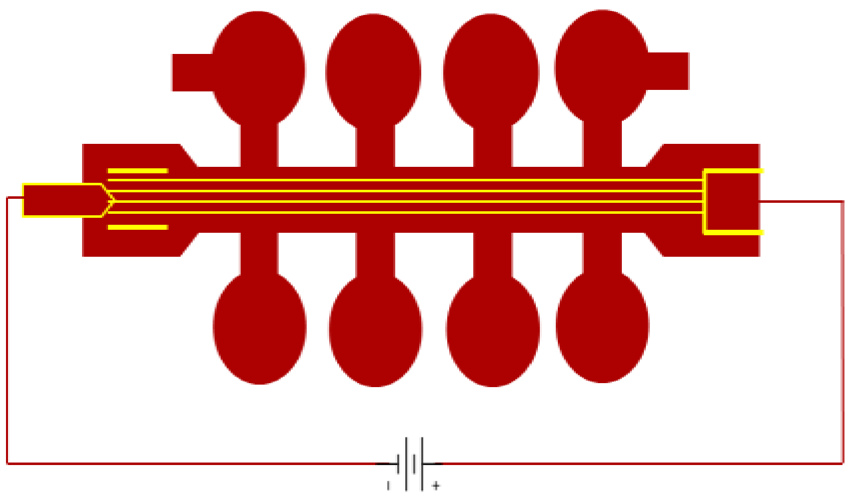
WINTER– 18 EXAMINATION

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

Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in 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. No.	Sub Q. N.	Answer	Marking Scheme
1	A	**Attempt any Three of the following**	12
	a)	**Define the term cut-off frequency and cut-off wavelength.State their mathematical formulae.** **Ans:** **Cut off frequency:** It is the frequency of the signal above which propagation of waves occur. $$f_c = \frac{c}{2}\sqrt{(\frac{m}{a})^2 + (\frac{n}{b})^2}$$ Therefore lowest frequency which can propagate on the waveguide is fc TE10. No energy can propagate in a rectangular waveguide at a frequency below fc TE10. This is absolute cut off frequency of the waveguide. **Cut off wavelength:** Cut off wavelength can be given as $$\lambda_c = \frac{c}{f_c}$$	1M each for correct definitions &1M each for correct formula

		Where $f_c = \frac{c}{2}\sqrt{(\frac{m}{a})^2 + (\frac{n}{b})^2}$ Therefore $\lambda_c = \frac{2}{\sqrt{(\frac{m}{a})^2+(\frac{n}{b})^2}}$ Cut-off wavelength for a parallel plane waveguide where only side walls are present i.e. only the a dimension is present. The formula will become; $\lambda_c = \frac{2a}{m}$	
	b)	**State significance of two cavities in multicavity Klystron.State its effect on Bandwidth.** **Ans:** **Multicavity Klystron:** A typical two cavity klystron tube gives 10 - 20 dB gain. A higher overall gain can be achieved by connecting several two cavity tubes in cascade, feeding the output of of each tube to the input of the next cavity.  *Figure: Multi Cavity Klystron* **Effect on Bandwidth:** 1.If the buncher cavities are tuned-off the center frequency from the input and output cavities,they have the effect of broadening the bandwidth of the tube. 2.The operating frequency of a klystron is set by the sizes of the input and output cavities. 3.Since cavities have high Q's their bandwidth is limited. 4.By lowering the Q's of the cavities and by introducing intermediate cavities,wider bandwidth operation can be achieved.	2M for significance with diagram & 2M for effect on Bandwidth

	c)	**State advantages and disadvantages of continuous wave Radar(Two each)** **Ans:** **Advantages continuous wave RADAR :** 1.Single frequency transmission and hence narrow receiver bandwidth 2.Duty cycle is unity, so mean power can be as high as transmitters will permits. 3.Ability to see moving targets in presence of large number of echoes from stationary target to which it is blind. 4.Target velocity can be measured using Doppler shift. 5.Zero minimum range. 6.Simple to design and construct. **Disadvantages of continuous wave RADAR** 1.No timing marks, so unable to measure range. 2.Separate antennas are required for receiver and transmitter. 3.Cannot detect targets crossing its beam at right angles.	2M each for correct advantages and disadvantages
	d)	**Define the term Geostationary satellite:State its advantages.** **Ans:** **Geostationary satellite:** A geostationary satellite is an earth-orbiting satellite, placed at an altitude of approximately 35,800 kilometers (22,300 miles) directly over the equator, that revolves in the same direction the earth rotates .At this altitude, one orbit takes 24 hours, the same length of time as the earth requires to rotate once on its axis. The term geostationary comes from the fact that such a satellite appears nearly stationary in the sky as seen by a ground-based observer. **Advantages of Geostationary Satellites:** 1. This satellite remains almost stationary in respect to a given earth station. Consequently expensive tracking equipment is not required at earth stations.	2M for definition & 2M for advantages

2. High altitude geosynchronous satellites can cover a much larger area of the earth than their LEO satellite counterpart.

3. There is no need to switch from one satellite to another as they orbit overhead. Consequently there are no breaks in transmission because of switching times.

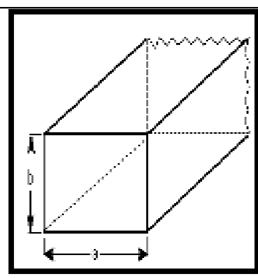
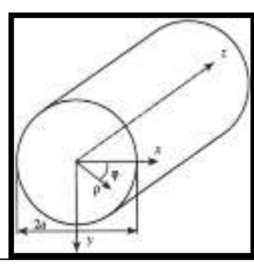
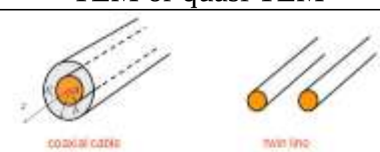
4. The effects of Doppler shift are negligible.

