MODEL ANSWER

SUMMER– 18 EXAMINATION

Subject Title: ADVANCED COMMUNICATION **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
Q.1	**A)**	**Attempt any THREE:**	**12 Total Marks**
	a)	**Define the term w.r.t. wave guide (a) group velocity, (b) phase velocity.**	**4 Marks**
	Ans:	**Phase velocity:** Phase velocity is defined as the rate at which the wave changes its phase in terms of the guide wavelength. **OR** The phase velocity is the velocity with which the wave changes phase in a direction parallel to the conducting surface. The phase velocity is given by equation $v_p = \frac{v_c}{\sqrt{1-(\frac{\lambda}{\lambda_c})^2}}$ Where V_c is velocity of light. λ is free space wavelength λ_0 is cutoff wavelength **Group velocity:** Group velocity is defined as the rate at which the wave propagates through waveguide . Group velocity is given by equation	**2 Marks** **2 Marks**

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

OR

$$v_g = v_c \sin\theta$$

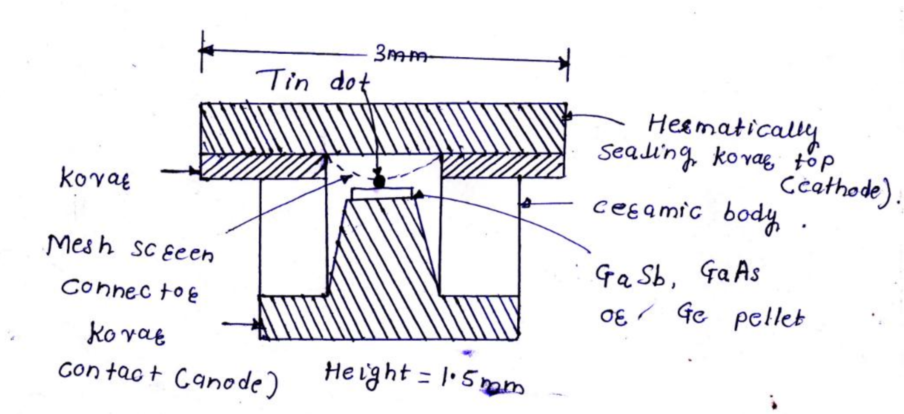
Where
V_c is velocity of light.
λ is free space wavelength
λ_0 is cutoff wavelength
The group velocity is also can be defined as the velocity of energy flow in the waveguide system.

b) **With neat sketch, describe operations of tunnel diode.** **4 Marks**

Ans:

Diagram 2 Mark

Operation 2 Mark

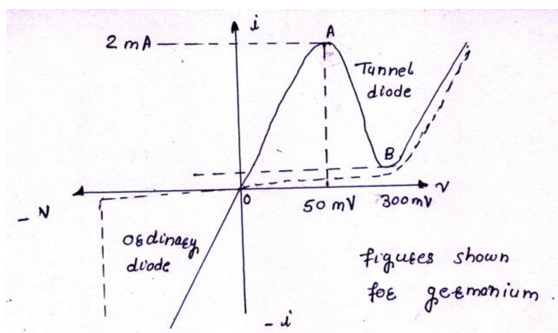


Operation.

- Tunnel diode is a thin junction diode which under low forward bias conditions exhibits negative resistance useful for oscillation or amplification.
- The junction capacitance of the tunnel diode is highly dependent on the bias voltage and
- temperature.
- A very small tin dot about 50μm in diameter is soldered or alloyed to a heavily doped pellet of n- type Ge, GaSb or GaAs.
- The pellet is then soldered to a kovar pedestal, used for heat dissipation, which forms the anode contact.
- The cathode contact is also kovar being connected to the tin dot via a mesh screen used to
reduce inductance.
- The diode has a ceramic body and hermetically sealing lid on top.
- In tunnel diode semiconductor material are very heavily doped, as much as 1000 times more than in ordinary diodes.
- This heavy doping result in a junction which has a depletion layer that is so thin

(0.01µm) as to prevent tunneling to occur.

