WINTER– 17 EXAMINATION

Subject Name: Advanced Communication Systems

Model Answer Subject Code: 17656

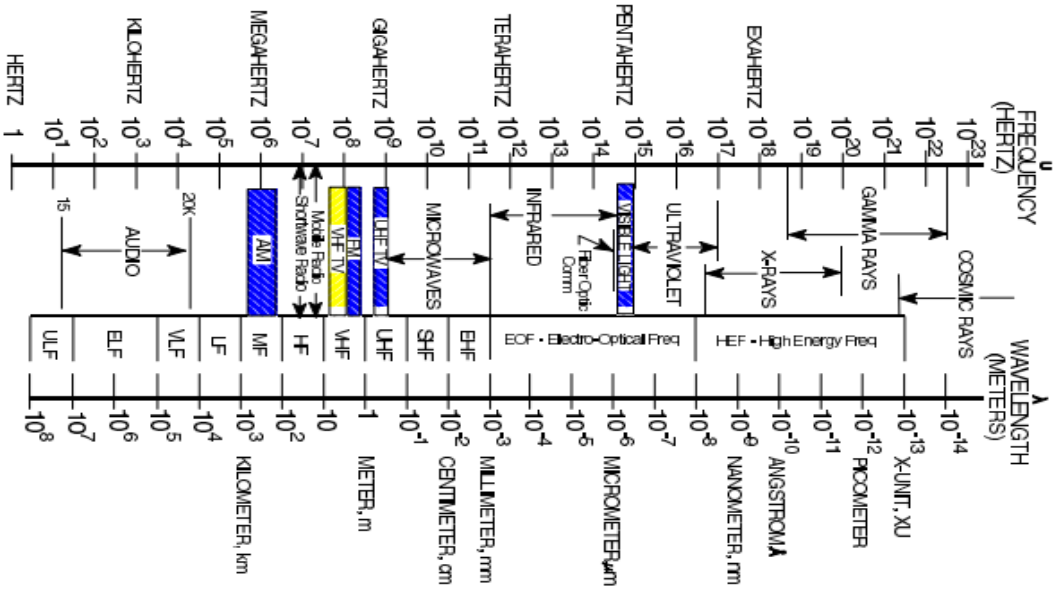
Important Instructions to examiners:

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

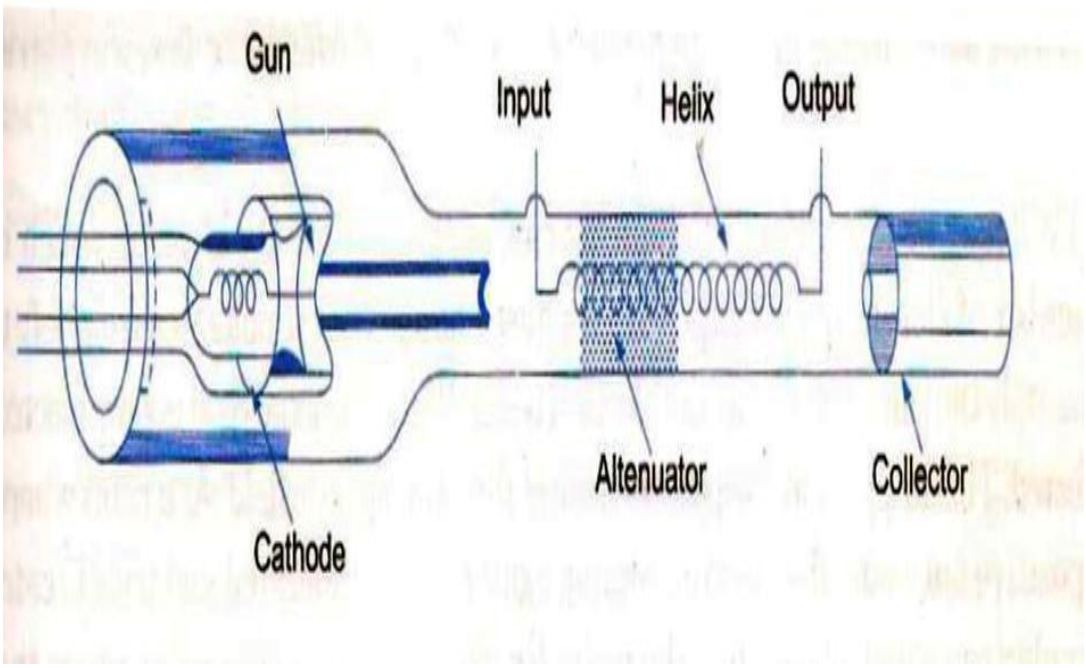
1A) Attempt any three **12**

a) Draw the microwave spectrum and designate the appropriate band in it.(2marks for any 4 band and 2 marks for spectrum)

Band	Frequency Range
L	1-2GHz
S	2-4Ghz
C	4-8 GHz
X	8-12Ghz
Ku	12-18Ghz
K	18-26.5Ghz
Ka	26.5-40Ghz
Q	30-50Ghz



b) Sketch the constructional details of TWT and explain its working. .(2marks for diagram and 2 marks for explaination)



Working Principle:

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

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

c) Define Radar beacons and state their uses. .(2marks for defination and 2 marks for uses)

- A Radar beacon is a small radar set consisting of a receiver, a separate transmitter and an antenna which is often omnidirectional.
- When another radar transmits a coded set of pulses at the beacon i.e it interrogates it, the beacon responds by sending back its specific pulse code.
- The pulse from the beacon or transponder may be at the same frequency as those from the interrogating radar, in which case they are received by the main station together with its echo pulses.
- They may alternatively be at a special beacon frequency, where a separate receiver is required by the interrogating radar.
- The beacons does not transmit pulses continuously in the same way as a search or tracking radar but only to the correct interrogation.

Radar beacons are used as:

- One of the application of a beacon may be to identify itself. The beacon may be installed on a target (aircraft) and will transmit a specific pulse code when interrogated these pulses then appear on the PPI of the interrogating radar and inform it of the identity of the target. The system is used in airport traffic control and also for military purpose, where it is called identification, friend or foe (IFF).

- Another use is similar to that of lighthouses, except that radar beacons can operate over much larger distances.

d) Define and explain the terms: .(2marks for uplink and 2 marks for downlink)

i) Uplink frequency ii) downlink frequency

UPLINK FREQUENCY:

- The communication between earth station transmitter towards satellite is known as uplink frequency.
- Uplink of satellite is the frequency at which the earth station is transmitting the signal and satellite receiving it.
- Uplink frequency range = 5.9 GHz to 6.4GHz

DOWNLINK FREQUENCY:

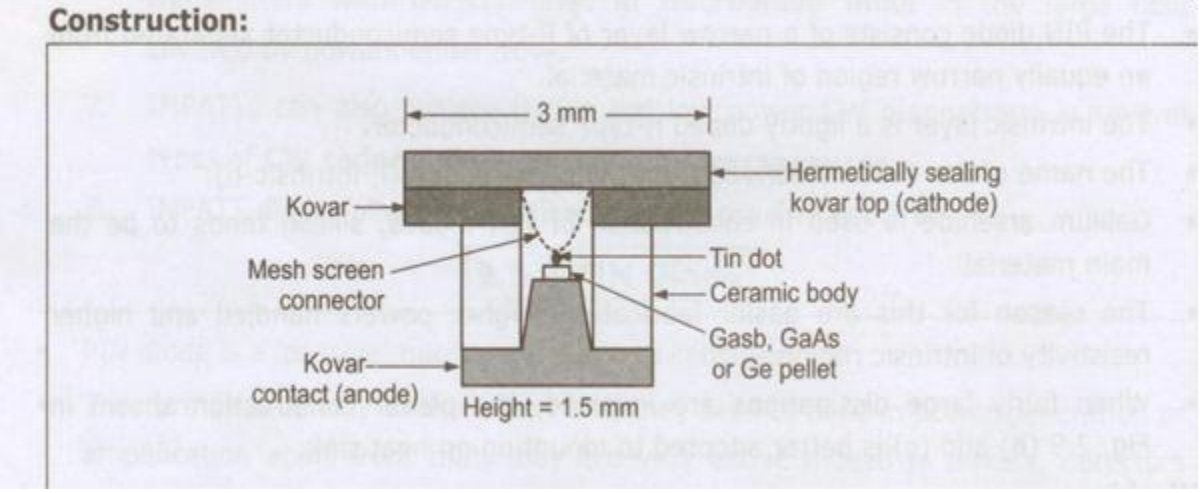
- The communication between satellite towards earth station receiver is known as downlink frequency.
- Downlink frequency of satellite is the frequency at which the satellite is transmitting the signal and earth station receiving it.
- Downlink frequency range = 3.7 GHz to 4.2 GHz.

B) Attempt any ONE: 6

a) Differentiate between TEm,n and TM m,n modes (6 points)(1 marks for each point)

TEmn	TMmn
It is Transverse electric mode	It is transverse magnetic mode
Ez=0 that means energy transmission is done by Hz.	Hz=0 that means energy transmission is done by Ez
Dominant mode is TE_{01} mode	Dominant mode is TE_{11} mode
Cutoff frequency of dominant mode is less than TE_{11} mode	Cutoff frequency of dominant mode is more than TE_{10} mode
TE_{01} and TE_{10} mode exist	TM_{01} and TM_{10} mode does not exist
Cutoff wavelength for dominant mode=2a	Cutoff wavelength for dominant mode=$2ab/\sqrt{a^2+b^2}$.