1(B) **Attempt any One of the following** — 6

a) **Compare waveguide and transmission line on the basis of definition,operating mode,construction,frequency range,applications & limitations**

1M each for correct comparison point

Ans:

Parameter	Waveguide	Transmission line
Definition	A waveguide is a hollow metallic pipe design to carry microwave energy from one place to another	Transmission on line is a conductor or wire designed to carry electrical energy below microwave range from one place to anoth
Operating mode	TE or TM	TEM or quasi TEM
Construction	 	
Frequency range	Used for Microwave frequency above 1GHz	Used for RF up to 500 in GHz. Upto 18 GHz. For short distance.
Applications	For microwave frequency range to connect transmitter to transmitting antenna and receiving antenna to	For low frequency range to connected transmitter to transmitting antenna and receiving antenna to receiver Ex-T.V.

	receiver Ex-Radar	
Limitations	If the other end is also closed, then the hollow box so formed can support a signal which can bounce back and forth between two shorting plates resulting in resonance.	If one of the end of the waveguide is closed using a shorting plate, there will be a reflection and hence standing waves will be formed

Q. No.	Sub Q.	Answer	Marks
	b)	**State the name of microwave diode suitable for following each application.** **1.Microwave Oscillator** **2.Replacing TWT Transmitter** **3.Microwave power switching** **4.Airborne Radar** **5.Logic operations** **6.Pulse modulation** **Ans:** 1.Microwave Oscillator-Gunn diode 2.Replacing TWT Transmitter-IMPATT diode 3.Microwave power switching-PIN diode 4.Airborne Radar-IMPATT diode 5.Logic operations-Tunnel diode 6.Pulse modulation-PIN diode	1M each for identification of correct microwave diode
2		**Attempt any Four of the following**	16
	a)	**For a rectangular waveguide with a wall separation of 4 cm and a desired frequency of**	1M each for formula & 1M each for

operation is 8 GHz determine cut-off frequency & Phase velocity.

correct answer

Ans:

Q2 a) a = 4 cm, f = 8 GHz

Cut off frequency:

$$f_c = \frac{c}{2a} = \frac{3\times10^8}{2(0.04)} = 3.75\ \text{GHz} = 3.75\times10^9\ \text{Hz}$$

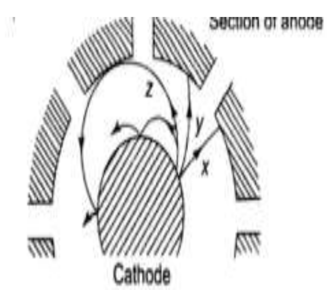
Phase velocity:

$$v_{ph} = \frac{c}{\sqrt{1-\left(\frac{f_c}{f}\right)^2}} = \frac{3\times10^8}{\sqrt{1-\left(\frac{3.75\ \text{GHz}}{8\ \text{GHz}}\right)^2}} = 339.62\times10^6\ \text{m/sec}$$

b) **With neat cross sectional constructional details,write effect of magnetic and electric field in magnetron**

2M for diagram & 2M for Explanation

Ans:



Electron paths in magnetron without oscillations, showing effect of increasing magnetic field.

1)When magnetic & electric fields act simultaneously upon the electron,its path can have any of a number of shapes dictated by the resistive strengths of the mutually perpendicular electric & magnetic fields.

2)Some of these electron paths are shown in figure in the absence of oscillations in a magnetron in which the electric field is constant and radial and the axial magnetic field can have any number of values.

3)When the magnetic field is zero,the electron goes straight from the cathode to anode accelerating all the time under the force of the radial electric field.

4)This is indicated by path x in figure.

5)When the magnetic field has a small but definite strength ,it will exert a lateral force on the electron,bending its path to the left as shown in figure by path y,that the electrons motion is no longer rectilinear.

6)As the electron approaches the anode its velocity continues to increase radially as it is accelerating.

7)The effect of magnetic field upon it increases also.

8)It is possible to make the magnetic field so strong the electrons will not reach the anode at all.

9)The magnetic field required to return electrons to the cathode after they have just grazed the anode it is called the cut off field.The resulting path is z shown in figure.

10)Knowing the value of the required magnetic field strength is important because this cut off field just reduces anode current to zero in the absence of oscillations.

11)If the magnetic field is stronger still,the electron path as shown will be more curved still and the electrons will return to the cathode even sooner(only to be reemitted)

12)All these paths are naturally changed by the presence of any RF field due to the oscillations but the state of affairs without the RF field must still be appreciated for two reasons.

a)First it leads to the understanding of the oscillating magnetron.

b)Second it draws attention to the fact that unless a magnetron is oscillating ,all the electrons will be returned to the cathode ,which will overheat and ruin the tube .

13)This happens because in practice the applied magnetic field is greatly in excess of the cutoff field.

c)

State RADAR range equation and write factor influencing maximum range.

Ans:

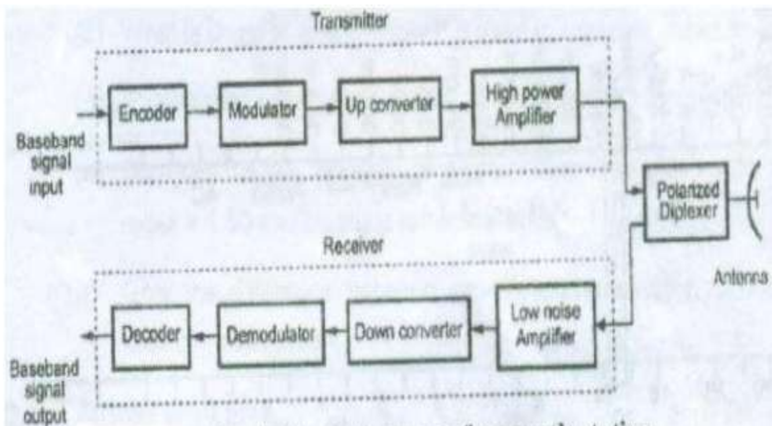
Free Space RADAR range Equation:

1.RADAR range equation relates the range of a RADAR to the chara. Of Tx, Rx, Antenna, target & environment.

2.Free space means RADAR and target are isolated in an unbound empty space.

2M for RADAR range equation & 2M for factor influencing maximum

		3.There is no obstacle between RADAR antenna & the target. 4.There will be No absorption of EM waves. ***For Calculation consider*** ➔ If power of RADAR transmitter is Pt. ➔ An isotropic antenna (Omni direction) is used The power density at a distance R from RADAR is **$= P_t/4\pi R^2$ watts/m^2** Power density at distance R from directive antenna **$= P_tG/4\pi R^2$ watts/m^2** *G is the Gain of the antenna.* The amount of incident power intercepted by the target and radiated back in the direction of RADAR is denoted as RADAR cross-section of target **(σ)** The power density of echo signal at the RADAR station = **$(P_tG\sigma/4\pi R^2) \times (1/4\pi R^2)$** Power Received by RADAR is: **$Pr = PtG\sigma Ae/(4\pi R^2)^2$ watts** **Maximum RADAR range Equation** It is the distance beyond which target cannot be detected. It occurs when received echo signal power just equals the minimum detectable signal (Smin) i.e. when Pr = Smin, R= Rmax. Equation becomes: **$S_{min} = P_tG\sigma Ae/(4\pi)^2R_{max}^4$** **$R_{max} = [P_tG\sigma Ae/(4\pi)^2S_{min}]^{1/4}$** From Antenna theory: G = gain of transmitter **$G = 4\pi Ae/(\square\lambda^2)$** **Therefore $R_{max} = [(P_tG^2\sigma\square\lambda^2)/(4\pi)^3S_{min}]^{1/4}$** **The factors influencing maximum range are as follows :** **1.Transmitted power (Pt):** if the radar range is to be doubled we have to increase a transmitted power by 16 times. **2.Frequency(f) :** increase in frequency increase the range **3.Target cross sectional area(S):** Radar cross sectional area of the target is not a controllable factor. **4.Minimum received signal (Pmin):** A decrease in minimum receivable power will have	range.