- In addition, the thinness of the junction allows microwave operation of the diode because it considerably shortens the time taken by the carriers to cross the junction.
- A current-voltage characteristics for a typical Germanium tunnel diode is shown in figure.
- Forward current rises sharply as voltage is applied. At point A, peak voltage occurs.
- As forward bias is increased past this point, the forward current drops and continues to drop until point B is reached, this is the valley voltage.
- At point B current starts to increase once again and does so very rapidly as bias is increases further.
- Diode exhibits dynamic negative resistance between A and B therefore, useful for oscillator applications.



c)	List different display methods used in Radar. Explain any one display method.	**4 Marks**

Ans: **Different display methods used in Radar are.**

- A-Scope display
- Plan-position indicator (PPI)

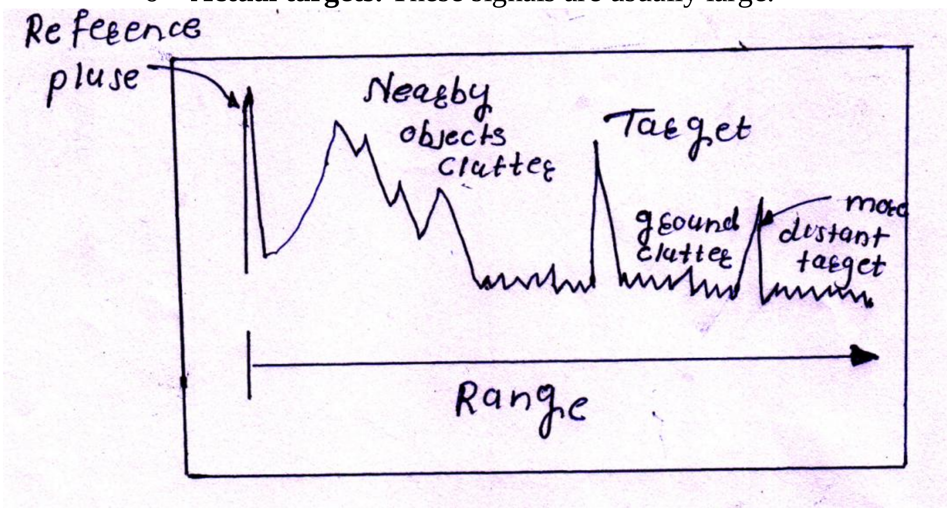
A-scope Display :

Display methods : 1 Marks

Explanation : 3 Marks

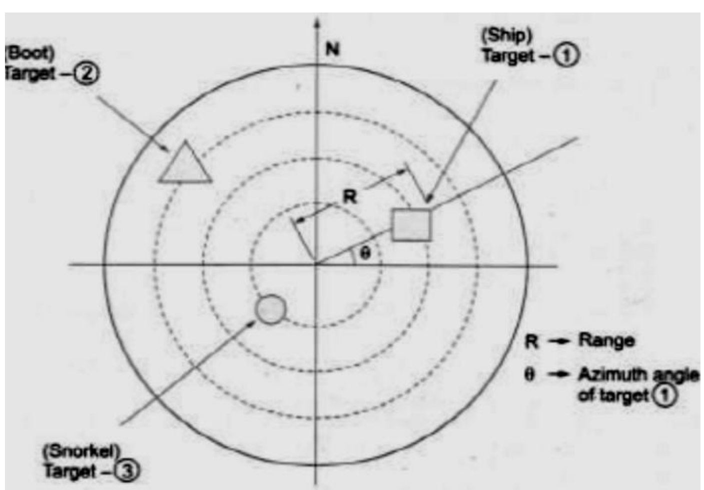
- This is the most popular type of the deflection modulation type display system which indicates the range of the target.
- The A-scope display, shown in figure, presents only the range to the target and the relative strength of the echo.
- The A-scope normally uses an electrostatic-deflection crt. The sweep is produced by applying a sawtooth voltage to the horizontal deflection plates. The electrical length (time duration) of the sawtooth voltage determines the total amount of range displayed on the CRT screen.
- The ranges of individual targets on an A-scope are usually determined by using a movable range gate or step that is superimposed on the sweep.
- In addition to this there are various signals displayed on the screen corresponding to:
  - **Ground clutter** i.e. echoes from various fixed objects near the transmitter