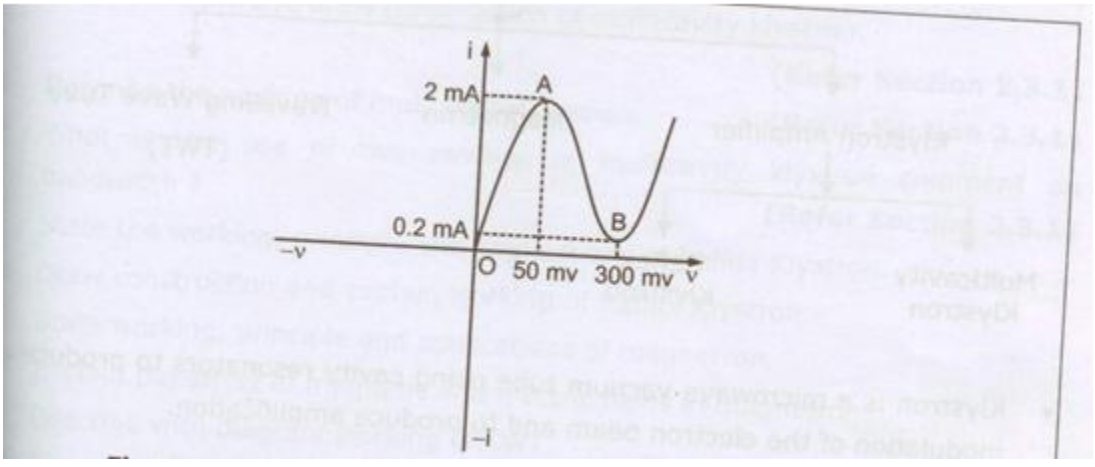
b) Draw a constructional diagram of tunnel diode . Describe its working . State its applications. a .(2marks for diagram, 2 marks for working and 2 marks for application)



Working:

1. Tunnel diode is a thin junction diode which under low forward bias conditions exhibits negative resistance useful for oscillation or amplification.
2. The junction capacitance of the tunnel diode is highly dependent on the bias voltage and temperature.
3. A very small tin dot about 50μm in diameter is soldered or alloyed to a heavily doped pellet of n- type Ge, GaSb or GaAs.
4. The pellet is then soldered to a kovar pedestal, used for heat dissipation, which forms the anode contact.

5. The cathode contact is also kovar being connected to the tin dot via a mesh screen used to reduce inductance.
6. The diode has a ceramic body and hermetically sealing lid on top.
7. In tunnel diode semiconductor material are very heavily doped, as much as 1000 times more than in ordinary diodes.
8. This heavy doping results in a junction which has a depletion layer that is so thin (0.01μm) as to prevent tunneling to occur.
9. In addition, the thinness of the junction allows microwave operation of the diode because it considerably shortens the time taken by the carriers to cross the junction.
10. A current-voltage characteristics for a typical Germanium tunnel diode is shown in figure.
11. Forward current rises sharply as voltage is applied.
12. At point A, peak voltage occurs.
13. As forward bias is increased past this point, the forward current drops and continues to drop until point B is reached, this is the valley voltage.
14. At point B current starts to increase once again and does so very rapidly as bias is increases further.
15. Diode exhibits dynamic negative resistance between A and B therefore, useful for oscillator applications.



Application:

1)Tunnel diode maybe used as a mixers.

2)Being high speed device ,tunnel diodes also used for high speed switching and logic operations as flip flop gates

3)They are used s oscillators upto 100 Ghz.

2 Attempt any FOUR 16

a) Explain the dominant mode of wave propagation through a rectangular waveguide.(4 marks for explaination)

Explanation:-

- The walls of the waveguides can be considered as nearly perfect conductors.
- Therefore, the boundary conditions require that electric field be normal i.e., perpendicular, to the waveguide walls.
- The magnetic fields must be tangential i.e., parallel to the waveguide walls. Because of these boundary conditions a zero subscript can exist in the TE mode but not in the TM mode. For e.g., TE_{10}, TE_{01}, TE_{20}, etc. modes can exist in a rectangular waveguide but only the TM_{11}, $TM_{12,}$ TM_{21} etc. modes can exist.
- Also the cut-off frequency relationship shows that the physical size of the waveguide determines the propagation of modes depending on the values of m and n.
- The minimum cut-off frequency for a rectangular waveguide is obtained for a dimension a>b for m= 1 and n= 0, i.e., TE_{10} mode is the dominant mode for a rectangular waveguide.(Since for TM_{mn} modes m# 0or n# 0, the lowest order mode TE_{10} is the dominant mode for a> b.)

b) List the specifications of two cavity Klystron amplifier and give its applications. .(2marks for 4 specification and 2 marks for 2 application)

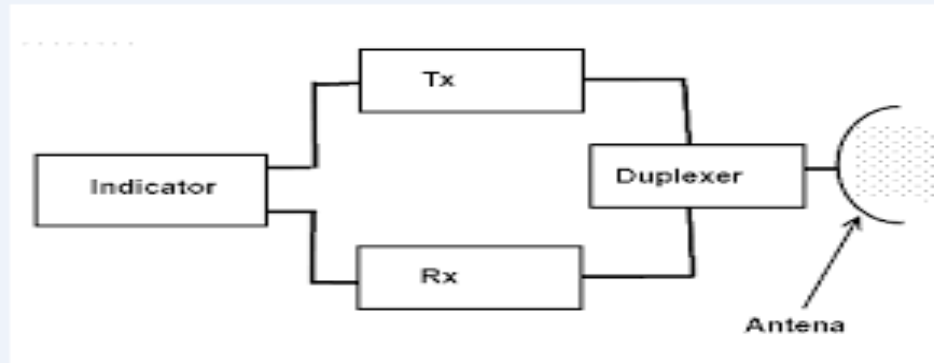
Two cavity Klystron: 2M

- **Frequency**: 250 MHz to 100 GHz. (60 GHz nominal).
- **Power** : 10KW-500KW (CW) 30MW (pulsed).
- **Power gain:** 15 dB-70 dB (60dB nominal).
- **Bandwidths**: Limited (because cavity resonators are being used) 10-60 MHz- generally used in fixed frequency applications.
- **Noise figure**: 15-20dB (Sometimes greater than 25dB).
- **Theoretical efficiency**: 50% (30-40% nominal).

Applications:

- Medium,high and very high poweramplifier in the UHF and Microwave range,for either continuous or pulse operation.
- In satellite station transmitter as power amplifier
- In UHF tv transmitter .

c) Draw block diagram of basic radar system and describe its working.(2marks for block diagram and 2 marks for explaination)

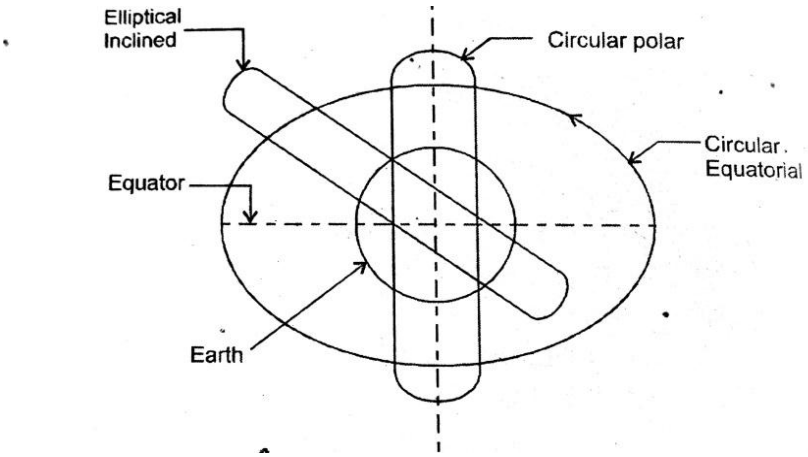


- The diagram shows basic radar system which consist of transmitter receiver and antenna which act as both transmitting and receiving antenna.
- The main function of the duplexer is to connect the transmitter to these antenna, when the pulses are to transmitted and connect the antenna to these receivers, when echo –pulses are received.
- Pulse modulated Magnetrons, Klystrons, and Travelling Wave tubes (TWT) or Crossed-field amplifier (CFA) are used as transmitter output tubes. In the receiver for first stages usually a diode mixer is used. The antenna generally uses a parabolic reflector.
- Antenna can scan continuously the scanning speed of antenna is mechanically is higher part, it is small in comparison with the time taken by pulses to return from.

d) List the types of orbits used in satellite system and describe them. .(1 mark list,1marks for diagram and 2 marks for discription)

There are three orbital patterns used in satellite communication:

- Circular polar orbit
- Inclined elliptical orbit
- Circular equatorial orbit
- Geo synchronous orbit
- Geo stationary orbit
- Clarkes orbit



The polar orbiting satellite follows an orbit that is close to earth and passes over the poles i.e. Inclined in nearly 90^0.The average height of this orbit is typically 800 to 1000Km above earth .Satellite in this orbit are mainly for earth observation and surveillance and for resarchwork.

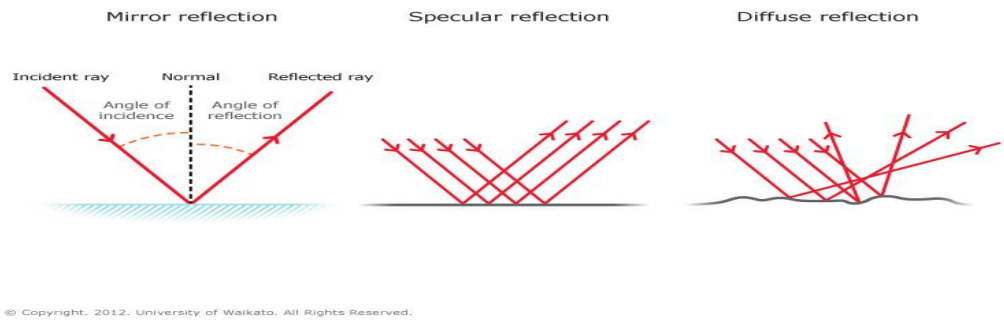
When satellite is inclined in highly elliptical orbit, centre of the earth is one of the focal point of ellipse .In this case the distance of the satellite from earth varies depending upto its position. Satellites in this orbit are used when communication is required in high altitude region.

The geo-synchronous orbit is located at a height of 22282 miles above the earth in earth equatorial plane. A satellite moving in geo synchronous orbit in same direction as the earth's surface with forward velocity of 6874mph will complete the orbit in 24 hrs.the satellite will therefore appear stationary with respect to earth and hence it is called geo stationary satellite and orbit is called geo stationary unit.

Define: Proper definitions 3 marks)

i) Reflection ii) Refraction iii) absorption in scattering w r to light theory.

Reflection:



When the ray incident on a conducting surface it reflects making an same angle with normal is called reflection.

Or Reflection is the change in the direction of a wavefront at an interface between two different media so that the wavefront returns into the medium from which it originated.

Refraction:

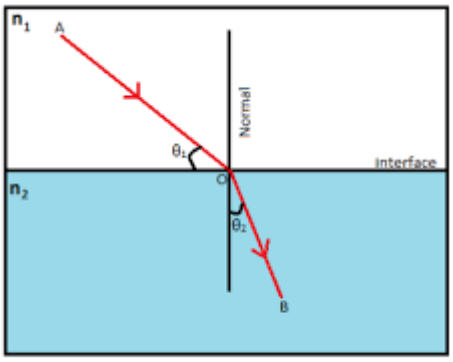
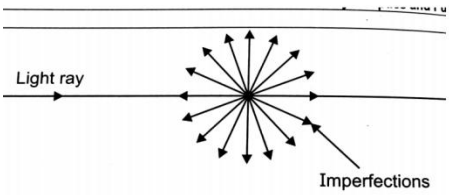


Figure 1

Refraction is the bending of the wave when it enters a medium where the speed is different. The refraction of light when it passes from a fast medium to a slow medium bends the light ray towards the normal to the boundary between the two media.
Due to change in speed of light when it travels from different medium as air,water,glass nad other transparent material .

