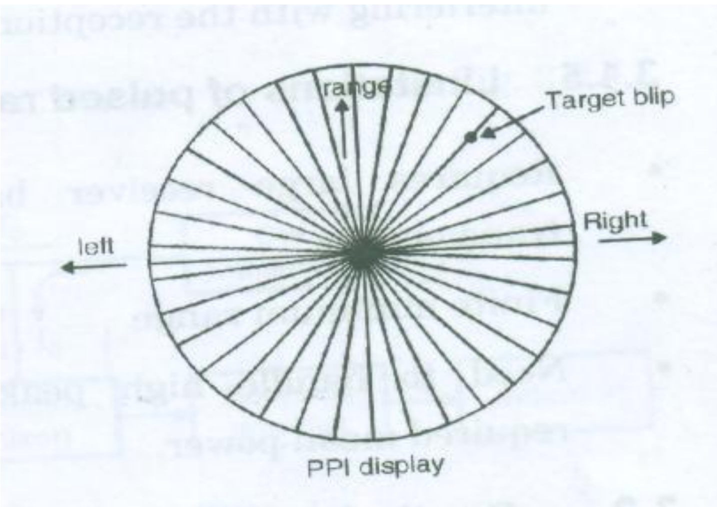
<u>PPI (Plan Position Indicator) method</u> **(6M)**

Plan position indicator (PPI), is the most common type of radar display. The radar antenna is usually represented in the center of the display, so the distance from it and height above ground can be drawn as concentric circles. As the radar antenna rotates, a radial trace on the PPI sweeps in unison with it about the center point.

The radar antenna sends pulses while rotating 360 degrees around the radar site at a fixed elevation angle. It can then change angle or repeat at the same angle according to the need. Return echoes from targets are received by the antenna and processed by the receiver and the most direct display of those data is the PPI.

The height of the echoes increases with the distance to the radar, This change is not a straight line but a curve as the surface of the Earth is curved and *sinks* below the radar horizon. For fixed-site installations, north is usually represented at the top of the image. For moving installations, such as small ship and aircraft radars, the top may represent the bow or nose of the ship or aircraft, *i.e.*, its heading (direction of travel) and this is usually represented by a lubber line. Some systems may incorporate the input from a gyrocompass to rotate the display and once again display north as "up".

Also, the signal represented is the reflectivity at only one elevation of the antenna, so it is possible to have many PPIs at one time, one for each antenna elevation.



c) Compare between step index and graded index fiber (any four points).

Ans : (8M)

Sr. No.	Parameter	Step Index Fiber	Graded Index Fiber
1	Data rate	Slow	Higher
2	Coupling efficiency	Higher	Lower
3	Ray path	By total internal reflection	Travels in oscillatory manner.
4	Index variation	$\Delta = n_1 - n_2 / n_1$	$\Delta = n_1^2 - n_2^2 / 2 n_1^2$
5	Numerical Aperture	NA remains same	Changes continuously with distance from fiber axis.
6	Material	Normally plastic or glass	Only glass is preferred.
7	Pulse spreading	More	Less
8	Attenuation	Less 0.34 dB / km	More 0.6 – 1 dB / km
9	Light source	LED	LED, LASER
10	Application	Subscriber local n/w communication	Local and WAN

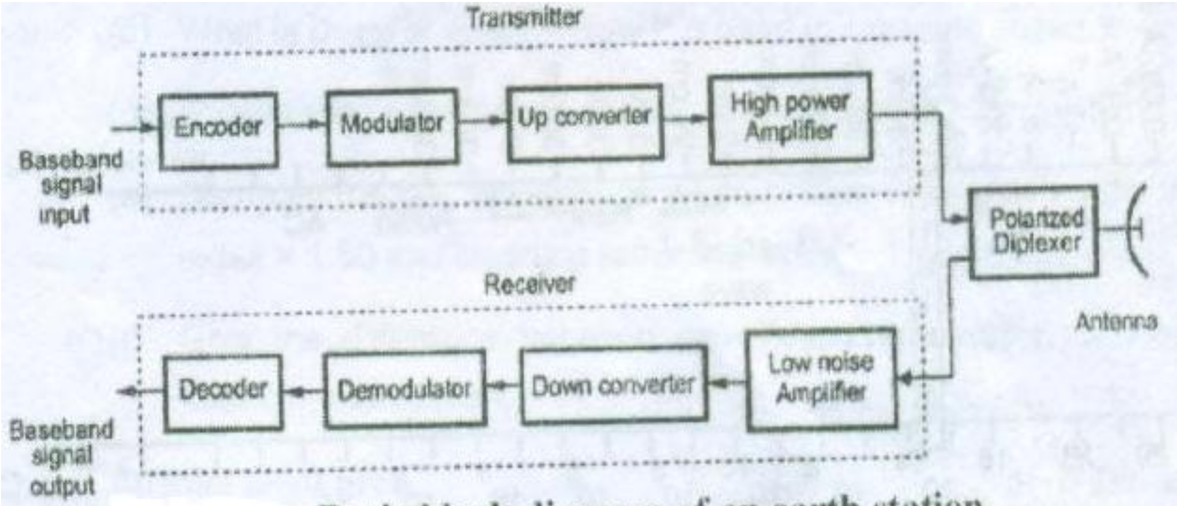
B) Attempt any one : (8 Marks)

a) Draw the block diagram of satellite earth station and explain each block in brief.