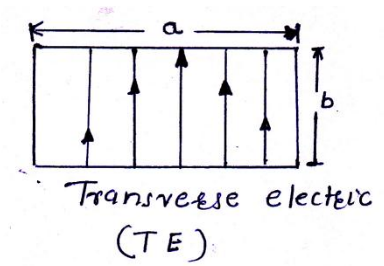
& from the ground.
- **Grass noise** i.e. an almost constant amplitude & continuous receiver noise.
- **Actual targets.** These signals are usually large.

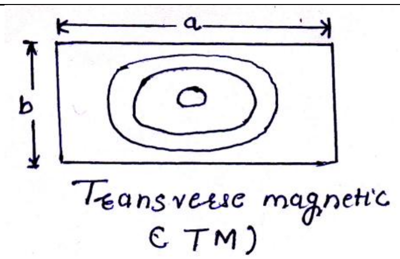
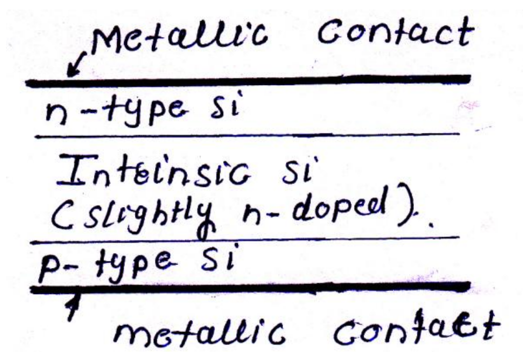
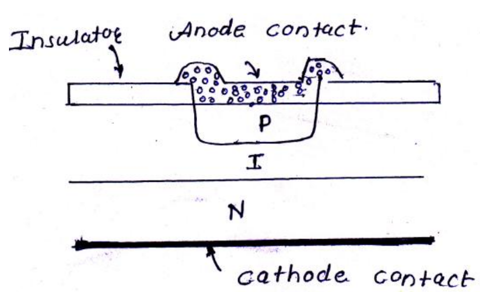


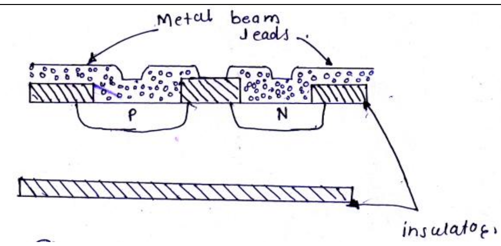
Plan-Position indicator (PPI):

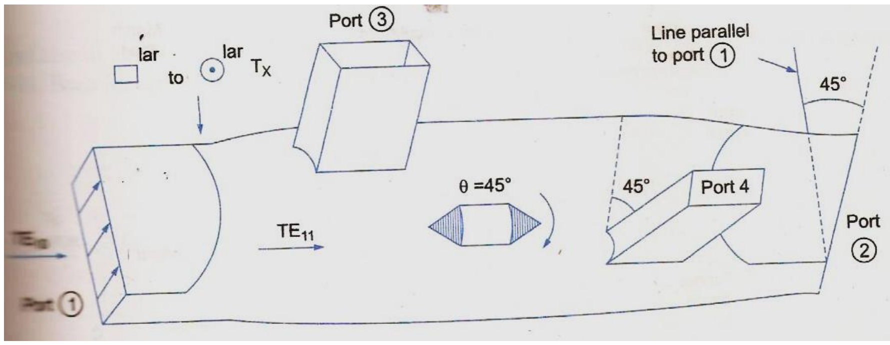
- This is an intensity- modulation type displays system which indicates both range and azimuth angle of
- the target simultaneously in polar co-ordinate as shown in figure.
- The Demodulated echo signals from the receivers is applied to the grid of the CRT which is biased slightly beyond cut-off.
- Only when Blips corresponding to the targets occur, a saw tooth current applied to a pair of coils(on opposite side of the neck of the tube) flows.
- Thus, a beam is made to deflect radially outward from the center and also continuously around the tube(mechanically) at the same angular velocity as that of the antenna.
- The brightness spot at any point on the screen indicates the presence of an objet there.
- Normally PPI screens are circular with a diameter of 30cm or 40cm. Long persistence phosphors are used to ensure that the PPI screen dose not flicker.