Absorbtion in scattering.

Absorption is the process where impurities in the fibre absorb optical energy and dissipate it as a small amount of heat, it scatters light in all direction when it hits a point.



e) List any four types of losses in optical fiber. .(1mark each and any 4 losses)
Predominant losses in optical fibre cable are:

1. Absorbtion loss

2. Scattering loss
3. Dispersion loss
4. Radiation loss
5. Coupling loss

3. Attempt any FOUR: 16

a) State the advantages of circular waveguide and list its applications.

Ans: (2M- each (any two))

Advantages:

1)The circular waveguide are easier to manufacture than rectangular waveguides and are easier to join.

2)The TM01 modes are rotationally symmetrical and hence rotation of polarization can be overcome.

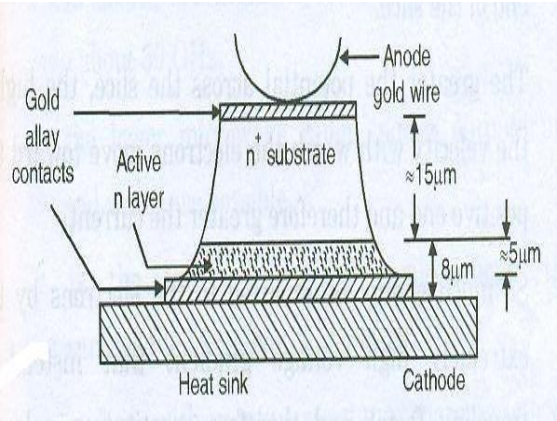
3) TE01 mode in circular for long distance waveguide transmission.

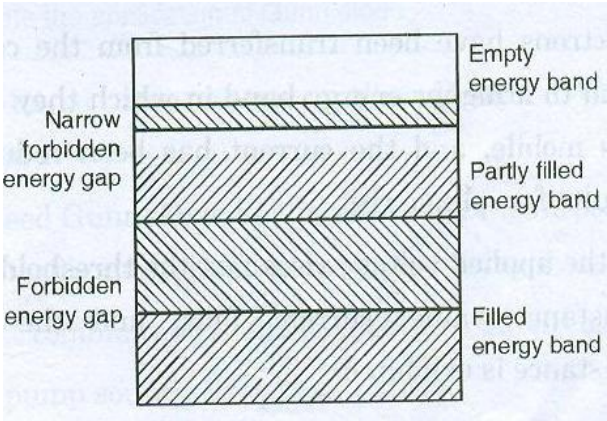
Applications:

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

b) Draw the construction of Gunn diode and describe its working.

Ans: (2M-diagram,2M- working)





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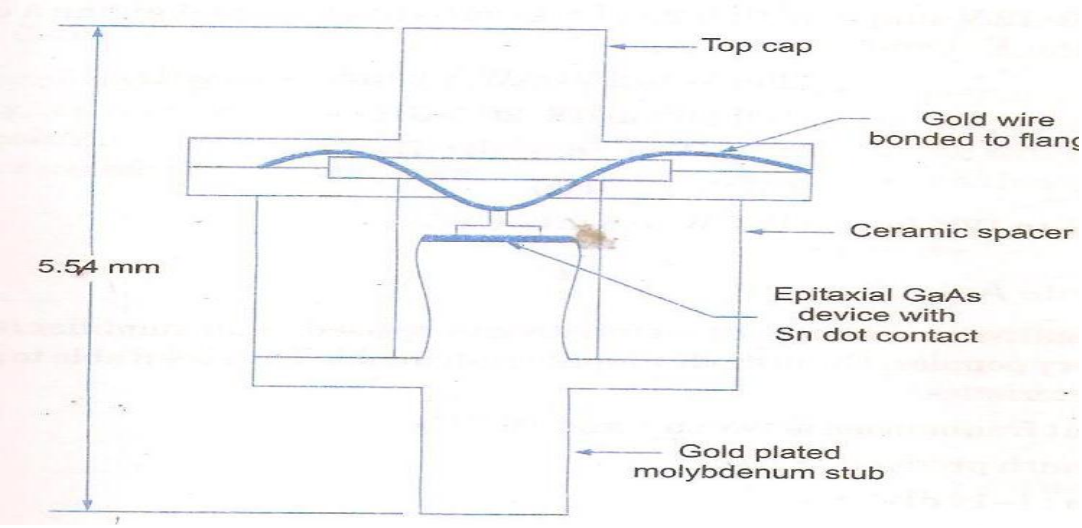


WORKING:

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) List the antenna tracking methods used in Radar system. Explain any one of them.

Ans: (1M-types,3 M-correct description of any one)

Types of anternna tracking methods are:

1- Angle tracking

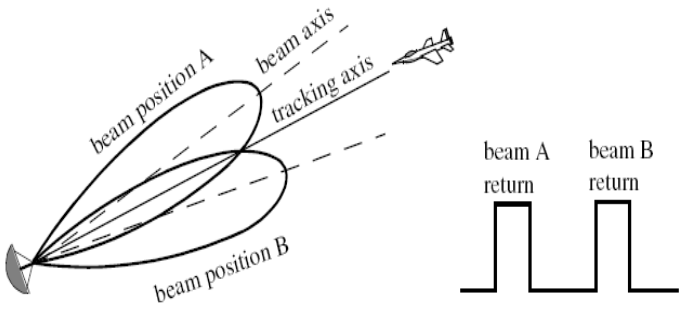
- Sequential lobing
- Conical scan
- Amplitude compression monopulse
- Phase compression monopulse

2- Range tracking

. Sequential lobbing

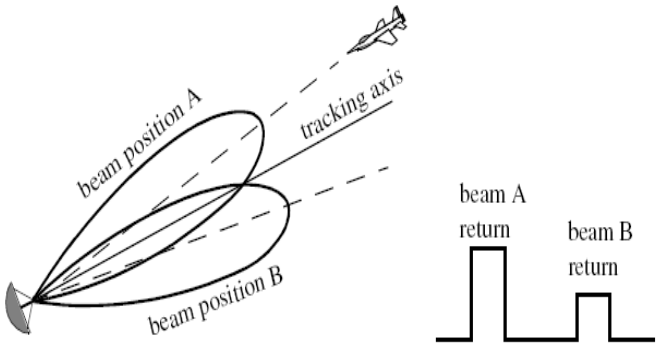
Sequential lobing is often referred to as lobe switching or sequential switching.Accuracy depends on the pencil beam width. Measuring the difference between the echo signals voltage levels. It is very simple to implement. The difference between the echo signals voltage in (A) and (B) equal zero, that's mean zero error signal.

1. When the target being on the LOS

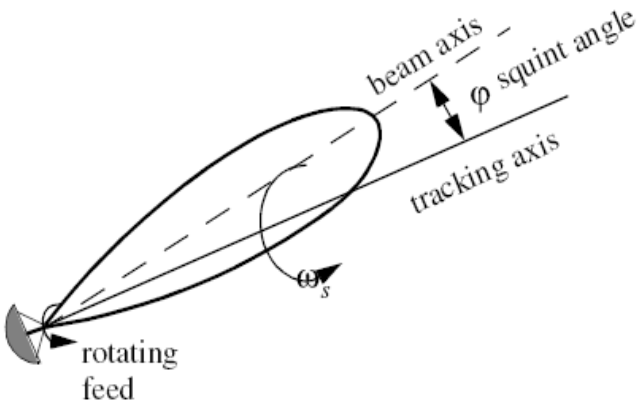


2. When the target being off the LOS

Signal in position(A) will attenuate more than signal in position(B) , that's mean a nonzero error signal.



2. Conical scanning: It's an extension of sequential lobbing.



Some older tracking radar uses the conical scanning principle. A conical scan pattern, as shown can be generated by using a rotating feed driven by a motor in the housing at the rear of the dish. The axis of the radar lobe is made to sweep out a cone in space; the apex of this cone is, of course, at the radar transmitter antenna or reflector. At any given distance from the antenna, the path of the lobe axis is a circle. Within the useful range of the beam, the inner edge of the lobe always overlaps the axis of scan. If the target is on the scan axis, the strength of the reflected signals remains constant (or changes gradually as the range changes). But if the target is slightly off the axis, the amplitude of the reflected signals will change at the scan rate. For example, if the target is to the left of the scan axis, as shown in the following animation the reflected signals will be of maximum strength as the lobe sweeps through the left part of its cone; the signals will quickly decrease to a minimum as the lobe sweeps through the right part. Information on the instantaneous position of the beam, relative to the scan axis, and on the strength of the reflected signals is fed to a computer. Such a computer in the radar system is referred to as the angle-tracking or angle-servo circuit (also angle-error detector). If the target moves off the scan axis, the computer instantly determines the direction and amount of antenna movement required to continue tracking. The computer output is used to control servomechanisms that move the antenna. In this way, the target is tracked accurately and automatically.

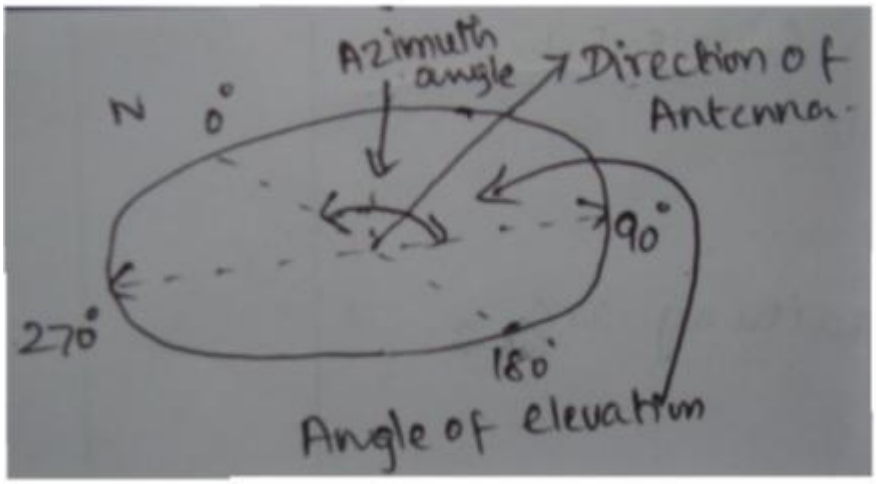
d) Explain the following terms w.r.t satellite:

i) Elevation ii)Altitude

Ans: (2M- each)

i) Elevation angle:-

It is the angle between horizontal plane & the line of sight between the earth station antenna and the satellite.



ii) Altitude:- The vertical elevation of an object above a surface such as sea level or land of a satellite is called as Altitude.