Ans : (Diagram 4 M, Explanation 4M)

Satellite earth station

The communication is established to the satellite through earth station. The earth station can be located on the ship at the sea, or it can be located on the space craft or actually on the earth. The location of the earth station is decided depending upon the ease of control of satellite and the function of the satellite. The type of earth station depends upon the (a) function of the station, (b) type of service, (c) frequency bands used, (d) transmitters, (e) receiver and (f) antenna characteristics. The four major subsystems of any earth station are, receiver, antenna, transmitter and tracking equipment. The special earth station like TVRO (TV receiver only or direct broadcast satellite receivers) does not have transmitting function. Some other earth stations are very special, like tracking and control of satellite.



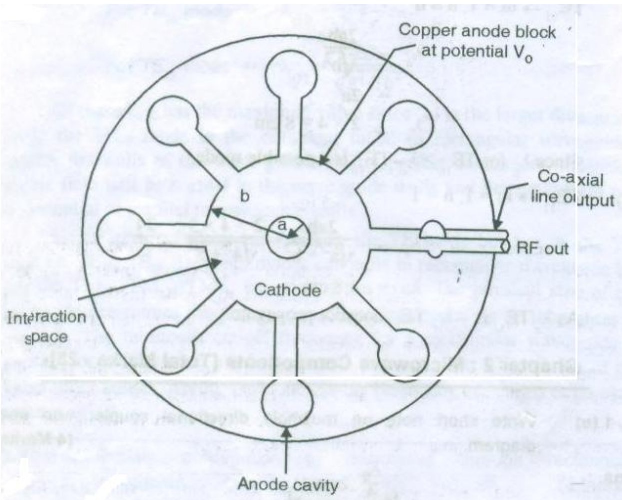
Basic block diagram of an earth station

The baseband signal is applied to the encoder. Encoder converts the format ready for modulation. The carrier is modulated by the encoded baseband signal. The modulated carrier is then upconverted to the uplink frequency of the satellite. The amplifier then amplifies this signal to high power level, ready for transmission. The signal is then passed through the polarization feed of the antenna. The signal received from the antenna is of different frequency (downlink frequency) and is very small in amplitude. This signal is amplified by the low noise amplifier. It is then down converted to the intermediate frequency by the down converter. This signal is then demodulated and decoded to get baseband signal.

b) Draw constructional details of magnetron and explain its working. List its applications.

Ans : (Diagrams 4 M, Explanation 2M Applications 2M)

Working



Cavity magnetron having 8 cavities tightly coupled to each other. Generally a N-cavity tightly coupled system will have N-modes f operation. Each operation is characterized by a combination of frequency and phase of oscillation relative to the adjacent cavity. These modes must be self consistent so that the total phase shift around the ring of cavity is 2πn. The correct minimum phase shift of 8-cavity should be 45^o ($45 \times 8 = 360^o$).

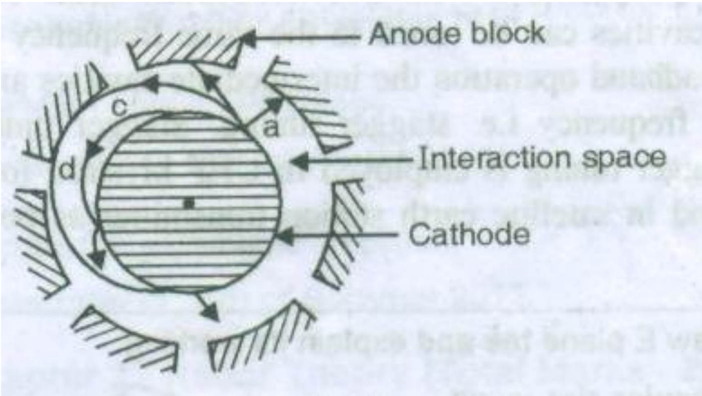
If ϕ_v is relative phase charge of ac electric field across adjacent cavities then,

ϕ_v $= 2\pi n / N$ where n = 0, ± 1, + 2, ± (N/2 – 1), ± n/2

n – integer number

N – Number of cavities.

If N is an even number, N/2 mode of resonance can exist. If n = N/2, $\phi_v = \pi$. This mode of resonance is called the π-mode. If n = 0, $\phi_v = 0$, this is zero mode. Zero mode means there will be no RF electric field between anode and cathode and this mode is not used in magnetron. Now we will discuss about how the electrons behave in the presence of closed electric and magnetic fields. Assume RF field is absent i.e. static case.



Depending on the relative strength of the electric and magnetic field the electrons emitted from the cathode and moves towards anode by traversing through the interaction space. If magnetic field is absent, the electron travels straight from cathode to the anode due to radial electric field force acting on it as shown by trajectory 'a' shown in Fig. If magnetic field strength is increased slightly, it will exert a force bending the path of the electron as shown by path 'b' in fig. If the strength of magnetic field is made sufficiently high it prevents the electrons from reaching the anode shown by path 'c' and anode current becomes zero.