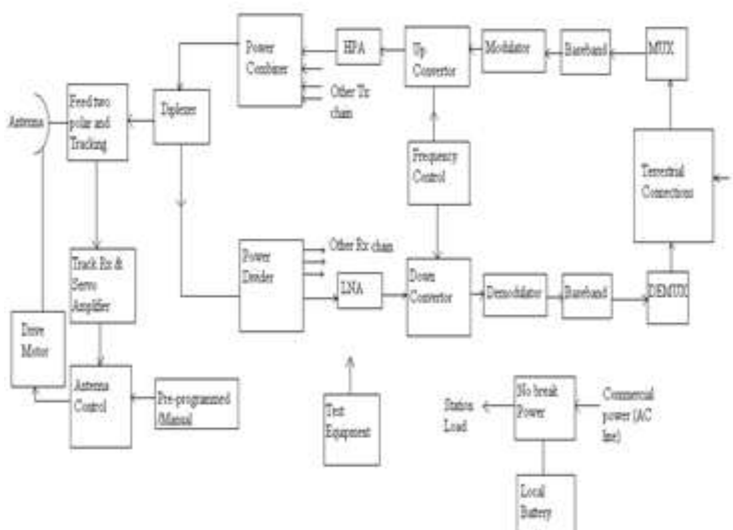
		the same effect has raising the transmuting power.	
	d)	**Sketch block diagram of satellite earth station and state functions of each block** **Ans:**  Basic block diagram of an earth station Satellite earth station: The communication is established to the satellite through earth station. The earth station 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	2 M for Diagram & 2M for Explanation

(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.

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

OR



The figure below shows the general block diagram of an earth station capable of transmission, reception and antenna tracking. The following are the major subsystems of the earth station –

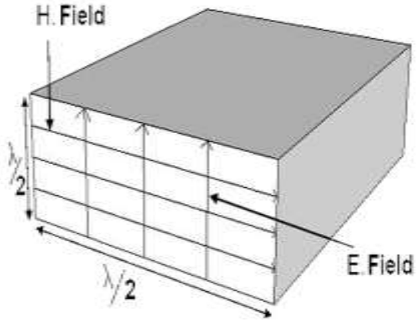
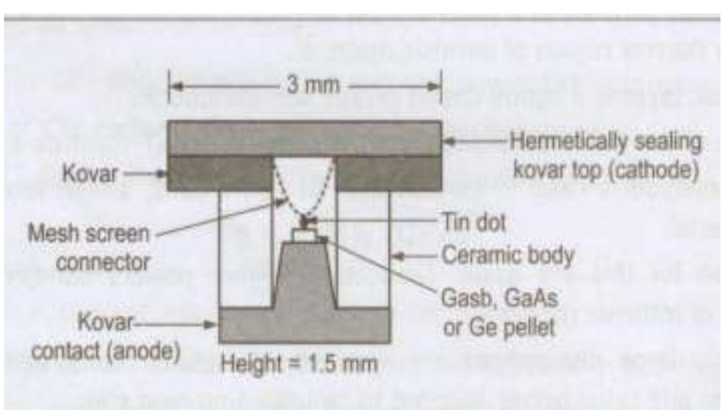
Transmitter:

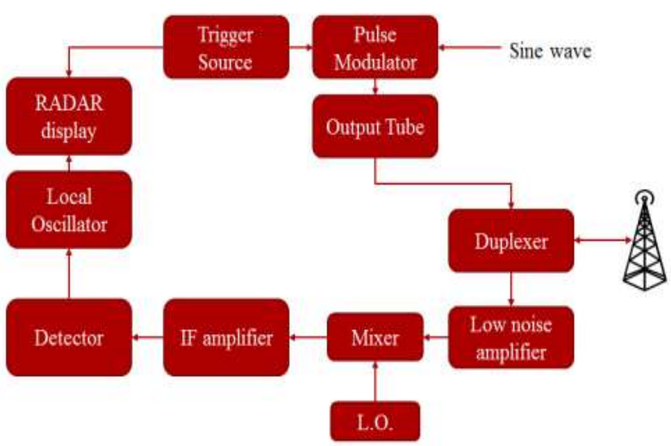
There may be one or many transmit chains depending on the number of separate carrier frequencies and satellites with which the station must operate simultaneously.

It consists of MUX, modulators and filters, HPA. Microwave transmitters are expensive devices that employ costly HPA's such as TWTA and multi-cavity klystrons.

		Receiver: There may be many receiver chains depending on the number of separate frequencies and satellites to be received and various operating conditions. The receiver subsystem consists of LNA and filters, down convertors, filters, demodulators and DEMUX equipment. **Antenna:** Usually one antenna is used for both transmission and reception but not necessarily. Within the antenna subsystem are the antenna reflector and feed, separate feed systems to permit automatic tracking and a duplexer and MUX arrangement to permit simultaneous connection of many transmitters and receiver chains to the same antenna. **Tracking System:** This comprises of control circuit and drive which are necessary to keep the antenna pointed at the satellite. Tracking system keeps antenna pointing in the direction of the satellite in spite of relative movement of the satellite and the station. **Terrestrial Interface:** This is the interconnection with whatever terrestrial system if any is involved. In case of small receive only and transmit only stations, the user may be at the earth station itself. **Power Subsystem:** This system includes the primary sources (the standard AC lines) for running the earth station. The subsystem operates power supplies which distribute a variety of dc voltages to the other equipment. The power subsystem also consists of emergency power sources such as diesel generators, batteries and inverters to ensure continuous operation during power failures. It often includes provision for no break changeover from one source to another. **Test Equipment:** This includes the equipment necessary for routine checking of the earth station and terrestrial interface, possible monitoring of satellite characteristics and occasionally for the measurement of special characteristics.	
	e)	**State any four advantages and four disadvantages of fiber optic communication** **Ans:** **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. **Disadvantage of fiber optic communication:**	2M each for correct advantages and disadvantage s