	d)	**Why is the uplink is more than downlink frequency in satellite communication?**	**4 Marks**
	Ans:	The uplink frequency is the frequency which is used for transmission of signals from earth station transmitter to the satellite. At higher frequency attenuation is more hence more power will be required for signal transmission to ensure that it reaches the destination with the required minimum power. Higher power requirements involve the use of high power amplifiers with high ratings and heat sinks. This will increase the weight and power supply ratings will not make any difference. However for the satellite this will result in higher power consumption, which results in avoidable inefficiency.	**4 Marks for Explanation .**
	B)	**Attempt any ONE:**	**06 Marks**
	a)	**Describe rectangular waveguide in TE and TM mode.**	**6 Marks**
	Ans:	**TE Modes:**  TE mode stands for transverse Electric mode. In TE Mode electric Field of the signal is perpendicular to the direction of propagation through waveguide and the magnetic field component can be in the direction of propagation. It is labelled as $TE_{m,n}$ where *m* and *n* are integers denoting the number of half wavelengths of EF intensity variations along the broader and narrower dimension . The characteristic wave impedance for TE modes is given by equation. $$Z_0 = \frac{377}{\sqrt{1-\left(\frac{\lambda}{\lambda_c}\right)^2}}$$ The cut-off wavelength for $TE_{m,n}$ mode is given by- $$\lambda_c = \frac{2}{\sqrt{\left(\frac{m}{a}\right)^2+\left(\frac{n}{b}\right)^2}}$$ **TM Mode:**	**3 Marks** **(TE mode 1mark diagram, 2 mark description.)** **3 Marks (TM mode**

		 TM stands for transverse Magnetic mode. In TM Mode magnetic Field of the signal is perpendicular to the direction of propagation through waveguide and the electric field component can be in the direction of propagation. . Since lines of magnetic force are closed loops, if a magnetic field exists and is changing in the *x* direction, it must also exist and be changing in the *y* direction. Hence $TM_{m,0}$modes cannot exist in rectangular waveguides. The formula for characteristic wave impedance for TM modes is, $Z_0 = 377\sqrt{1-\left(\frac{\lambda}{\lambda_c}\right)^2}$.	**1mark diagram, 2 mark description.)**
	b)	**Sketch the construction of PIN diode and write its operation.**	**6 Marks**
	Ans:	 (a) Schematic  (b) Planar Orientation	**Construction diagram 3 Marks, Operation 3Marks**

		 (c) Inline Orientation. **Operation:** The PIN diode has following modes of operation: **1. Forward biased:** 1. When the diode is forward biased, it behaves as if it possesses a variable resistance controlled by the applied current. 2. When a PIN diode is forward biased, holes and electrons are injected from the P and N regions into the I-region. 3. This results in the carrier concentration in the I layer becoming raised above equilibrium levels and theresistivity drops as forward bias is increased. Thu low resistance is offered in the forward direction. 4. The high-frequency resistance is inversely proportional to the DC bias voltage applied to the diode. A PIN diode, suitably biased, therefore acts as a variable resistor. This high-frequency resistance may vary over a wide range from 0.1Ω to 10 kΩ. **2. Reverse biased:** When the diode is reversed biased the space charge regions in the p and n layers will become thicker. The reverse resistance will be very high and almost constant. **3. Zero Bias:** At zero bias, the diffusion of the holes and electrons across the junction causes space charge region of thickness inversely proportional to the impurity concentration. The diode has high impedance.	
Q 2	**A)**	**Attempt any FOUR:**	**16 Marks**
	a)	**Draw the construction of microwave circulator and isolator. List applications Of each (any two).**	**4 Marks**
	Ans:	**Circulator:** Construction diagram	**(Circulator construction 1 Mark Applicaion 1 Mark Isolator construction 1 Mark Applicaion 1 Mark)**