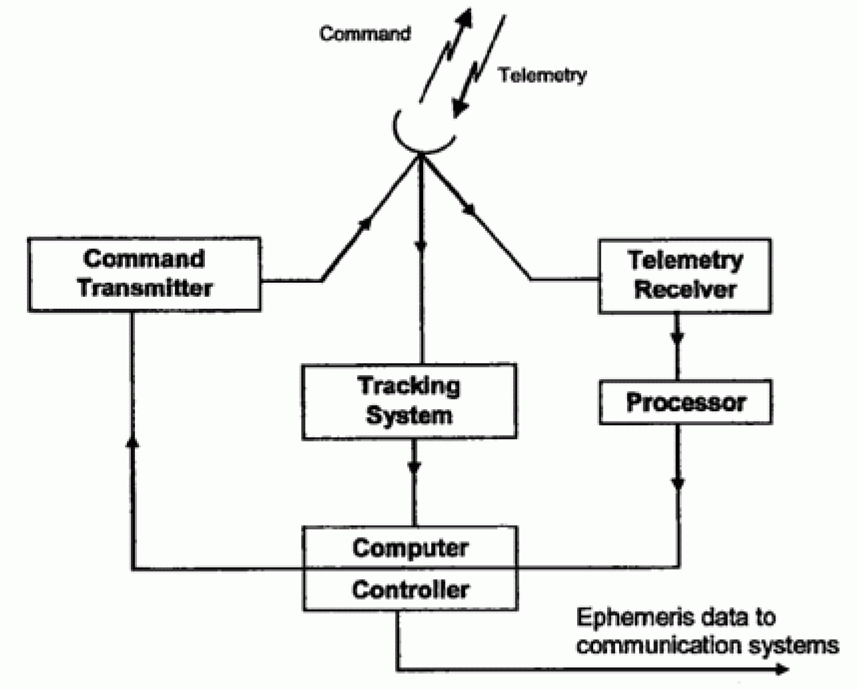
Applications :

i. Klystron, reflex klystron, TWT etc. are linear beam tubes called O tubes or original type.
ii. The other types of microwave tubes are cross field tubes.
iii. Cross field tubes are those in which electric and magnetic fields are perpendicular to each other.
iv. Magnetron is cross field tube.
v. Magnetron provide microwave oscillations of very high peak power.

Q.5. Attempt any FOUR **(16 Marks)**

a) Explain working of Telemetry and Tracking control sub-system in satellite, state its use.

Ans: **2 marks for each**



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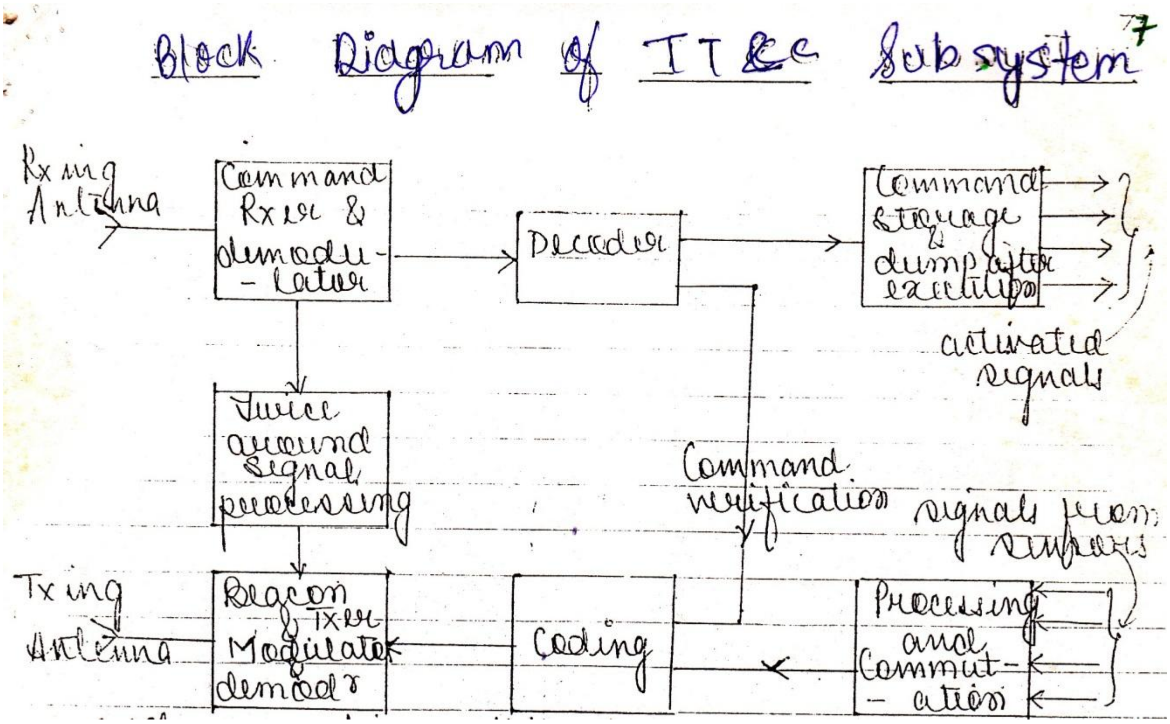


Telemetry, Tracking and Command (TT&C) Subsystem

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 centre 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 centre 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:

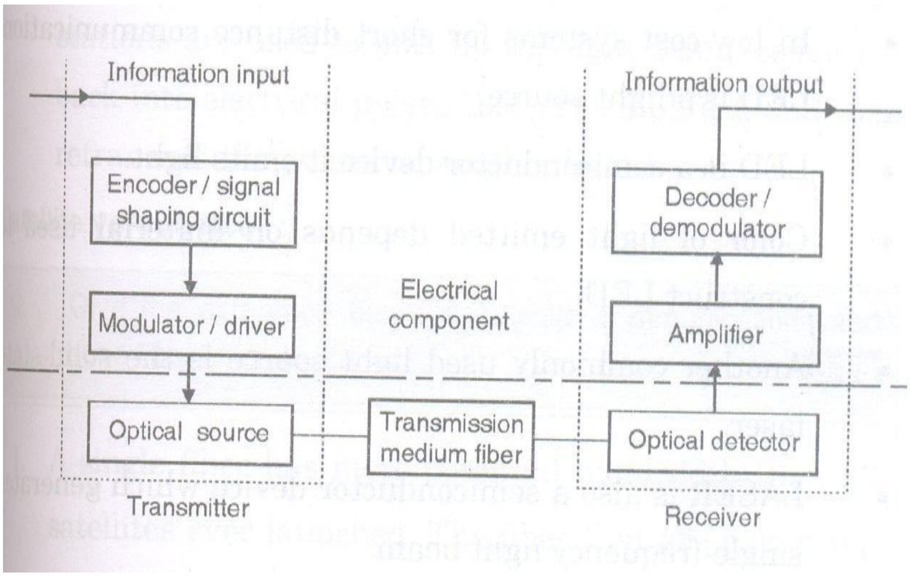
- It collects data from all sensors on the satellite and send to the controlling earth station.
- The sighting device is used to maintain space craft altitudes are also monitored by telemetry.
- At a controlling earth station using computer telemetry data can be monitored and decode.
- And status of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