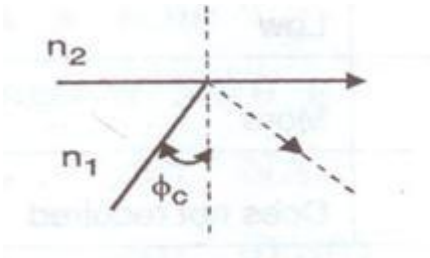
e) Define: Critical angle. State snell's law.

Ans: (2M- each definition)

Critical angle: (2M)

It is smallest possible angle of incidence at which light rays are totally reflected at an interface between substances of different refractive indices.

Critical angle (Øc) = Sin $^{-1}$ (n2/n1)



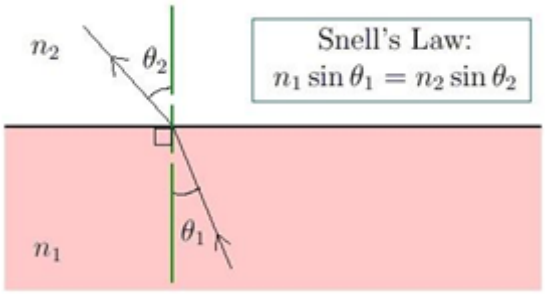
Snell's Law:

Snell's law tells us the degree of refraction and relation between the angle of incidence, the angle of refraction and refractive indices of given pair of media. We know that light experiences the refraction or bending when it travels from one medium to another medium. Snell's law predicts the degree of the bend. It is also known as the law of refraction. Snell's law is defined as "*The ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant, for the light of a given colour and for the given pair of media".* Snell's law formula is expressed as:

$$\frac{\sin i}{\sin r} = constant = \mu$$

Where *i* is the angle of incidence and *r* is the angle of refraction. This constant value is called the refractive index of the second medium with respect to the first.

The following is a diagrammatic representation:

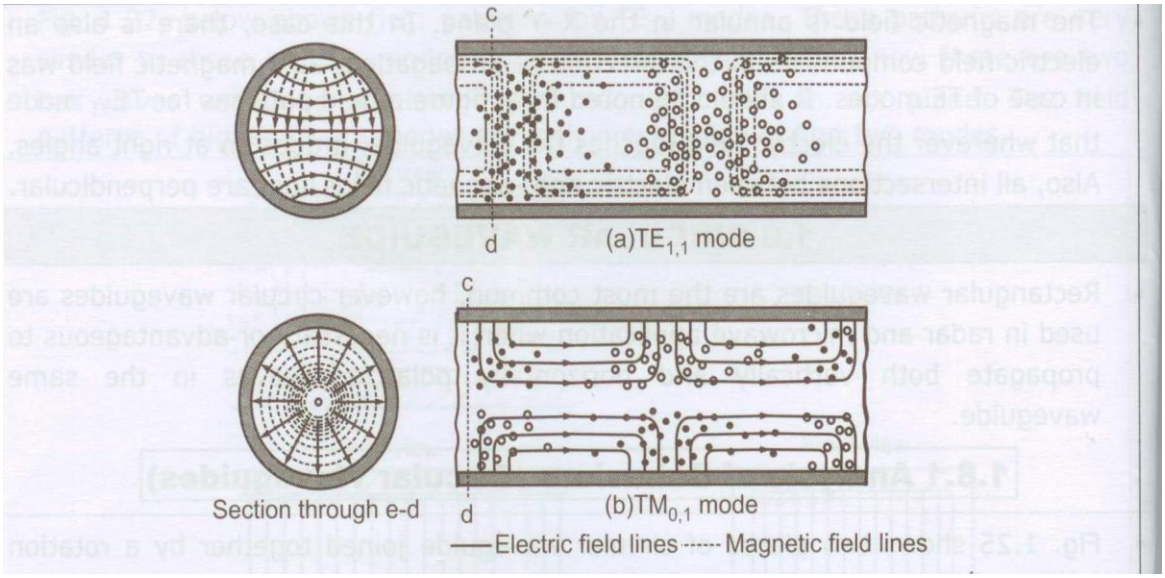


The normal on the surface is used to gauge the angles that the refracted ray creates at the contact point. ***n1*** and ***n2*** are the two different mediums that will impact the refraction.

4. (A) Attempt ant THREE: 12

a) Draw the field pattern of circular waveguide.

Ans: (correct Field pattern- 4 M)



b) State the two applications of each:

i) IMPATT diode

ii) PIN diode

Ans: (1/2M- each application of each diode)

i) IMPATT diode

1. Intruders alarm

2. Basic forms of radar

3. General detectors using RF technology.

ii) PIN diode

1. High voltage rectifiers

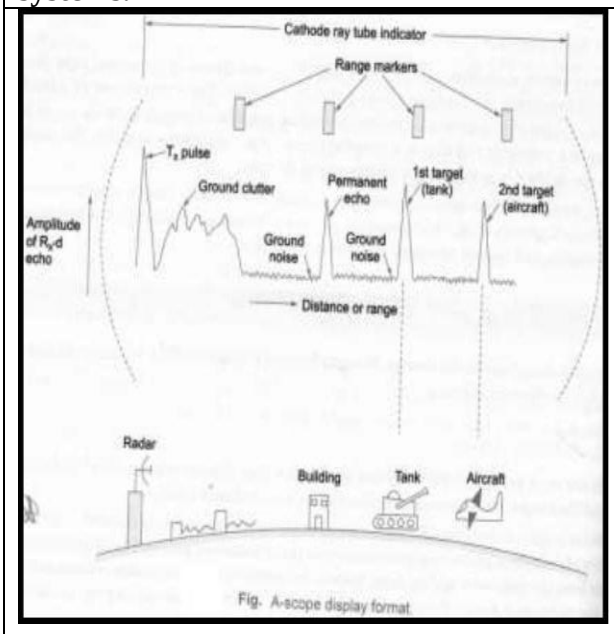
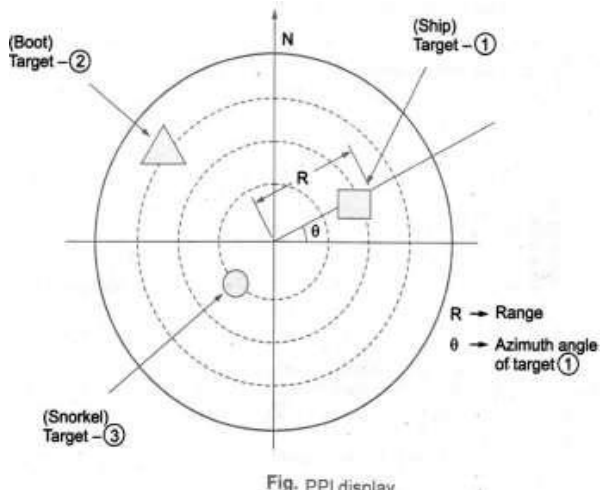
2. RF switch

3. Photodetector

c) Compare between A-scope and PPI display methods.

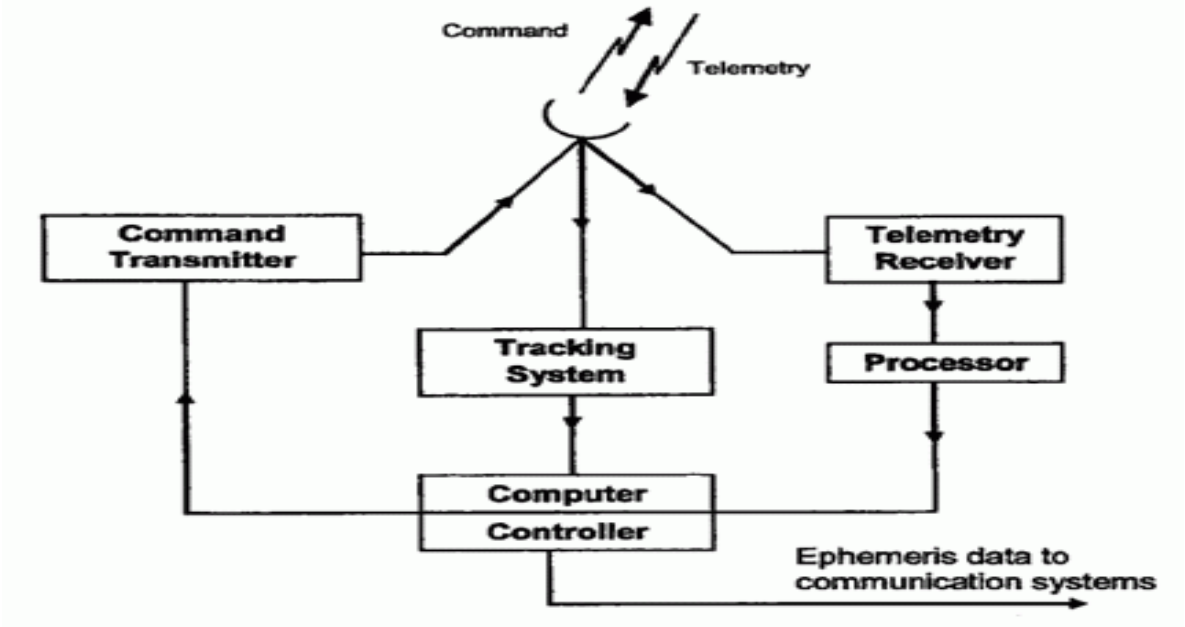
Ans: (1M-each correct point)

NOTE: Any other correct relevant point should be given marks.

A-scope	PPI
1. It presents only range to the target and the relative strength of the echo.	1.It displays range and Azimuth.
2. It uses electrostatic deflection CRT.	2. It uses a radial sweep pivoting about the center of the presentation
3.These were used in old systems as monitoring oscilloscopes.	3. It is the most used radar display.
4. It is used in weapon control radar systems.	4.It is used for survelliance and acquisition purpose.
 Fig. A-scope display format	 Fig. PPI display

d) Draw the block diagram of telemetry tracking and command subsysytem and state its principle of operation.