		1.Its small size and brittleness make its difficult to work with. 2.Special expensive tools and techniques required. 3.High cost 4. With fragile material and poor mechanical strength 5.The bending radium of optic fiber cable can not be too short（>20cm). 6.Separation and coupling are not flexible 7.Requiring more protection around the fiber cable compared with copper cable	
	f)	**Define the term multimode fiber,step index fiber,Graded index fiber and single mode fiber.** **Ans:** **Multimode fiber:** A fiber having core radius large,supports hundreads of modes & lesser bandwidth also suitable for short distance communication is called Multi mode fiber. **Step index fiber:** For an optical fiber, a step-index profile is a refractive index profile characterized by a uniform refractive index within the core and a sharp decrease in refractive index at the core-cladding interface so that the cladding is of a lower refractive index **Graded-index fiber:** The core refractive index is made to vary as a function of the radial distance from the center of the fiber is called Graded index fiber **Single mode fiber:** A fiber having core radius small,supports one mode of operation & larger bandwidth also suitable for long distance communication is called single mode fiber.	1M each for correct definitions

3		Attempt any FOUR	16
	(a)	Sketch field pattern for TE_{11} mode of Rectangular wave guide. State its any two advantages. TE_{11} mode  Advantages: 1.The electric field shows a half wavelength variation of intensity along width and height of the waveguide 2. It uses the top and bottom walls for propagation in addition to the sidewalls.	Sketch – 2 mks, any 2 advantages- 2 mks
	b)	Sketch constructional diagram of Tunnel diode and state any four features.  	Constructional diagram- 2 mks, Any 4 features- 2 mks

		Features-1. Provides oscillations upto 100GHz 2. High speed switching device 3.Exhibits negative resistance characteristics 4.It is a 1000 times heavily doped diode	
	c)	Explain Pulse Radar with neat block diagram.  **Explanation :** The Block diagram of high power Pulsed RADAR set is shown in fig. Above. **Trigger Source:** It Provides pulses for the modulator. **Pulse Modulator:** This Modulator provides rectangular voltage pulses which act as the supply voltage to the output tube, thus switching ON & OFF as required. **Output tube:** It may be an oscillator tube such as a magnetron oscillator or an amplifier such as klystron, TWT or crossed field amplifier. If an amplifier is used, a source of microwave is also required. The pulse modulated sine wave carrier then travels via duplexer to the antenna where it is radiated into space. A single antenna is generally used for both transmission & reception. Usually parabolic	Block diagram- 2 mks, explanation- 2 mks

reflectors with center feed arrangements is used.

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

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

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

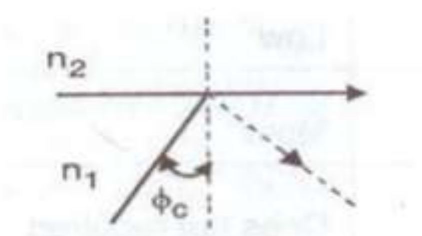
Mixer & Local Oscillator: These converts RF signal output from RF amplifier to comparatively lower frequency levels (IF). Thus, in a mixer stage, the Carrier frequency is reduced.

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

Detector: The Detector is often is a schottky-barrier diode which extracts the pulse modulation from the IF amplifier output. The detector output is the amplified by the video amplifier to a level where it can be properly displayed usually on CRT directly or via computer processing and enhancing. Sync pulses are applied by the trigger source to the display devices or the display indicator.

2 mks

	d)	State frequency range for up link and down link for C band and Ku band for satellite C band and ku band frequency value –**For C band**: Uplink frequency range = 5.9 GHz to 6.4GHz Downlink frequency range = 3.7 GHz to 4.2 GHz **For Ku band**: Uplink frequency range = 14 GHz to 14.5GHz Downlink frequency range = 11.7 GHz to 12.2 GHz	1 mks each

	e)	Define the term Numerical aperture, Acceptance Angle & Critical Angle for Optical fiber cable. Numerical Aperture and Acceptance Angle: The **Numerical Aperture (NA)** is a measure of how much light can be collected by an optical system such as an optical fibre or a microscope lens. The NA is related to the **acceptance angle θ_a**, which indicates the size of a cone of light that can be accepted by the fibre. Both numerical aperture and acceptance angle are linked to the refractive index via: $NA = n_a \sin\theta_a = (n_1^2 - n_2^2)^{1/2}$ Where n_1 = refractive index of core n_2 = refractive index of cladding n_a = refractive index of air (1.00) **Critical angle:** 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 ($\varnothing c$) = $\sin^{-1}$ (n2/n1)  	Each definition- 1 mks, formula for all – 1 mks

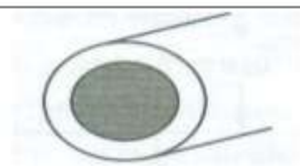
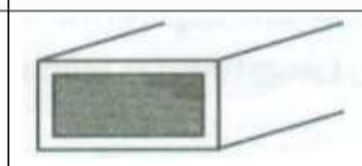
4 **A** Attempt any Three — 12

a) Compare:

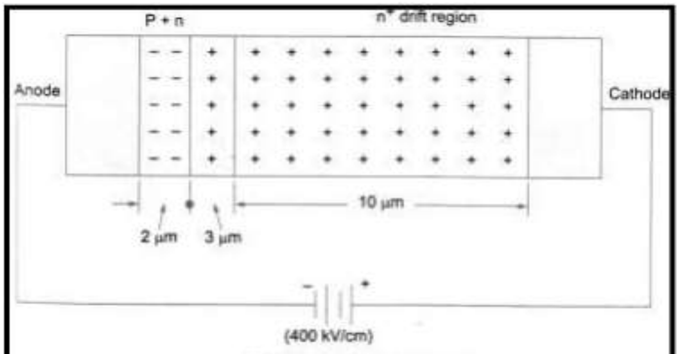
i) TE mode & TM mode
ii) Circular wave guide & Rectangular wave guide