b) Draw block diagram of optical communication system and explain it.

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



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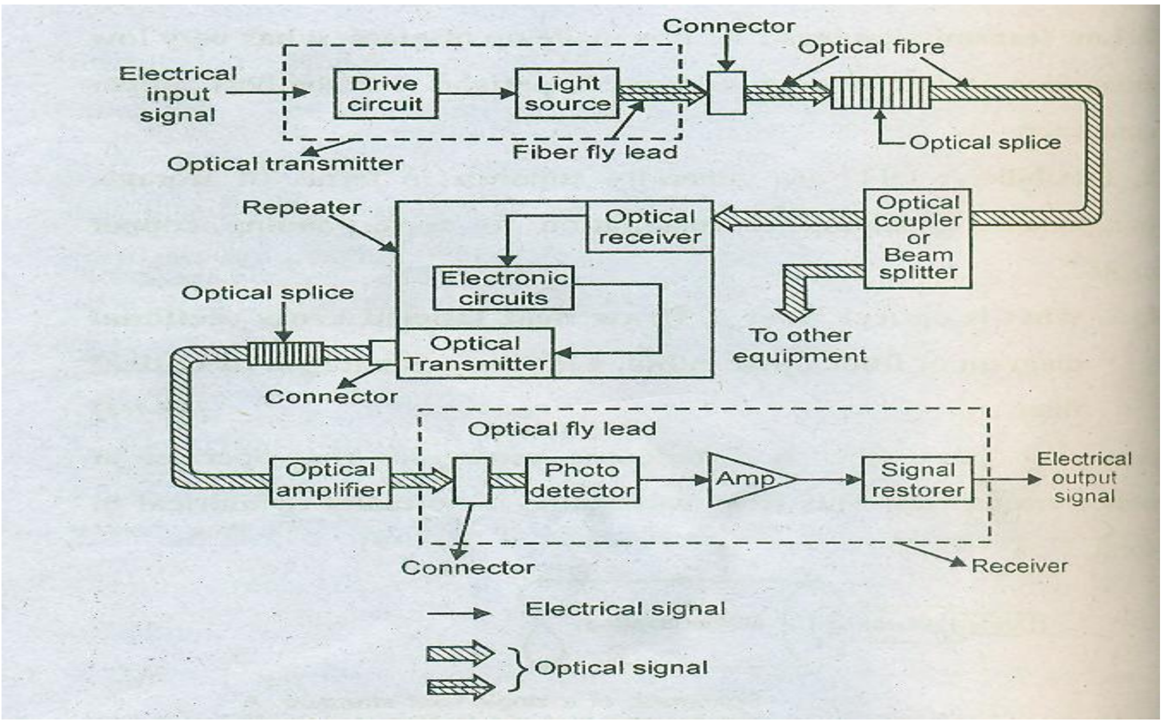


The main block diagram mainly involves a transmitter consisting of light source, a drive circuitry and a cable offering mechanical and environmental protection to the optical fibers contained inside, and a receiver consisting of a photo detector plus amplifier with a signal restoring circuit. Light emitted from the source is launched into an optical fiber. The light entering from the far end of transmission medium is converted back into electrical signal by an detector. Detector is positioned at input of receiver.

TRANSMITTER TERMINAL

1) Information input

Information signal transmitted may be voice, video or computer data. The information may be an audio conversation, a stream of data from one computer to another, or several simultaneous television broadcasts. Continuous analog signal such as voice and video signals are converted into series of digital pulse by ADC.

2) Encoder/Signal shaping circuit

Its purpose is to make the transmitted signal compatible to the communication channel by limiting the effective bandwidth of the transmission. In RF communication, pulse shaping is essential for making the signal fit in its frequency band.

3) Modulator / Driver

In electronics and telecommunications, modulation is the process of varying one or more Properties of a high-frequency periodic waveform, called the carrier signal, with a modulating signal which typically contains information to be transmitted. In optical communications, intensity modulation (IM) is a form of modulation in which the optical power output of a source is varied in accordance with some characteristic of the modulating signal

4) Optical Source

Then digital pulses are used to flash a powerful light source off and on very rapidly. In low cost system for shorter distance communication LED is used. Color of light emitted depends on material used to construct LED. Another commonly used light source is LASER. LASER generates single high frequency light beam these are then fed into FOC. For undersea installation, the splicing and repeater installation functions are carried out on- Board.

5) Transmission Medium

1) Fiber

An optical fiber is flexible and transparent made of very pure glass (silica) not much wider than a human hair that acts as a waveguide, or "light pipe", to transmit light between the two ends of the fiber Repeaters are used in long transmission system for avoiding losses of signal strength Since the light is greatly attenuated when it travels over long distances at some point it may be too weak to be recovered reliably. To overcome this attenuation problem, special relay stations are used to pick up the light beam, convert it back into electrical pulses that are amplified and then retransmit the pulses on another light beam.