Ans: (2M - diagram and 2M –explanation)



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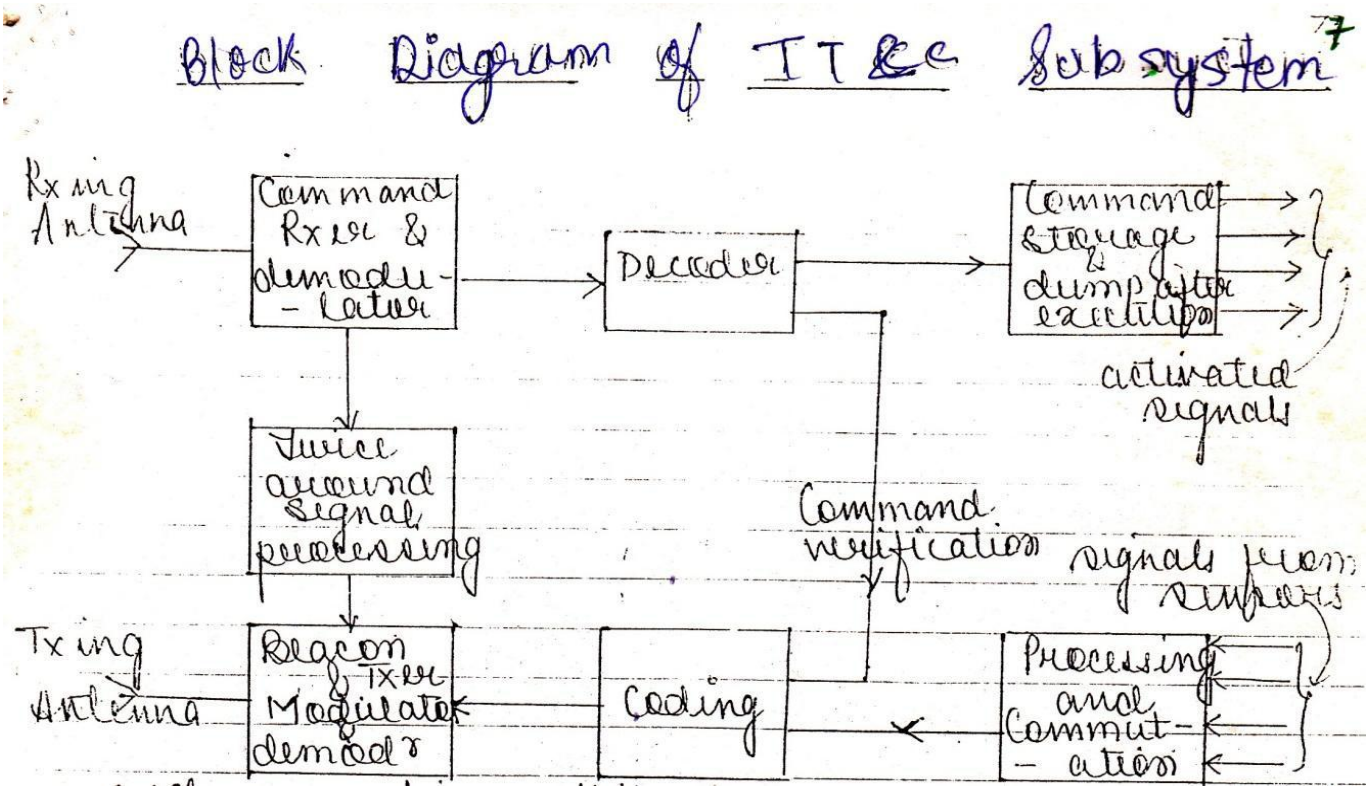


Telemetry, Tracking and Command (TT&C) Subsystem

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

1) To monitor the performance of all satellite subsystems and transmit the monitored data to the satellite control center via a separate Telemetry link.
2) To support the determination of orbital parameters.
3) To provide a source to earth station for tracking.
4) To receive commands from the control center for performing various functions of the satellite. Typical functions include:
    a. To correct the position and attitude of the satellite.
    b. To control the antenna pointing and communication system configuration to suit current traffic requirements.
    c. 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) Attempt any ONE: 6

a) Derive the radar range equation and describe the factors affecting the maximum range of radar.

Ans:- (4M-derivation, 2M-factors)

The Radar range equation is given by,

Power density at a distance R from isotropic antenna

$$R = \frac{P_t}{4\pi R^2} \text{ watts/m}^2$$

Power density at a distance R from directive antenna of gain G.

$$= \frac{P_t G}{4\pi R^2} \text{ watts/m}^2$$

The total power intercepted by a target having area 'A' is

$$= \frac{P_t G}{4\pi R^2} \cdot A \text{ watts}$$ where A is area seen by radar

Power density of echo signal signal at radar station is

$$= \frac{P_t G A}{4\pi R^2} \cdot \frac{1}{4\pi R^2} \text{ watts.}$$

The radar antenna captures a portion of echo power. Let effective area of receiving antenna is A_R the power P_r received by radar is.

$$P_r = \frac{P_t G A A_R}{(4\pi R^2)^2} \text{ watts}$$

$$R_{max} = \left(\frac{P_t G^2 \lambda^2 A}{(4\pi)^3 S_{min}} \right)^{1/4}$$

Factors affecting radar range:

1. Transmitter Power:

In case the radar range is to be doubled, we have to increase the transmitter power 16 times since Rmax α (Pt)1/4

2. Minimum Detectable Signal:

Rmax α (1/Smin)1/4 ; thus redusing Smin, the receiver has to be very sensitive and gain of the Rx should be high.

But Rx is more susceptible to interference as it now amplifier weak signals rather than amplifying low power
received signals.

3. Frequency and Effective Area of Antenna:

Rmax α 1/√λ or Rmax α √f (□□□=c/f).this implies that increase in frequency increases the range. But, in a parabolic antenna, the beamwidth is given by λ/D where D is the diameter of the parabola. If λ is reduced, beamwidth becomes very narrow which reduces the tracking range of the radar . This is particularly is in case of a search radar where the sweep of the antenna that covers a portion of the sky will require a longer time. If the lobe beam width is very narrow. Thus, radar frequency cannot be increased far too much as the radar becomes ineffective although range may increase.

Also, Rmax α √Ae. Hence, range can be increased if effective area of antenna is increased. In order to increase effective area diameter D of parabolic antenna must be increased ,which in turn reduces the beamwidth.

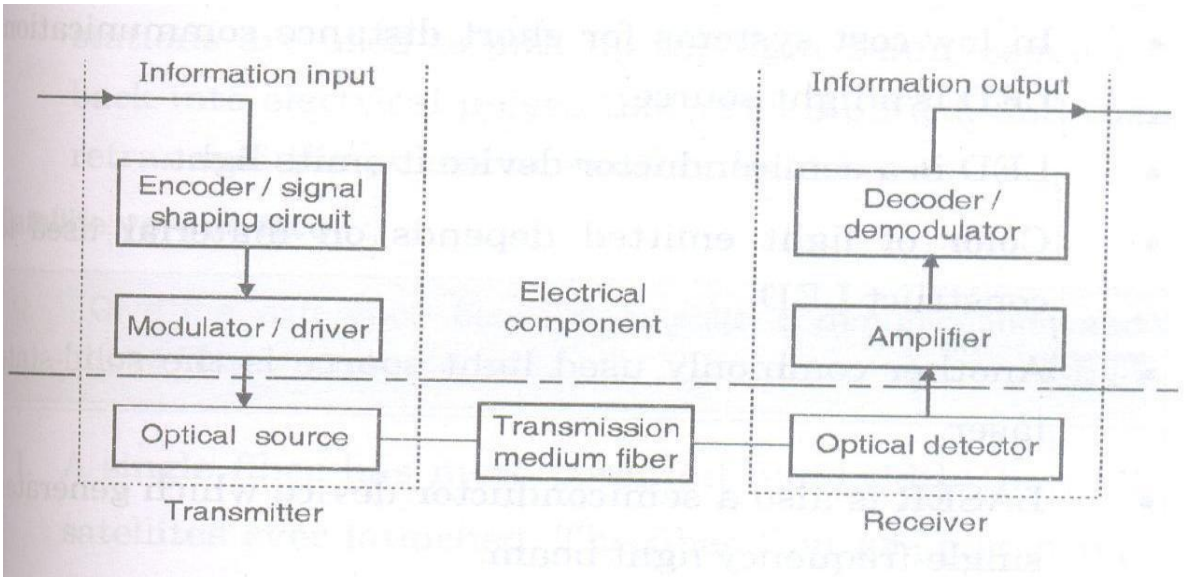
4.Target cross sectional area(□□):

The radar cross section of a target is the area of the target as seen by a radar. The radar cross sectional area of the target is not a controller factor

.

b) Draw and explain the block diagram of fiber optic communication system. List its advantages and disadvantages.

Ans: (4M- block diagram and explation,1M-advantages,1M-disadvantages)



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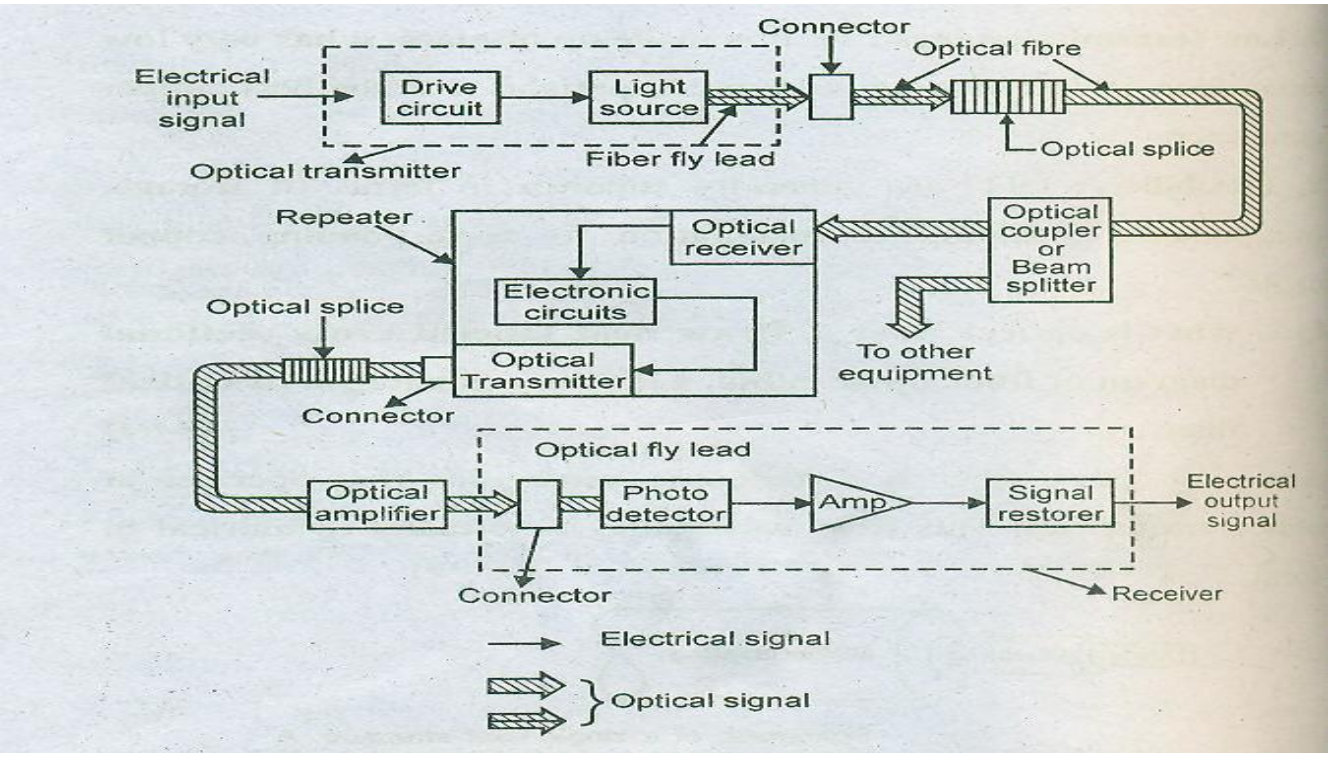