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=$2ab/\sqrt{a^2+b^2}$

i)Any 2 points- 2 mks

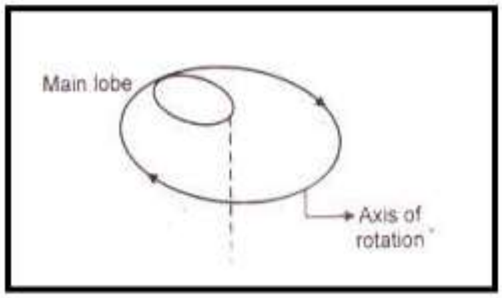
Sr. no	Parameter	Circular waveguide	Rectangular waveguide
1	Diagram		
2	Dominant mode	TE_{11}	TE_{10}
3	Manufacturing	Easy	Difficult compared to circular
4	Attenuation	Less	More
5	Cut off wavelength	Low	High
6	Power required	High	Low

ii)Any 2 points – 2 mks

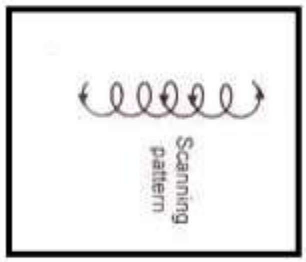
	b)	Sketch schematic diagram of IMPATT diode and write its working principle.  Fig. MPATT diode schematic. Working: • Any device which exhibits negative resistance for dc will also exhibits it for ac i.e., If an ac voltage is applied current will rise when voltage falls at an arc rate. • Hence negative resistance can also be defined as that property of a device which causes the current through it to be 1800 out of phase with voltage across it • Thus is the kind of negative resistance exhibited by IMPATT diode i.e., If we show voltage and current have a 1800 phase difference, then negative resistance in IMPATT diode is proved. A combination of delay involved in generating avalanche current multiplication together with delay due to transit time through a different space provides the necessary 1800 phase difference between applied voltage and the resulting current in an IMPATT diode.	Sketch – 2 mks, principle – 2 mks

	c)	State the meaning and sketch antenna scanning pattern for Horizontal scan, Helical scan, Spiral scan and Nodding Scan.	Each definition and pattern- 1 mks

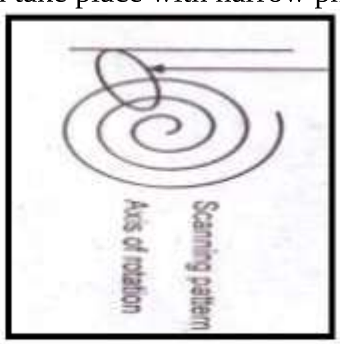
1) Horizontal Scanning: If scanning is required in only plane it is called horizontal scanning. e.g. Ship to ship communication, navigation.



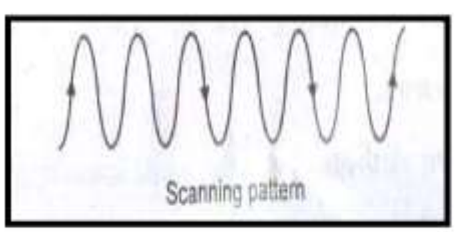
2) Helical: Elevation is slowly raised while it rotates more rapidly in assuming. Covers complete hemisphere and it takes place in both plane. e.g. tracking of satellite.



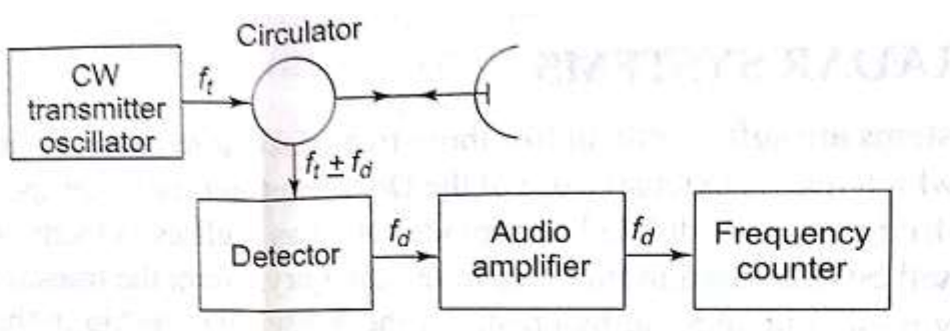
3) Spiral: It is required to scan limited area. When target is to be detected, scanning take place first with somewhat wide because of width. Whereas tracking is locate at exact position of target which take place with narrow phase shift beam width.

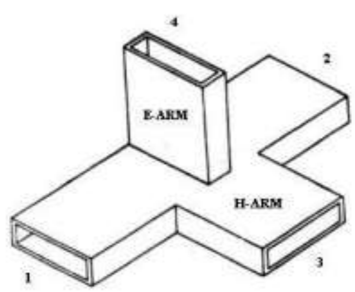


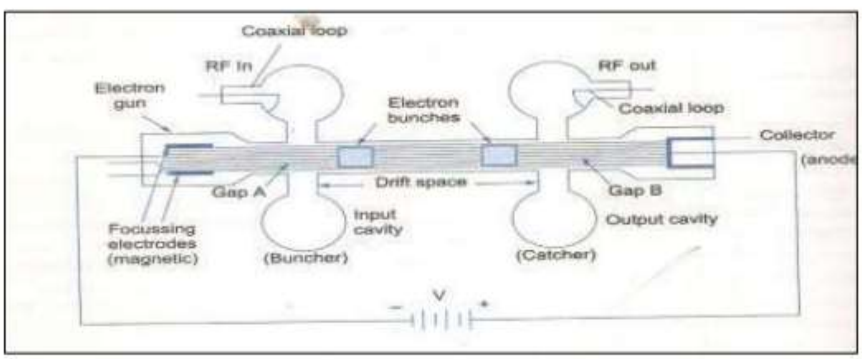
4) Nodding: In this scanning, antenna is moved rapidly assuming in slowly in elevation. It covers limited area or complete hemisphere

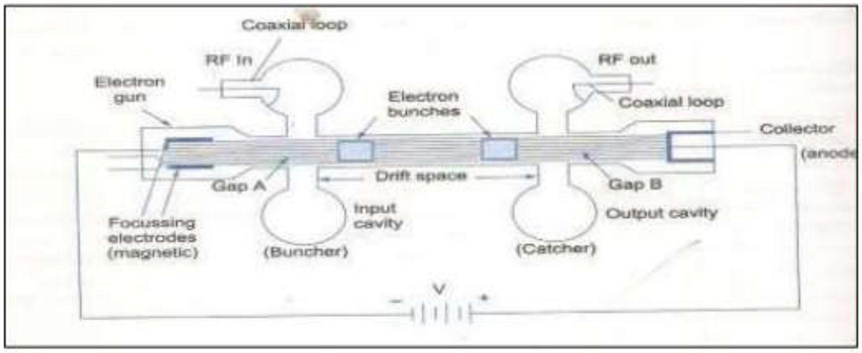


	d)	Why altitude control is essential for satellite? Hence write the role of altitude control subsystem for satellite? • The attitude of a satellite refers to its orientation in space. Attitude control of a satellite refers to the maintenance of the satellite stability at its assigned position. Attitude control is necessary to keep the antenna pointed towards the desired region on the surface of the earth. It is also used to help solar cells so that they face the sun. • A satellite maintains the desired orientation and orbital position through its attitude control subsystem. The attitude control subsystem must continue to perform all functions reliably throughout its lifetime because the loss of satellite attitude renders a spacecraft useless. • Satellites once placed in its orbit experience a number of forces due to gravitational fields of the earth and the moon, solar radiation pressure, magnetic field interaction and meteorite impacts. • Attitude control must not be confused with station keeping, which is the term used for maintaining a satellite in its correct orbital position. • The two commonly employed stabilizing techniques for the satellite attitude are: a) Spin Stabilization b) 3 – axis or Body Stabilization	