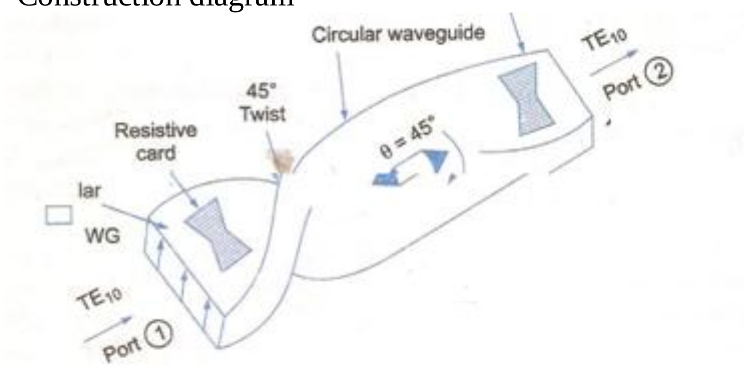
2 Marks

Applications:

1. Circulator used as coupling element for reactance amplifier.
2. Circulator used as duplexing and phase lock injection element.
3. Circulator used primarily in radar and communication system.

Isolator:

Construction diagram



2 Marks

Applications:

1. Isolators are widely used in measuring equipment , medical electronics and electric power Instruments
2. Isolator can take over various signals such as temperature sensor/transmitter, pressure sensor/transmitter, liquid level sensor/transmitter, humidity sensor/transmitter, flux sensor/transmitter, gas sensor/transmitter, optical sensor/transmitter.
3. An Isolator is used to shield equipment on its input side from the effect of condition on its output side for example to prevent a microwave source being detuned by a mismatched load.

Note: Any other relevant application can be considered

	b)	**Draw and explain the working of two cavity klystron amplifier.**	**4 Marks**

	Ans:		Diagram 2 Marks Working 2 Marks.

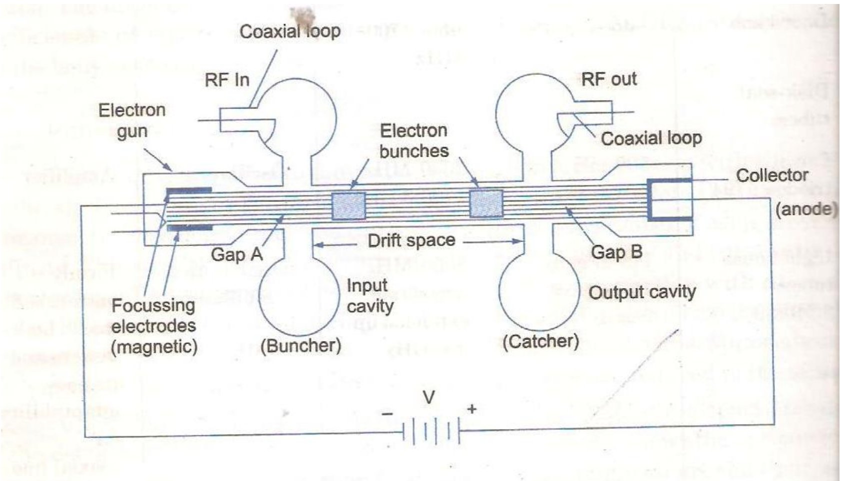
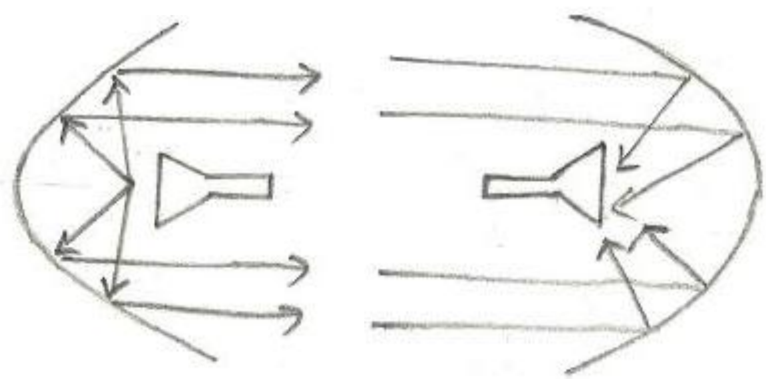
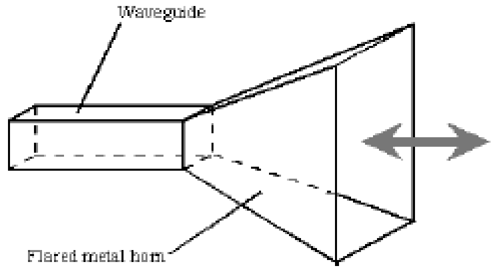