Transmitter:

1. The transmitter first converts the input voltage to current value which is used to drive the light source. Thus it interfaces the input circuit and the light source.

2. 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.

3. 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.

Advantages(any two):

1. Good information carrying capacity, which depends on bandwidth of the cable and fiber optical cable have much greater bandwidth.
2. Lower loss as there is less signal attenuation over long distances.
3. Fiber optical cable has lightweight and small size as compared to electrical cable.
4. Optical cable does not cause interface because they do not carry the signals, which cause interference.
5. Fiber optical cables cannot be tapped as easily as electrical cables.
6. Fiber optical cables do not carry electricity. Therefore, there is no shock hazard.
7. Fiber Optical cables are stronger than electrical cables.
8. Materials required for fiber optical cables are easily available.
9. They are simple in construction.

Disadvantages(any two):

1. Interfacing Costs:

To be practical and useful, they must be connected to standard electronic facilities, which often require expensive interfaces.

2. Strength:

Optical fibers by themselves have a significantly lower tensile strength than coaxial cable. This can be improved by coating the fiber with a protective jacket of PVC.

3. Remote electrical power:

Occasionally it is necessary to provide electrical power to remote interface or regenerating equipment. This cannot be accomplished with the optical cable, so additional metallic cables must be included in the cable assembly.

4. Optical fiber cables are more susceptible to losses introduced by bending the cable:

Bending the cable causes irregularities in the cable dimensions, resulting in a loss of signal power.

5. Specialized tools, equipment and training:

Optical fiber cables require special tools to splice and repair cables and special test equipment to make routine measurements. Sometimes it is difficult to locate faults in optical cables because there is no electrical continuity.

5. Attempt any FOUR **16**

a) Describe the function of following w r to waveguide:

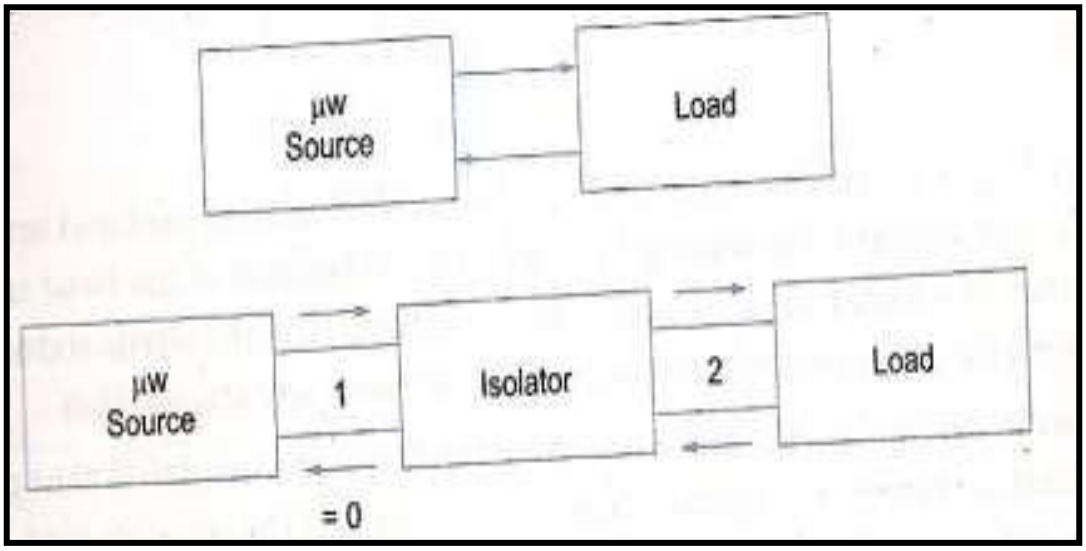
i) Isolators (2marks for function) ii) Circulators (2marks for function)

Function:

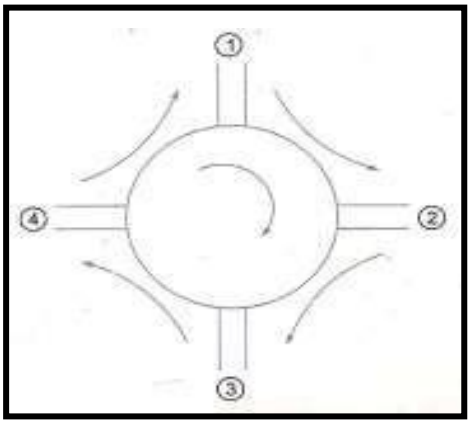
i. **Isolator**: An isolator is a 2 port device which provides very small amount of attenuation for transmission from port 1 to port 2 but provides maximum attenuation

for transmission from port 2 to port 1. This is very desirable when we want to match a source with a variable load.

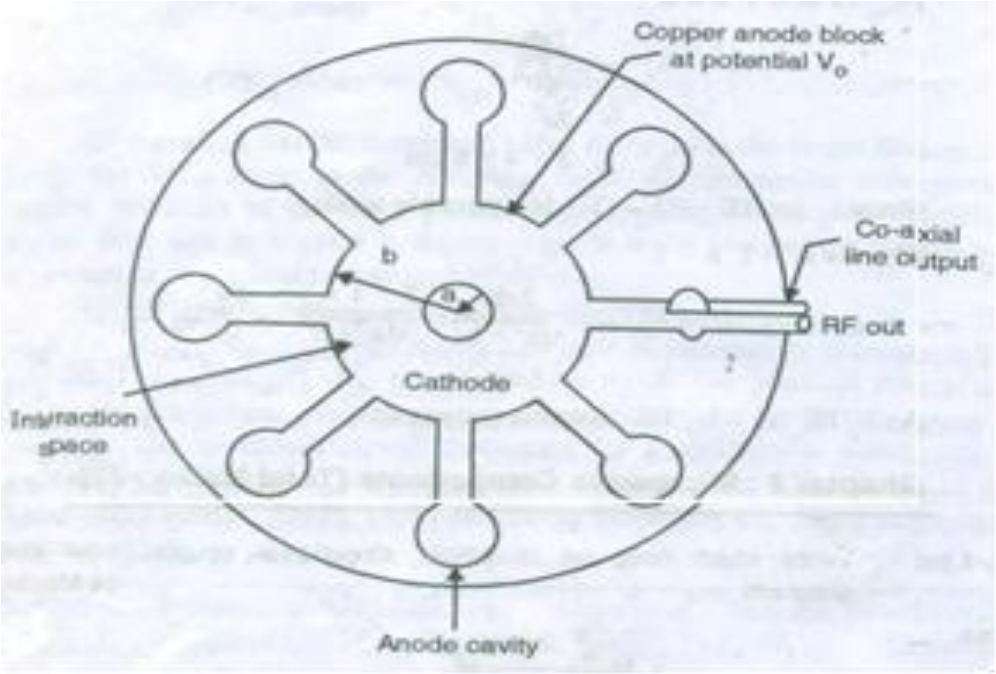
When an isolator is inserted between the microwave generator and the load, generator is coupled to the load with zero attenuation and reflections if any from the load side are completely absorbed by the isolator without affecting generator output.



ii. **Circulator**: A circulator is a 4 port microwave device which has a property that each terminal is connected only to the next clockwise terminal. They are useful in parametric amplifiers, tunnel diode, amplifiers and duplexers in radars.



b) Draw the construction of magnetron. Describe it's working. (2marks for diagram and 2 marks for working)



A magnetron is a very high frequency diode which is used for production of high power oscillatory waveform.A gap is maintained between the cathode and anode .output can be taken from any one of the cavity because of magnet present in any one of the tube.

When an electron is emitted by a cathode and if no magnetic field is present ,then electron will straight away strike the anode .when a small magnetic field is applied across the elctron ,it will be extended by an external force and tress to move into anti clock wise direction.the elctron is striking the anode and bending into the cavity towards the left.when magnetic field strength is strong ,the electon will not cross the barrier and it will bend back and strike the cathode .if magnetic field is strong then electron will try to reflect back from very short distance inside cavity.