	B)	Attempt any ONE	6
	a)	State the concept of continuous wave RADAR. Sketch its block diagram. State its any two applications. Concept- Transmission is continuous here, the circulator is used to provide isolation between the transmitter and the receiver. Since transmission is continuous, it would be pointless to use a duplexer. The isolation of a typical circulator is of the order of 30dB, so hat some of the transmitted signal leaks into the receiver. The signal can be mixed in the detector with returns from the target, and the difference is the Dopler frequency. Being generally in the audio range in most Doppler application, the detector output can be amplified with an audio amplifier before being applied to a frequency counter. The counter is a normal one, except that its output is shown as kilometers or miles per hour, rather than the actual frequency in hertz. The used to accommodate the high incoming frequency is not a very good device at the audio output frequency, because of the modulation noise which it exhibits at low frequencies.  Applications: 1. It is used to give Doppler information contained in echo signal. 2. It is used to measurement of relative velocity to distinguish moving target from stationary objects	Concept- 2 mks, sketch – 2 mks, any 2 applications 2 mks

	b)	A optical fiber with a core diameter large enough, has a core refractive index of 1.70 and a cladding refractive index of 1.65. Calculate critical angle, numerical aperture and acceptance angle. $n_1 = 1.70$ $n_2 = 1.65$ ① $\theta_c = \sin^{-1}\left(\frac{1.65}{1.70}\right)$ $\sin^{-1}(0.97) = 75.93$ $\boxed{\theta_c = 75.93}$ ② $NA = \sqrt{n_1^2 - n_2^2}$ $= \sqrt{(1.70)^2 - (1.65)^2}$ $= \sqrt{3.06 - 2.72}$ $= \sqrt{0.34}$ $\boxed{NA = 0.583}$ ③ Acceptance angle (θ_a) $\theta_a = \sin^{-1}(NA)$ $= \sin^{-1}(0.583)$ $\boxed{\theta_a = 35.66^\circ}$	Proper solution and steps- 2 mks for each answer
5		Attempt any Four	16
	a)	Explain Hybrid Tee with neat sketch. **Diagram :**  **Explanation:** **Magic tee (or magic T or hybrid tee) :** • is a hybrid or 3 dB coupler used in microwave systems. It is an alternative to the rat-	Diagram- 2 mks, explanation- 2 mks

		race coupler. • In contrast to the rat-race, the three-dimensional structure of the magic tee makes it less readily constructed in planar technologies such as microstrip or stripline. • The magic tee is a combination of E and H plane tees. Arm 3 forms an H-plane tee with arms 1 and 2. Arm 4 forms an E-plane tee with arms 1 and 2. Arms 1 and 2 are sometimes called the *side* or *collinear* arms. Port 3 is called the H-plane port, and is also called the Σ port, sum port or the P-port (for "parallel"). Port 4 is the E-plane port, and is also called the Δ port, difference port, or S-port (for "series"). • There is no one single established convention regarding the numbering of the ports. • To function correctly, the magic tee must incorporate an internal matching structure. This structure typically consists of a post inside the H-plane tee and an inductive iris inside the E-plane limb, though many alternative structures have been proposed. Dependence on the matching structure means that the magic tee will only work over a limited frequency band.	
	b)	Velocity modulation occurs in two cavity Klystron amplifier. Justify with neat sketch.  • In the two-chamber klystron, the electron beam is injected into a resonant cavity. The electron beam, accelerated by a positive potential, is constrained to travel through a cylindrical drift tube in a straight path by an axial magnetic field. • While passing through the first cavity, the electron beam is velocity modulated by the weak RF signal. In the moving frame of the electron beam, the velocity modulation is equivalent to a plasma oscillation. • Plasma oscillations are rapid oscillations of the electron density in conducting media such as plasmas or metals.(The frequency only depends weakly on the wavelength). So in a quarter of one period of the plasma frequency, the velocity modulation is converted to density modulation, i.e. bunches of electrons.	Sketch – 2 mks, explanation- 2 mks



- In the two-chamber klystron, the electron beam is injected into a resonant cavity. The electron beam, accelerated by a positive potential, is constrained to travel through a cylindrical drift tube in a straight path by an axial magnetic field.
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- Plasma oscillations are rapid oscillations of the electron density in conducting media such as plasmas or metals.(The frequency only depends weakly on the wavelength). So in a quarter of one period of the plasma frequency, the velocity modulation is converted to density modulation, i.e. bunches of electrons.

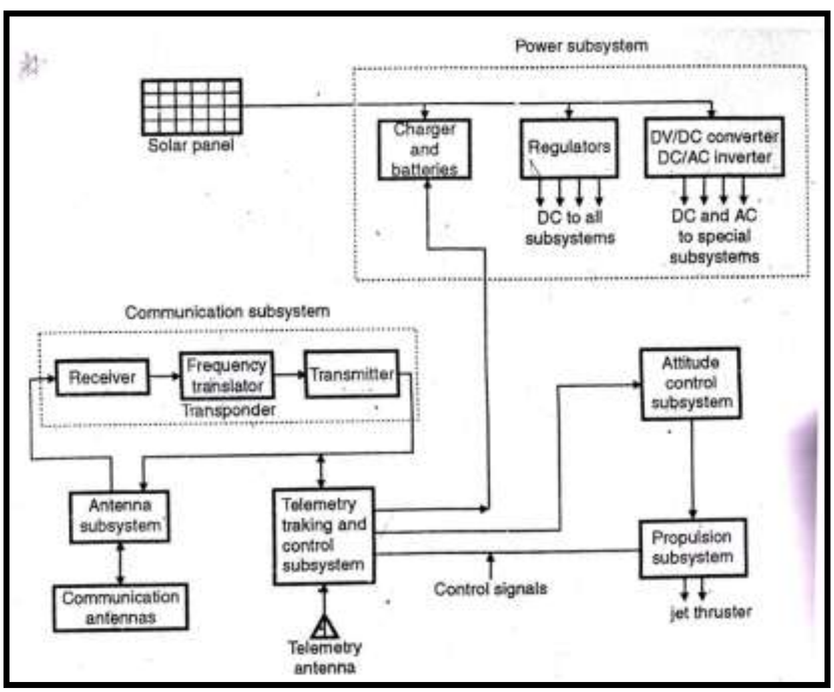
- As the bunched electrons enter the second chamber they induce standing waves at the same frequency as the input signal. The signal induced in the second chamber is much stronger than that in the first. When the tube is energized, the cathode emits electrons which are focused into a beam by a low positive voltage on the control grid.
- The beam is then accelerated by a very high positive dc potential that is applied in equal amplitude to both the accelerator grid and the buncher grids. The buncher grids are connected to a cavity resonator that superimposes an ac potential on the dc voltage.
- Ac potentials are produced by oscillations within the cavity that begin spontaneously when the tube is energized. The initial oscillations are caused by random fields and circuit imbalances that are present when the circuit is energized.
- The oscillations within the cavity produce an oscillating electrostatic field between the buncher grids that is at the same frequency as the natural frequency of the cavity. The direction of the field changes with the frequency of the cavity.
- These changes alternately accelerate and decelerate the electrons of the beam passing through the