RECEIVER TERMINAL

1) Optical Detector

A transducer is a device that converts input energy of one form into output energy of another. An optical detector is a transducer that converts an optical signal into an electrical signal. It does this by generating an electrical current proportional to the intensity of incident light. At the receiving end a light sensitive device i.e. Photocell or light detector generally avalanche photo diode is used to detect light pulses. Light detector converts light pulses into electrical signal.

2) Amplifier & Reshaper

These electrical pulses are reshaped and amplified back into digital form, then these are fed to decoder.

3) Decoder/Demodulator

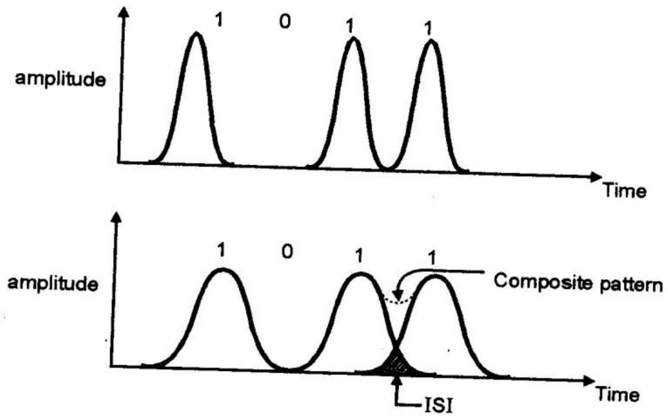
A DAC is used where the original voice or video is recovered. A demodulator is an electronic circuit (or computer program in a software defined radio) that is used to recover the information content from the modulated carrier wave.

4) Information Output

The information out may be an audio conversation, a stream of data from one computer to another, or several simultaneous television broadcasts depending on the demodulated input.

c) **Explain Intermodal and intramodal dispersion in optical fiber.**

Ans: 1M – diagram ,/2M each explanation



INTRAMODAL:

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.We know that optical sources do not just emit just a single frequency but band of frequencies. There may be propagation delay differences between the different spectral components of the transmitted signals. Delay in propagation causes broadening of each transmitted mode and so called intramodal dispersion.This delay may be caused by the dispersive properties of waveguide and the fiber structure.

Delay due to waveguide material is called material dispersion. Delay due to fiber structure is called waveguide dispersion.

The types are 1. Material dispersion 2. Waveguide dispersion

INTERMODAL:

It results from the propagation delay difference 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 slowest and fastest modes.Multimode step index fibers exhibit a large amount of 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.

It may be reduced by propagation mechanisms within practical fibers.The differential attenuation of modes reduces intermodal dispersion.

Mode coupling or mixing reduces the intermodal dispersion.The coupling between guided modes transfers optical power from the slower to fastest modes and vice versa.Strongly coupled, optical power transmits at an average speed i.e mean of various propagating modes.Intermodal dispersion in multimode fiber is minimized by using graded index fiber.In above figure meridoinal rays follow sinusoidal trajectories of different path lengths which results from the index grading.The group velocity is inversely proportional to the refractive index.The longer sinusoidal paths are compensated for by higher speed in the lower index medium away from axis.Rays travel in the high index region at core axis at the slowest speed.Various ray paths represent the different modes propagating in the fiber.The graded profile reduces in the mode transmit time

d) Compute the NA and acceptance angle of the fiber having core refractive index = 1.50 and cladding refractive index =1.45.

Ans:1M for each ans (1 mark for formula should be given)

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

$$NA = (1.50^2-1.45^2)^{1/2}$$

$$NA = 0.38$$

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

$$\theta a = \sin^{-1} 0.38$$

$$\theta a = 22.33°$$

e) State splicing techniques used for optical fiber. Explain any one in detail.

Ans:2M-diagram,2M- explanation

There are two types of splicing:

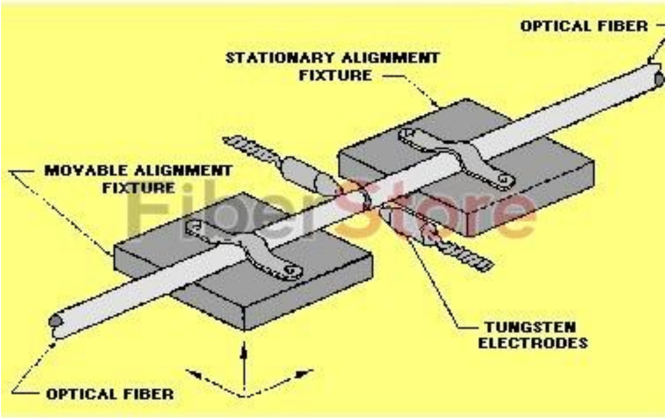
1.Fusion splicing or welding

2.Mechanical splicing

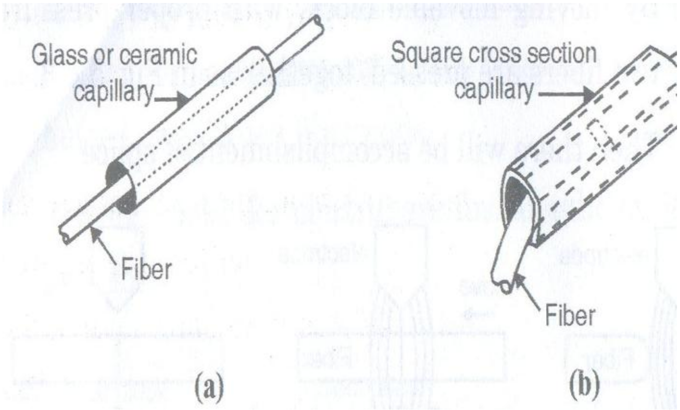
Fusion Splicing:

It is accomplished by applying localized heating i.e by a flame or an electrical arc at a interference between two butted, pre aligned fiber ends.