Fig. 8.9 Two cavity klystron amplifier.

Operation:

1. The RF signal to be amplified is used for exciting the input buncher cavity thereby developing an alternating voltage of signal frequency across gap A.
2. Consider the effect of this gap voltage on the electron beam passing through gap A by means of an Applegate diagram. At point B on the input RF cycle, the alternating voltage is zero and going positive.
3. At this instant, the EF across the gap A is zero and an electron which passes through the gap A at this instant is unaffected by the RF signal.
4. Let us consider this electron be called the reference electron $e_R$which travels with unchanged velocity $v_0 = \sqrt{\frac{2eV}{m}}$ where V is the anode to cathode voltage.
5. At point C of the input RF cycle, an electron which leaves the gap A later than the reference electron called the late electron $e_l$is subjected to maximum positive RF voltage and hence travels towards gap B with an increased velocity ($v>v_0$) and this electron tries to overtake the reference electron e_R.
6. Similarly an early electron e_e that passes the gap A slightly before the reference electron $e_R$is subjected to a maximum negative voltage field. Hence, this early electron is decelerated and travels with a reduced velocity. This electron falls back and the reference electron catches up with the early electron.
7. Therefore, the velocity of electron varies in accordance with the input RF voltage resulting in velocity modulation of the electron beam. As a result of these actions, the electrons in the bunching limit (between A and C) gradually bunch together as they travel down the drift space from gap A to gap B and excite oscillations in the output cavity (catcher).
8. The density of electrons passing gap B vary cyclically with time i.e. the

		electron beam contains an ac current and is current modulated. 9. The drift space coverts the velocity modulation into current modulation 10. Bunching occurs only once per cycle, centered on the reference electron.	
	c)	**Describe any one antenna used in RADAR.**	**4 Marks**
	Ans:	Antenna used in RADAR **Parabolic antenna**  (a) Transmiter antenna (b) Receiver antenna. A parabolic antenna is a high-gain reflector antenna used for radio, television and data communications, and also for radiolocation (RADAR), on the UHF and SHF parts of the electromagnetic spectrum. The relatively short wavelength of electromagnetic (radio) energy at these frequencies allows reasonably sized reflectors to exhibit the very desirable highly directional response for both receiving and transmitting. A typical parabolic antenna consists of a parabolic reflector illuminated by a small feed antenna. The reflector is a metallic surface formed into a paraboloid of revolution and (usually) truncated in a circular rim that forms the diameter of the antenna. This paraboloid possesses a distinct focal point by virtue of having the reflective property of parabolas in that a point light source at this focus produces a parallel light beam aligned with the axis of revolution. The feed antenna is placed at the reflector focus. This antenna is typically a low-gain type such as a half-wave dipole or a small waveguide horn. In more complex designs, such as the Cassegrain antenna, a sub-reflector is used to direct the energy into the parabolic reflector from a feed antenna located away from the primary focal point. The feed antenna is connected to the associated radio-frequency (RF) transmitting or receiving equipment by means of a coaxial cable **(OR)**	**4Marks Explanation**