grids. The area beyond the buncher grids is called the drift space. The electrons form bunches in this area when the accelerated electrons overtake the decelerated electrons. The function of the catcher grids is to absorb energy from the electron beam.

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

	c)	Compare LED with LASER on the basis of principle of operation, Spectral width, data rate, compatible fibers	Relevant 4 points of comparison- 4 mks

Parameter	LED	LASER
Principle of Operation	Spontaneous emission	Simulated emission
Spectral width	20 to 100 nm	1 to 5 nm
Data rate	Low(max.400Mbps)	High(Several Gbps)
Compatible fibers	Multimode SI/GI fiber	Single mode fiber

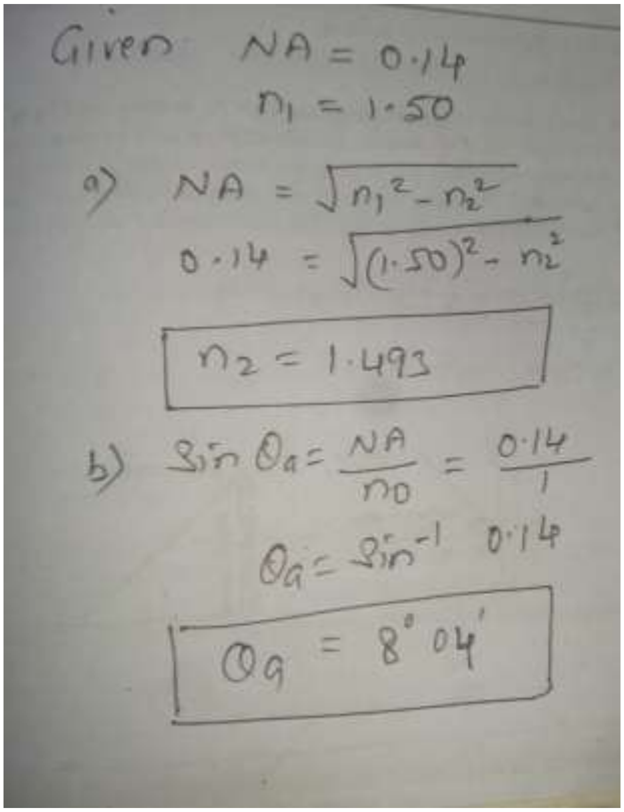
	d)	Draw the block diagram of satellite sub-system and explain power subsystem. 	Block diagram of satellite subsystem- 2 mks, explanation of power subsystem- 2 mks

POWER SUBSYSTEM- This system provides the necessary DC power to the satellite. All communication satellites derive their electrical power from solar cells. There is also a battery backup facility used during launch and eclipses. The batteries are of sealed Nickel Cadmium type and have good reliability and long life.

Everything on board operates electrically. Solar cells are large arrays of photocells connected in various series and parallel circuits as d.c. source. Solar panels are capable of generating many kilowatts. All solar panels always be pointed towards the sun, Solar panels generate a direct current that is used to operate the various components of satellite. D.C. power is used to charge the batteries which provides d.c. current to component of satellite when solar panels are not properly positioned. Voltage regulators are used to power individual electronic circuits.

Some components like TWT amplifier in transponder requires very high d.c. voltage to operate, so d.c. to d.c. converter is used to raise the level of low voltages to high voltage.

	e)	A step index fibre has a numerical aperture of 0.14 a core refractive index of 1.50 and core diameter 80 mm. Calculate acceptance angle and refractive index of cladding.	Each answer with formula – 2 mks



Given $NA = 0.14$

$n_1 = 1.50$

a) $NA = \sqrt{n_1^2 - n_2^2}$

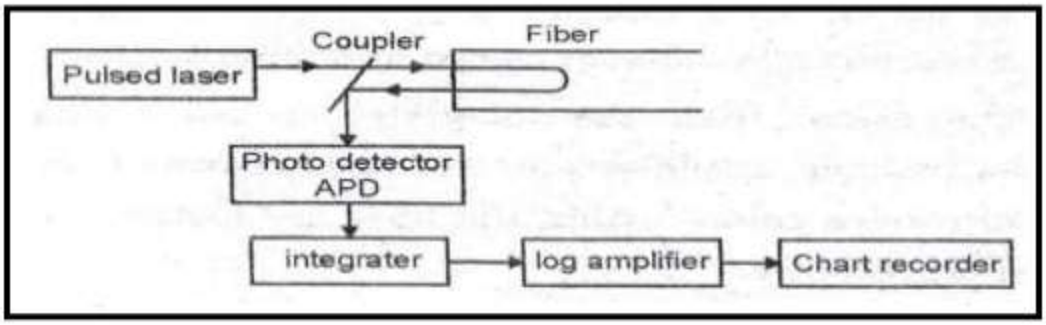
$0.14 = \sqrt{(1.50)^2 - n_2^2}$

$n_2 = 1.493$

b) $\sin\theta_a = \frac{NA}{n_0} = \frac{0.14}{1}$

$\theta_a = \sin^{-1} 0.14$

$\theta_a = 8^\circ 04'$

	f)	Explain OTDR with neat diagram & give its advantages  Fig. Block diagram of OTDR **Explanation:-** • A light pulse is launched into the fiber in the forward direction from an injection laser using either a directional coupler or a beam splitter. • Beam splitter or coupler makes possible to couple the optical power impulse into the tested fiber and simultaneously to deviate the backscattered power to the optical receiver. • The backscattered light is detected using avalanche photodiode receiver. Output of photodiode receiver drivers an integrator. **Advantages:** i. A number of optical time domain reflectometers are commercially available for operation over the entire wavelength range. ii. These instruments are capable of carrying out tests over single or dual wavelengths for multimode and for single-mode optical fiber links iii. Although the OTDR functionality is provided, these instruments are also often capable of performing a number of other optical system and network tests (e.g. optical loss, dispersion measurement etc.) Such instruments are usually referred as universal or optical network test systems rather than simply optical time domain reflectometers.	Diagram-2mks, explanation-1 mks, any 2 advantages-1 mks

6 Attempt any FOUR — 16

a) Explain Reflex Klystron with neat sketch & define Transit Time. Give two application of it.