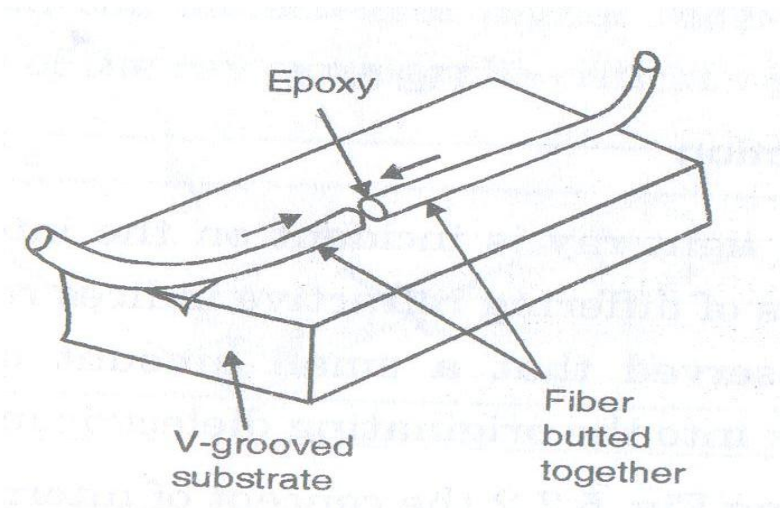
The figure shown below:



- This technique involves heating of two prepared fiber ends to their fusing point by applying sufficient axial pressure between the two optical fibers.
- For heating most widely source is electric arc.
- Following are steps for fusion process
- PREFUSION: It is a technique, which involves the rounding of the fiber ends with a low energy discharge before pressing the fibers together.
- By moving movable block, with proper pressure two fibers are pressed together.
- Then there will be accomplishment of splice.
- Drawbacks of fusion splicing:
- Heat necessary to fuse the fibers may weaken then fiber.
- Possibility of fiber fracture in fused joint.
    - MECHANICAL splicing
    - There are number of mechanical splicing techniques.
    - The common methods are
- Using rigid alignment tube.
- In this method accurately produced rigid alignment tube is used to bond the prepared fiber ends permanently.
- Figure shows the snug tube splicing.



- In snug tune splicing technique uses a glass or ceramic capillary tube with an inner diameter just large enough to accept the optical fibers.
- Transparent adhesive is injected through a transverse bore in capillary to give mechanical sealing and index matching of the splice.
- Average insertion losses as low as 0.1dB have been obtained.
- Figure shows the loose tube splice.
- In this splice an oversized square section metal is used to accept the prepared fiber ends.
- Transparent adhesives are first inserted into the tube followed by the fibers.
- The splice is self aligned, when fibers are curved in a same plane.
- Mean splice insertion losses of 0.73dB have been achieved.
    - Using V-grooves:

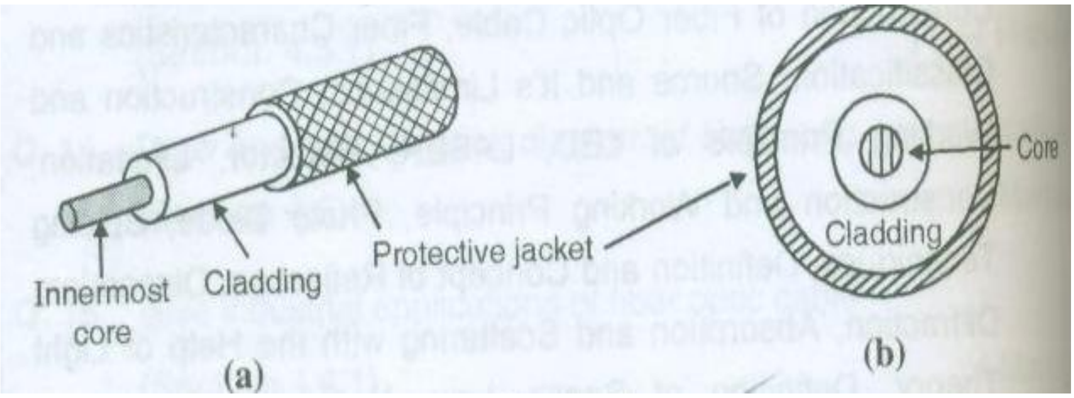


- In this technique V-grooves are used to secure the fibers to be joined.
- This method utilizes a V-groove into which the two prepared fiber ends are pressed.
- The V-groove splice ends through insertion in the groove.
- The splice is made permanent by securing the fibers in the V-grooves with epoxy resin.
- For single mode fiber splice insertion losses of less than 0.01 dB.

Q.6. Attempt any FOUR **(16Marks)**

a) Give constructional sketch of fiber. Give classification of fiber.