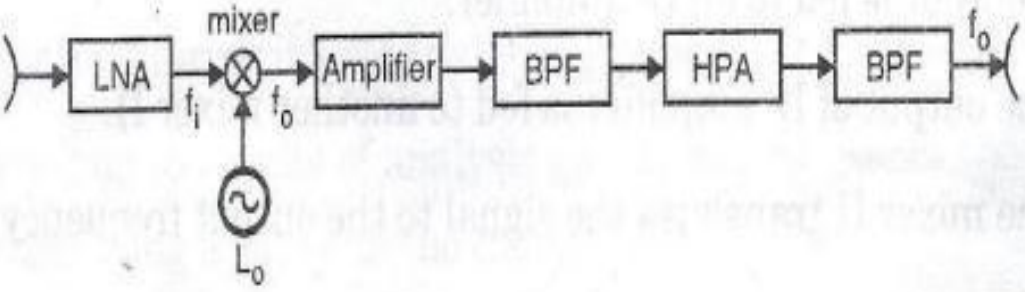
c) Compare between edge emitter and surface emitter LEDs. (Any 4-1 mark each)

SR. No.	Surface emitter LED	Edge emitter LED
1.	Easy to fabricate	Difficult to fabricate
2.	Easy to mount and handle	Difficult to mount and handle
3.	Require less critical tolerances	Need critical tolerance on fabrication

4.	Less Reliable	Highly reliable
5.	Low system performance	High system performance
6.	Less modulation Bandwidth	Better Modulation, Bandwidth of the order of hundreds of MHz
7.	Couple less optical power into low NA fiber	Couple more optical power into low NA fiber
8.	Light is emitted from the surface of active Layer	Light is emitted from edge of active Layer
9.	Wider spectral width	Narrow spectral width
10.	Maximum quantum efficiency is up to 60%	Internal quantum efficiency is in the range of 60% to 80%

d) Draw the block diagram of communication channel subsystem and state its principle of operation. . (2marks for diagram and 2 marks for explaination)

(a) **Single - conversion transponder :**



1. In this transponder only a single-frequency translation process takes place
2. First uplink frequency signal is picked up by the receiving antenna and is routed to LNA (Low Noise Amplifier)
3. The signal is very weak at this point, so LNA amplifies the signal
4. Once the signal is amplified, it is translated in correct frequency by mixer.
5. The output of mixer is then amplified again and fed to band pass filter (BPF1)
6. BPF1 allows only a desired down-link signal of 4 GHz

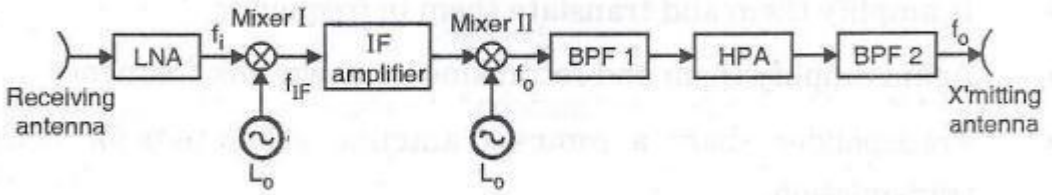
7. At last, the down-link signal is amplified by high power amplifier (HPA) usually TWT (Travelling wave tube)

8. Again output of BPF2 is fed to the down-link antenna

9. If common antenna is used for transmission or reception then diplexer is used to share the antenna.

OR

Double - Conversion transponder :



1. First uplink signal is received by the receiving antenna.

2. LNA amplified the received signal.

3. Amplified signal first fed to first mixer (1).

4. The mixer 1 translates the received signal frequency into intermediate frequency (typically 70 and 150 MHz). If output is fed to an IF amplifier.

5. The output of IF amplifier is fed to another mixer 2.

6. The mixer 2 translates the signal to the output frequency.

BPF1 filters the output signal and eliminates the unwanted output

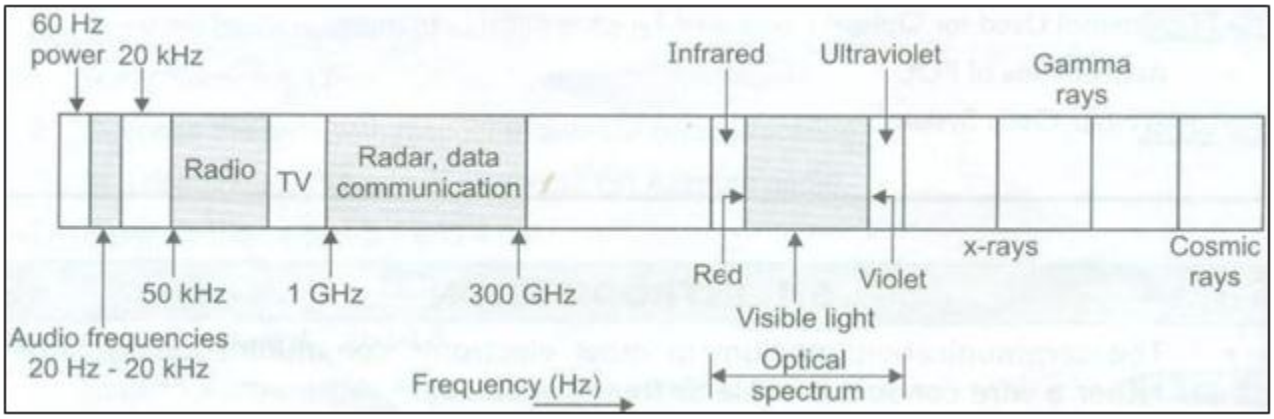
8. HPA increases the output signal level.

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

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

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

e) Classify the optical fibers based on bands and specify their operating frequency range. (2marks for diagram and 2 marks for frequency range)



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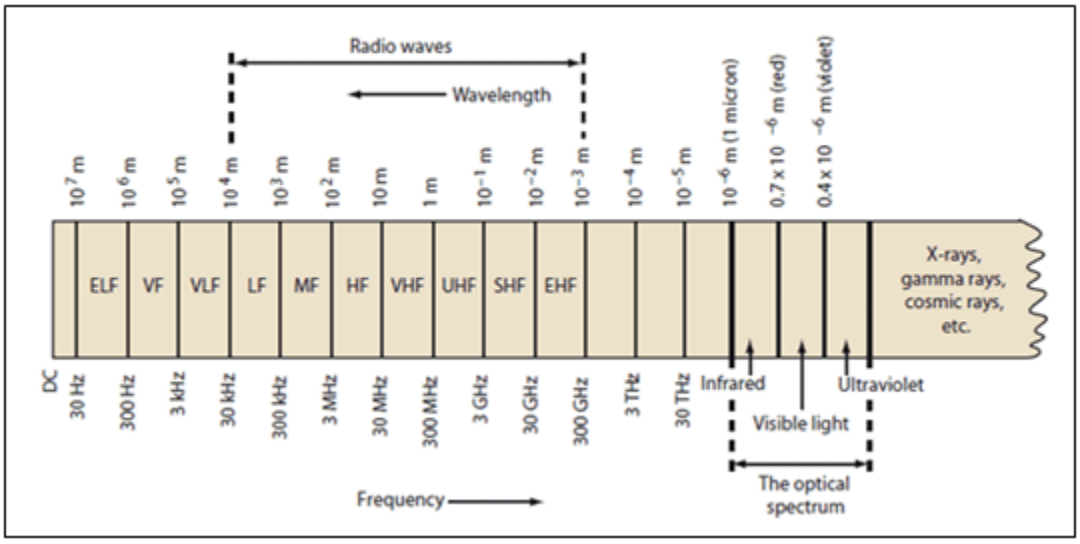


Band Name	Wavelengths
O-band	1260 – 1360 nm
E-band	1360 – 1460 nm
S-band	1460 – 1530 nm
C-band	1530 – 1565 nm
L-band	1565 – 1625 nm
U-band	1625 – 1675 nm

f) List and explain the properties of splicing.(2Marks List, 2 marks Explanation)
Properties:

5) Work Site Preparation:

Careful site preparation is essential to produce a reliable fusion splice. Adverse environmental conditions such as dust, precipitation, high wind and corrosive atmospheres should be controlled to avoid problems with fiber alignment and contamination. Once the fiber is stripped, cleaved and cleaned, speed is essential to minimize contamination-related problems. Contamination on the bare fiber surface during the arc-fusion step may increase splice loss, reduce splice tensile strength, or both.

6) Cable Preparation:

Cable preparation and handling procedures for a particular cable design normally are recommended by the specific cable manufacturer, and should be followed carefully. However, some general fiber-related precautions apply for all cable designs. Sufficient individual fiber lengths should be available such that when each spliced fiber pair is completed, the slack fiber will mount properly into the organizer without sharp bends or kinks. Also, some excess fiber length may be required should an unacceptable splice need to be remade.

7) Fiber Preparation:

Fiber Stripping:

The fiber coating can be removed by a number of techniques such as a mechanical stripping tool, thermal stripping equipment, or chemically. For typical acrylate-coated fibers, mechanical stripping is recommended because it is fast, safe, inexpensive and creates a well-defined coating termination. It is important to note that, when mechanically or thermally stripping fibers, care must be taken to avoid damaging the fiber surface. The stripping tool should be the proper size and designed for the fiber and coating combination being stripped. Also, to avoid damage to the glass surface, no more than two inches of the coating should be stripped at one time. Chemicals that soften the acrylate coatings are slower and create a poorly defined coating termination. Additionally, residual action of chemicals may cause the acrylate coating to soften and degrade long after the splice has been packaged, potentially causing splice failure. For this reason, all fibers exposed to the chemical solvent must be thoroughly cleaned after stripping.

Surface Cleaning:

Any acrylate coating residue that remains after stripping should be removed from the bare fiber surface. A clean, lint-free cotton (or alcohol-soaked) pad gently pulled over the fiber surface works well for most mechanically stripped fibers with acrylate coatings. It is important to handle bare fibers as little as possible from this point until the splice is complete. Taking this precaution will minimize the chance of contaminating the fibers with dust or body oils, which may contribute to higher splice losses and lower tensile strengths. It also is important to complete

the remaining splicing process as quickly as possible, since delays will expose the fiber to additional airborne contaminants. Failure to utilize careful cleaning practices may cause the glass surface to become abraded leading to lower splice strength.

Fiber-end Angle:

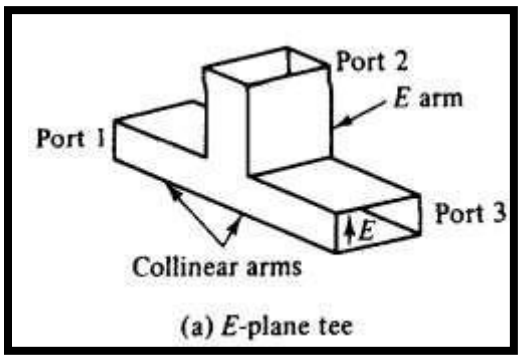
Since the primary attribute affecting single fusion splicing is the end angle, proper fiber-end preparation is a fundamental step in obtaining an acceptable fusion splice. Fiber-end angle requirements vary slightly from user to user, depending on the splice loss requirements and the cleavers used. However, in general, end angles less than two degrees yield acceptable field fusion splices (typical end angles with well-controlled cleavers are around one-half

6. Attempt any FOUR **16**

a) Describe the function of following junctions(1 marks diagram and 1 marks explanation for each)

i) E Plane junction ii) H Plane junction in microwave transmission.