Reflex klystron – Diagram- 1 ½ mks, explanation 1 mks, - Definition of transit time - 1/2 mks, any 2 applications- 1 mks

(Note- The question is quiet lengthy for 4 mks, assessor should consider the attemption level and justify 4 mks for the correct answer)

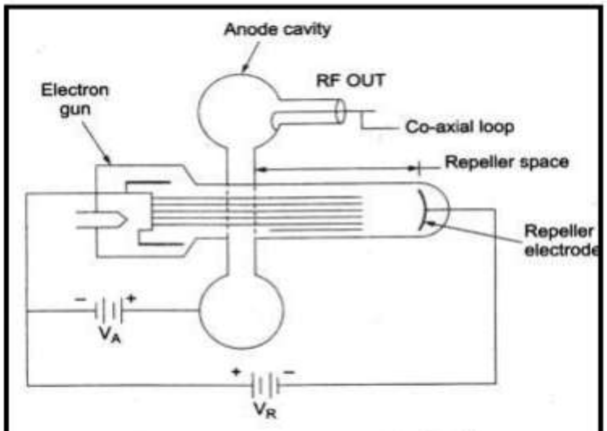


Fig. Constructional details of reflex klystron.

Working :

- The RF voltage that is produced across the gap by the cavity oscillations act on the electron beam to cause velocity modulation. er is the reference electron taken as the one that passes the gap on its way to the repeller at the time when the gap voltage is zero and going negative. This electron is unaffected, overshoots the gap and is ultimately returned to it having penetrated some distance into the repeller space
- The early electron ee that passes the gap before the reference electron, experiences a• positive voltage at the gap. This electron is accelerated and moves with greater velocity and penetrates deep into repeller space. This electron will take slightly greater time than the reference electron to return to the gap
- The late electron el that passes through the gap later than reference electron experiences negative voltage at the gap. This electron is retarded and shortens its stay in the repeller space and will return earlier to the gap as compared to the reference electron. So, the late electron will be able to catch up with ee and er electrons forming the bunch.
- Bunches occur once per cycle centered on the reference electron. These bunch transfer maximum energy to the gap to get sustained oscillations

Transit time- Operation of reflex klystron is such as to maintain oscillations for that the transit time in the repeller space must have correct value. The best time for electrons to return to the gap is given by

		$T= n+{}^{3}/_{4}$ Where, T= transit time of electronss N= any integer (practically n=2/3 is used) **Applications: (any two)** This is the most widely used in applications where variable frequency is desired as • In radar receivers. • Local oscillator in microwave receivers. • Signal source in microwave generator of variable frequency. • Portable microwave links and • Pump oscillator in parametric amplifier.	

	b)	Define the term absorption loss. State type of absorption losses. How these losses occur? Definition- Absorption loss is related to the material composition and fabrication process of fiber. Absorption loss results in dissipation of some optical power as hear in the fiber cable. Although glass fibers are extremely pure, some impurities still remain as residue after purification. The amount of absorption by these impurities depends on their concentration and light wavelength. Types of Absorption Losses: i) Intrinsic absorption ii) Extrinsic absorption Causes- 1) Intrinsic absorption: Intrinsic absorption in the ultraviolet region is caused by electronic absorption bands. Basically, absorption occurs when a light particle (photon) interacts with an electron and excites it to a higher energy level. The main cause of intrinsic absorption in the infrared region is the characteristic vibration frequency of atomic bonds. In silica glass, absorption is caused by the vibration of silicon oxygen (Si-O) bonds. The interaction between the vibrating bond and the electromagnetic field of the optical signal causes intrinsic absorption. Light energy is transferred from the electromagnetic field to the bond Extrinsic absorption: Extrinsic absorption is much more significant than intrinsic Caused by impurities introduced into the fiber material during manufacture – Iron, nickel, and chromium Caused by transition of metal ions to higher energy level Modern fabrication techniques can reduce impurity levels below 1 part in 1010. For some of the more common metallic impurities in silica fiber the table shows the peak attenuation wavelength and the attenuation caused by an impurity concentration of 1 in 10^9 .	Definition- 1 mks, causes- 1 mks, Types – 2 mks

	c)	List out any four essential properties of fiber connector. • Low insertion loss: Insertion Loss is smaller the better. Generally speaking, the required value of insertion loss should not be more than 0.5 dB to ensure a quality fiber link. • High return loss: return loss is a measure of how well two connectors or lines are matched. The higher the return loss, the lower the insertion loss. • High reliability: outside plant applications may require fiber connectors be located underground, or outdoor walls. High reliability connectors are needed in these harsh environments to make sure smooth optical transmission. Ease of use: currently fiber optic connectors can generally be plugged more than l000 times. Therefore, a fiber connector that is easy to use will help users save lots of installation time and improve working efficiency.	Any 4 properties- 4 mks
	d)	State the functions of telemetry and tracking sub-system of satellite 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. • 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.	Each system atleast 2 functions- 2 mks

e) Compare PIN diode with avalanche photo diode. (any four Factors)

PIN diode	APD
(1) It has poor sensitivity and poor sensitivity ratio.	(1) APD has better sensitivity as compared to PIN diode.
(2) Responsivity of PIN diode is 0.5 μA/μW.	(2) Responsivity of APD is 15 μA/μW.
(3) Rise time of PIN diode is 1 ns.	(3) Rise time of APD is 2 ns.
(4) Bias voltage required for PIN diode is 6 - 15 V.	(4) Bias voltage required of APD is 40 - 170 V.
(5) Avalanche gain is 1.	(5) Avalanche gain is 80 - 150.
(6) Quantum efficiency of PIN diode is 50.	(6) Quantum efficiency of APD is 80.

Any 4 relevant points of comparison- 4 mks