Ans: 2M-diagram,2M- explanation



Classification of fibers is as follows;

1 .Step index fibers

  i. Single mode

  ii. Multimode

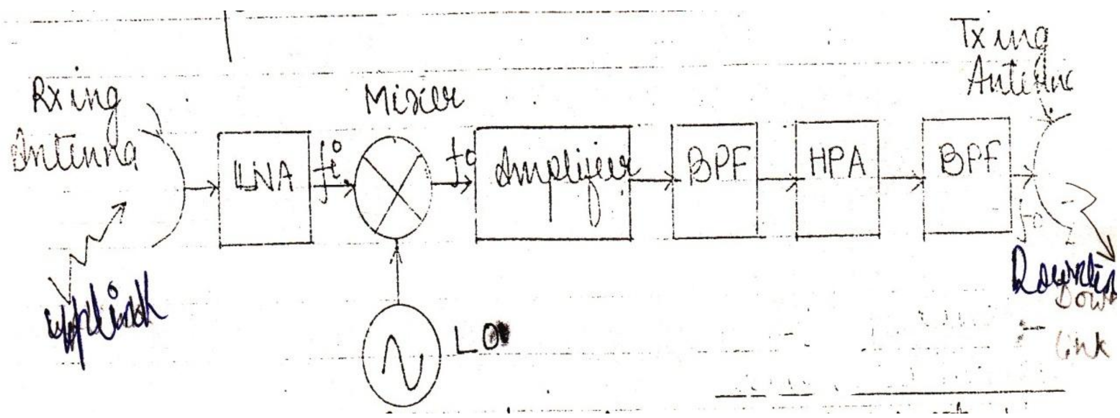
2. Graded index

  i. Multimode

b) Explain working of communication sub system in satellite.

Ans: 2M-diagram,2M- explanation

Working of communication sub system in satellite.



Explanation: The block diagram of single conversion transpoder is shown in figure.

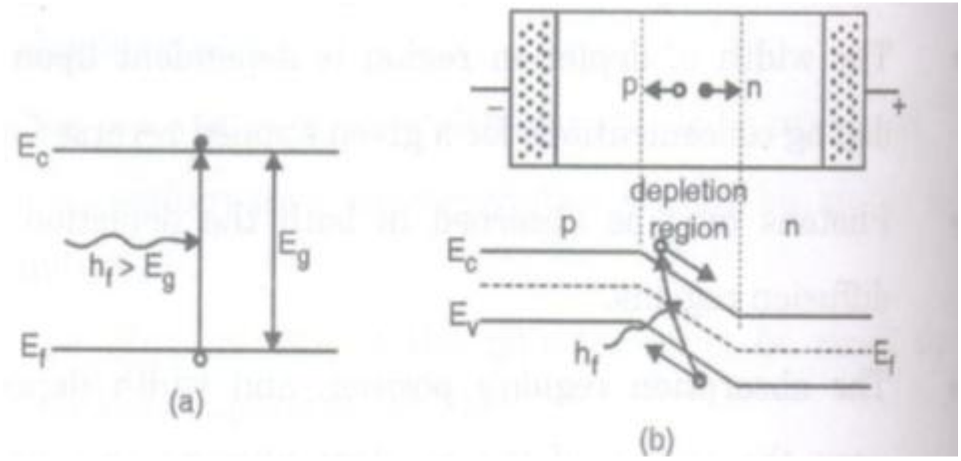
- Uplink signal from the antenna & the field system is first routed to low noise amplifiers (LNA).
- The signal is very weak at this point even through it has been multiplied somewhat by the gain of the receive antenna.
- The LNA's should sufficiently high gain with low noise figure. Earlier tuned diode amplifier (TDA) were used as LNA's in satellite receiver. But the first stage in transponder amplifier chain is provided by solid state GASFET amplifier.
- These drivers required careful design to minimize noise & intermodulation effect after amplification the LAN output is given to the mixer where it is mixed with a stable reference signal generated locally & output of the mixer consist of sum &

difference frequency of the mixer output is amplified again & fed to the band pass filter (BPF).

- The BPF is used to pass the difference frequency (downlink signal) & reject all other.
- The other function of BPF is to channelize the output i.e. only input signal on a specific frequency will be accepted by the band pass filter.
- Finally the downlink signal is transmitted by the antenna to desired earth station.

c) Draw the constructional diagram of photodiode and explain.

Ans: 2M-diagram,2M- explanation



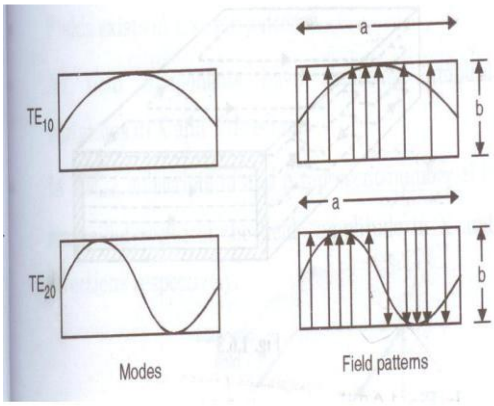
P-i-n photo diode In order to allow operation at longer wavelength where the light penetrates more deeply in to the semiconductor material a wider depletion region is necessary. To achieve this the n-type material is doped so that it can be considered as intrinsic and to make a low resistant contact a highly doped n-type (n+)layer is added. In fig. device structure consist of p and n regions separated by very lightly doped intrinsic (i) region.

Normally sufficient large reverse bias voltage is applied across the device so that the intrinsic regions is fully depleted of carriers .When an incident photon has energy greater than or equal to the band gap energy of semiconductor material, the photon can give up its energy and Excite an electron from valence band to conduction band. This process generates free electrons and hole pairs which are called as photo carriers. In photo detector photo carriers are generated in the depletion region where most of incident light is absorbed. The high electric field presents in depletion region causes the carrier to separate and be collected across the reverse bias junctions.
This gives rise to current flow in external circuit.

d) Explain TE and TM modes in rectangular waveguide.