		Horn Antenna  A horn antenna or microwave horn is an antenna that consists of a flaring metal waveguide shaped like a horn to direct radio waves in a beam. Horns are widely used as antennas at UHF and microwave frequencies, above 300 MHz. They are used as feeders (called feed horns) for larger antenna structures such as parabolic antennas, as standard calibration antennas to measure the gain of other antennas, and as directive antennas for such devices as radar guns, automatic door openers, and microwave radiometers. Their advantages are moderate directivity, low standing wave ratio (SWR), broad bandwidth, and simple construction and adjustment. In order to function properly, a horn antenna must be a certain minimum size relative to the wavelength of the incoming or outgoing electromagnetic field. If the horn is too small or the wavelength is too large (the frequency is too low), the antenna will not work efficiently. Horn antennas are commonly used as the active element in a dish antenna. The horn is pointed toward the center of the dish reflector. The use of a horn, rather than a dipole antenna or any other type of antenna, at the focal point of the dish minimizes loss of energy (leakage) around the edges of the dish reflector. It also minimizes the response of the antenna to unwanted signals not in the	
	d)	**Define with respect to fiber optic cable (i) Numerical Aperture. (ii) Acceptance angle.**	**4 Marks**
	Ans:	**(i)Numerical Aperture (NA)**: Numerical Aperture is the light gathering ability or capacity of an optical fiber. More the NA. the more efficient will be fiber. It is also known as figure of merit. NA is given by equation NA = $\sqrt{(n_1^2 - n_2^2)}$ Where $n_1$is refractive index of core $n_2$refractive index of cladding **(ii) Acceptance angle.** Acceptance angle (θ): It is the maximum angle made by the light ray with the fiber axis, so that light can propagate through the fiber after total internal reflection.	**2 Marks**

		Relation NA and acceptance angle: NA = Sin θ $\theta = \text{Sin}^{-1}$ NA.	**2 Marks.**
	e)	**Describe losses in optical fiber.**	**4 Marks**
	Ans:	**Losses in optical fiber**: 1. Absorption loss, 2. Scattering loss, 3. Dispersion loss, 4. Radiation loss, 5. Coupling loss. **Absorption loss** Absorption loss is related to the material composition and fabrication process of fiber. Absorption loss results in dissipation of some optical power as hear in the fiber cable. Although glass fibers are extremely pure, some impurities still remain as residue after purification. The amount of absorption by these impurities depends on their concentration and light wavelength. 1. Intrinsic absorption Intrinsic absorption in the ultraviolet region is caused by electronic absorption bands. Basically, absorption occurs when a light particle (photon) interacts with an electron and excites it to a higher energy level. The main cause of intrinsic absorption in the infrared region is the characteristic vibration frequency of atomic bonds. In silica glass, absorption is caused by the vibration of silicon-oxygen (Si-O) bonds. The interaction between the vibrating bond and the electromagnetic field of the optical signal causes intrinsic absorption. Light energy is transferred from the electromagnetic field to the bond. 2. Extrinsic absorption Extrinsic absorption is much more significant than intrinsic Caused by impurities introduced into the fiber material during manufacture – Iron, nickel, and chromium Caused by transition of metal ions to higher energy level Modern fabrication techniques can reduce impurity levels below 1 part in 1010. For some of the more common metallic impurities in silica fibre the table shows the peak attenuation wavelength and the attenuation caused by an impurity concentration of 1 in 10^9 **OR** **Radiative losses:** Radiative losses also called bending losses, occur when the fibre is curved. There are two types of radiative losses: Micro bending losses. Macro bending losses. **OR**	