E Plane junction



(a) *E*-plane tee

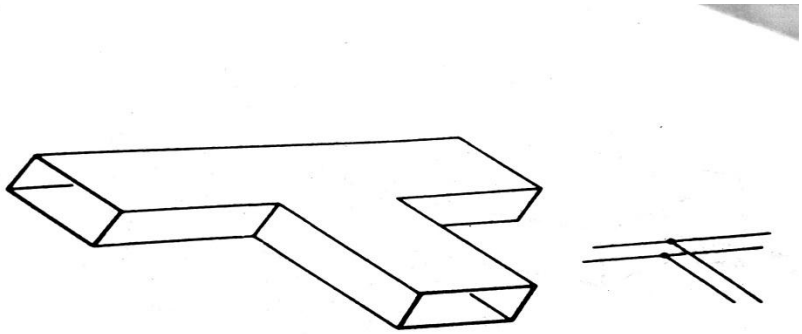
Explanation:

The E-plane tee is a voltage or series junction. Each junction is symmetrical about the central arm, so that the signal to be split up is fed into it or signals to be combined are taken from it. Some form of impedance matching is required to prevent unwanted reflections. (When mode is made to propagate into port 3, the two outputs at port 1 and port 2 will have a phase shift of 180° as shown in figure (a.)). Also, when powers entering port 1 and 3 are in phase

opposition, maximum energy comes out of port 2.

An input at port 2 equally divides between ports 1 and 3 but introduces a phase shift of 180° between the outputs. Hence E-plane Tee also acts as a 3dB splitter.

H-Plane Junction:



Hplane Tee is so called because the axis of side arm is parallel to planes of H-field of main transmission line.
As all three arms of H plane tee lay in the plane of magnetic field,the magnetic field divide itself in arms this is thus the current junction.
Since the electricity is not bent as the wave passes through a Hplane junction but merely divide between two arms ,fields of same polarity approaching the junctionfrom two main arms produce component of electric field that add in side arm
The effective valve of field leaving through the side arm is proportional to phasor sum of entering fields.

b)State and explain the characteristics of optical fibers.(any 4-1mark each)

1. **Extremely wide system bandwidth:**
   Fiber systems have greater capacity due to the inherently larger BWs available with optical frequencies. Metallic cables exhibit capacitance between and inductance along

their conductors. These properties cause them to act as low pass filters which limit their transmission frequencies and hence bandwidths.

2. **Immunity to electromagnetic interference:**
Fiber cables are immune to static interference caused by lightning, electric motors, fluorescent light and other external electrical noise sources. This immunity is due to the fact that optical fibers are non-conductors of electricity. Also fiber cables do not radiate RF energy and therefore cannot cause interference with other communication system.

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

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

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

6. **More resistive to environmental extremes and non-corrosiveness:**
Fiber cables operate over a larger temperature variation than their metallic counterparts and fiber cable are affected less by corrosive liquids and gases. Fibers are used around volatile liquids and gases without worrying about their causing explosions.

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

8. **Conservation of the earth's resources:**
The supply of copper and other good electrical conductors is limited whereas the principal ingredient of glass is sand and it is cheap and in unlimited supply

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

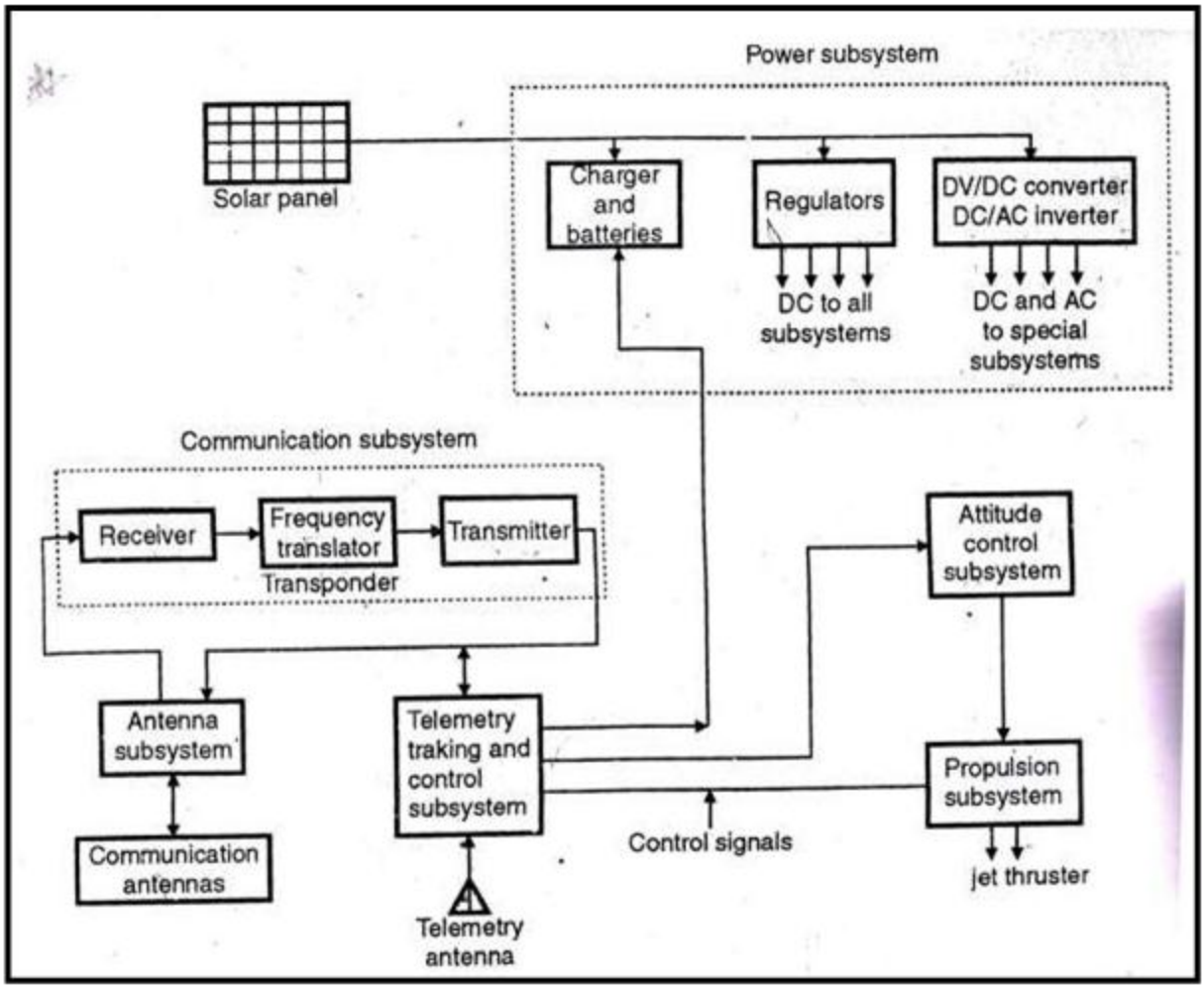
10. **Safety:**

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

c) Differentiate between fusion splice and V- groove splice.(Any 4 difference- 1 mark each)

Fusion Splicing	V-groove Splicing
Fusion splicing is the method of joining two optical fiber end to end using heat	V groove align two fiber in a small glass tube with a hole just slightly larger than the outer diameter of the fiber
The source of the necessary heat is usually an electric arc	It is formed by sandwiching the butteend between a v grove glass substrate and the flat glass retainer plain
Fusion splicing does not have higher insertion loss	It has a very high insertion loss
It has a high reliability	It has a low reliability
It has a very less return losses	It has a very high returned Losses
It is used for single mode fiber product	It is used for single fiber and fiber ribbons
It is expensive	It is inexpensive
It is not a simplest method of splicing	It is simplest method of splicing.

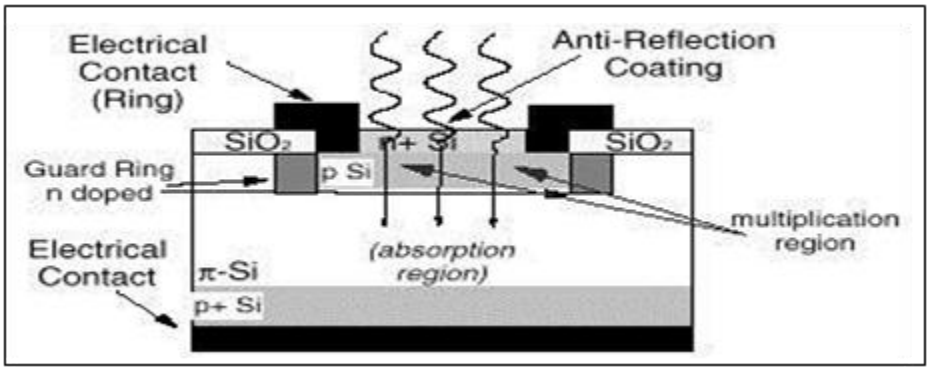
d) Describe the antenna subsystem of satellite. (2marks for diagram and 2 marks for discription)

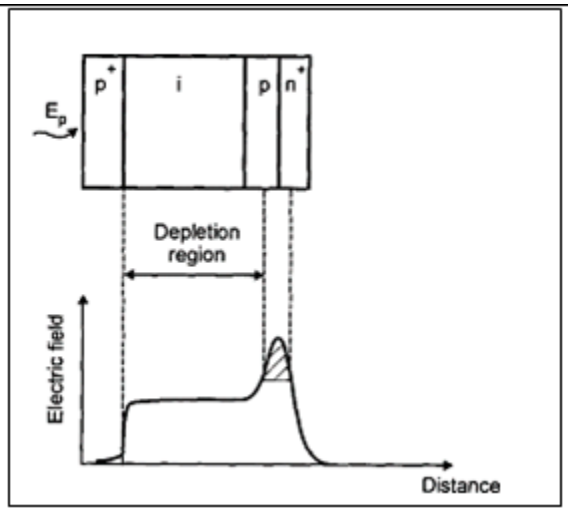


The antenna subsystem are complicated mechanical assemblies that are folded into dense packet for launch and must be deployed in large accurately alight assembly during orbit. Antenna receive the uplink signal and transmit the downlink signal .In addition they provide a signal link for satellite telemetry command and ranging system which alone with the attitude control sub system provide tracking signal for precise pointing of antenna towards the earth coverage area.

Satellite communication system uses a variety of antenna system. This maybe linear dipole, helix, horn antenna array and parabolic reflector. However, the parabolic reflector is most commonly used antenna as it gives a highly directional symmetric radiation pattern.

e) Draw the construction of avalanche photodiode. State its working principle. (2marks for diagram and 2 marks for working)





Working Principle:

- 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-n^+ layer. Because of the high field intensity, electrons are imparted with high kinetic energy.
- The kinetic energy of electrons is greater than bandgap 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.