Ans: 1M-diagram, 1M- explanation for each.

TE mode



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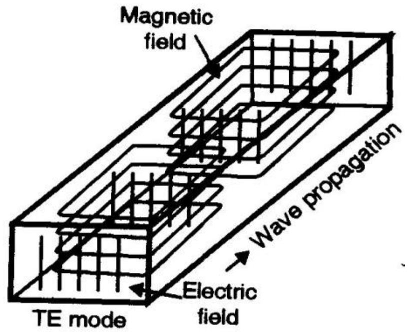
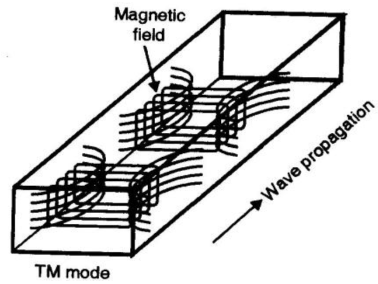


When an electromagnetic wave propagates down a hollow tube , only one of the field either electric or magnetic will be transverse to the direction of wave of propagation and other fields will loop longitudinally to the direction of travel, but still perpendicular to other field.In TE mode electric field remains perpendicular to the direction of travel or propagation In TE mode Hz ≠ 0 and Ez=0 if Z is the direction of propagation then no electric line is in the direction of propagation.For rectangular waveguide TE_{10} mode is dominant mode.It signifies all electric fields are transverse to the direction of propagation and no longitudinal electric field is present.The electric field is maximum at the centre of the waveguide and drops off sinusoidally to zero intensity at the walls.TEmn mode: m-indicates the number of half wave loops across the width of the guide, n- number of loops across the height of the guide or no E-field patterns across 'b' dimension. In above fig 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.

TM mode :



Conversely to TE modes, transverse magnetic (TM) modes have $H_z = 0$ and E_z ¹ 0 The expression for the cutoff frequencies of TM modes in a rectangular waveguide

$$f_{c,mn} = \frac{1}{2\pi\sqrt{\mu\varepsilon}}\sqrt{\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2} \quad m,n = 1,2\ldots$$

is very similar to that for TE modes given in (13). It can be shown that if either m = 0 or n = 0 for TM modes, then \`E = \`H = 0. This means that no TM modes with m = 0 or n = 0 are allowable in a rectangular waveguide.

e) When the optical power launched into an 8Km length of fiber is 120uW and mean optical power at the fiber output is 3uW.Determine

1. Overall signal attenuation or loss in decibels through the fiber assuming there are no connectors or splices
2. The signal attenuation per Km for the fibers.

   SOl: 2M- each (marks should be given for correct formula and steps)

   1. Overall signal attenuation or loss in decibels through the fiber assuming there are no connectors or splices is given by,

      Signal attenuation (α_{db} L) = $10\log_{10}P_i/P_o$

      $= 10\log_{10}(120\text{x}10^{-6}/3\text{x}10^{-6})$

      $= 10\log_{10}40$

      = 16.0dB

   2. The signal attenuation per Km for the fibers is given by,

      α_{db} L = 16.0 dB

      As L = 8 Km

      Therefore,

      α_{db} = 16.0/8

      = 2.0dB/Km.

f) Draw and explain light wave spectrum.

Ans: 2M-diagram,2M- explanation

Light can be defined as the part of the visible spectrum.Visible spectrum has a wavelength range between 0.4µm to 0.7 µm .Wavelengths of light are extremely short .Their distances are measured in units called Angstroms.A single Angstrom is 1/10 th billion of a meter.In industry ,nanometer or micrometer units are used to measure wavelength of light.All light waves travel at the same speed in air or in vacuum.Each color has a different wavelength and discrete frequency.

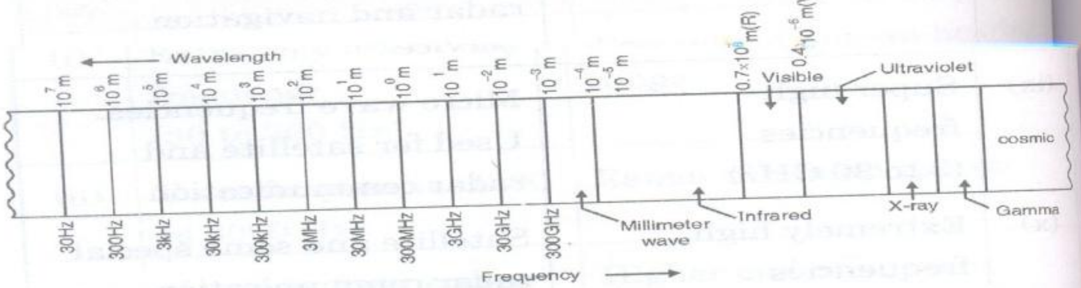


Fig. 4.1.3 : Electromagnetic spectrum

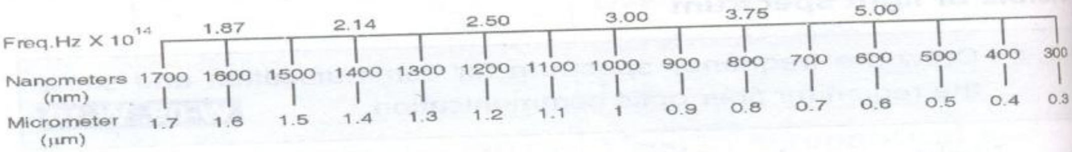


Fig. 4.1.4 : Light wave spectrum (visible and nonvisible)