		Scattering loss:- Basically, scattering losses are caused by the interaction of light with density fluctuations within a fiber. Density changes are produced when optical fibers are manufactured. • Linear Scattering Losses: Linear scattering occurs when optical energy is transferred from the dominant mode of operation to adjacent modes. It is proportional to the input optical power injected into the dominant mode. o Linear scattering is divided into two categories: Mie scattering and Rayleigh scattering. • Non- Linear Scattering Losses: o Scattering loss in a fiber also occurs due to fiber non-linearity's i.e. if the optical power at the output of the fiber does not change proportionately with the power change at the input of the fiber, the optical fiber is said to be operating in the non-linear mode. Non- Linear scattering is divided into two categories: Stimulated Raman Scattering and Stimulated Brillouin Scattering. **OR** **Dispersion loss:** Dispersion is a measure of the temporal spreading that occurs when a light pulse propagates through an optical fiber. Dispersion is sometimes referred to as delay distortion in the sense that the propagation time delay causes the pulse to broaden. ***Note:Any other relevant loss explanation***	
	f)	**Explain advantages of Satellite communication (4 points).**	**4 Marks**
	Ans:	**Broadcast property** – Wide coverage area. Satellites, by virtue of their very nature, are an ideal means of transmitting information over vast geographical areas. This broadcasting property of satellites is fully exploited in point-to-multipoint networks and multipoint interactive networks. The broadcasting property is one of the major plus points of satellites over terrestrial networks, which are not so well suited for broadcasting applications. **Wide bandwidth** – high transmission speeds and large transmission capacity. Over the years, satellites have offered greater transmission bandwidths and hence more transmission capacity and speeds as compared to terrestrial networks. However, with the introduction of fiber optic cables into terrestrial cable networks, they are now capable of providing transmission capabilities comparable to those of satellites. **Geographical flexibility** – independence of location. Unlike terrestrial networks, satellite networks are not restricted to any particular configuration. Within their coverage area, satellite networks offer an infinite choice of routes and hence they can reach remote location shaving rudimentary or nonexistent terrestrial networks. This feature of satellite networks makes them particularly attractive to Third World countries and countries having difficult geographical terrains and unevenly distributed populations. **Easy installation of ground stations**. Once the satellite has been launched, installation and maintenance of satellite Earth stations is much simpler than establishing a terrestrial infrastructure, which requires an extensive ground construction plan. This is particularly helpful in setting up temporary services. Moreover, one fault on the terrestrial communication link can put the entire link out of service, which is not the case with satellite networks. **Uniform service characteristics.** Satellites provide a more or less uniform service within their coverage area, better known as a 'footprint'. This overcomes some of the problems related to the fragmentation of service that result from connecting network segments from	**Any four-1 Mark for each advantage**

		various terrestrial telecommunication operators. **Immunity to natural disaster.** Satellites are more immune to natural disaster such as floods, earthquakes, storms, etc., as compared to Earth-based terrestrial networks. **Independence from terrestrial infrastructure.** Satellites can render services directly to the users, without requiring a terrestrial interface. Direct-to-home television services, mobile satellite services and certain configurations of VSAT networks are examples of such services. In general, C band satellites usually require terrestrial interfaces, whereas Ku and Ka band systems need little or no terrestrial links. **Cost aspects –** low cost per added site and distance insensitive costs. Satellites do not require a complex infrastructure at the ground level; hence the cost of constructing a receiving station is quite modest – more so in case of DTH and mobile receivers. Also, the cost of satellite services is independent of the length of the transmission route, unlike the terrestrial networks where the cost of building and maintaining a communication facility is directly proportional to the distances involved. **Note: Any other relevant advantage can be considered**	
Q. 3	**A)**	**Attempt any FOUR:**	**16 Marks**
	a)	**A rectangular waveguide is 5 cm x 2.5 cm. Calculate cutoff freq. of dominant mode.**	**4 Marks**
	Ans:	**The dominant mode of a rectangular waveguide is the TE1,0 mode, with m=1 & n=0** **Fc=** $1.5 \times 10^{8}\sqrt{\left(\frac{m}{a}\right)^{2}+\left(\frac{n}{b}\right)^{2}}$ **Fc=** $1.5 \times 10^{8}\sqrt{\left(\frac{1}{0.050}\right)^{2}+\left(\frac{0}{0.025}\right)^{2}}$ **Fc= 3GHz** **OR** **Given: a= 5cm, m=1, n=0** **Cutoff Wavelength:** λc **= 2xa** **λc =2x5 = 10cm = 0.01m** **Cutoff frequency** **Fc =** $c/\lambda c = (3 \times 10^{8})/0.01$ **Fc = 3GHz**	**Formula 1 mark, Substituting 1 mark, 2 marks answer**
	b)	**Describe the bunching process in Magnetron with neat diagram.**	**4 Marks**
	Ans:	1. Now assume RF oscillations are initiated due to some noise transient within the magnetron, the oscillations will be sustained by device operation.	**Diagram 2 Marks, description 2 Marks**

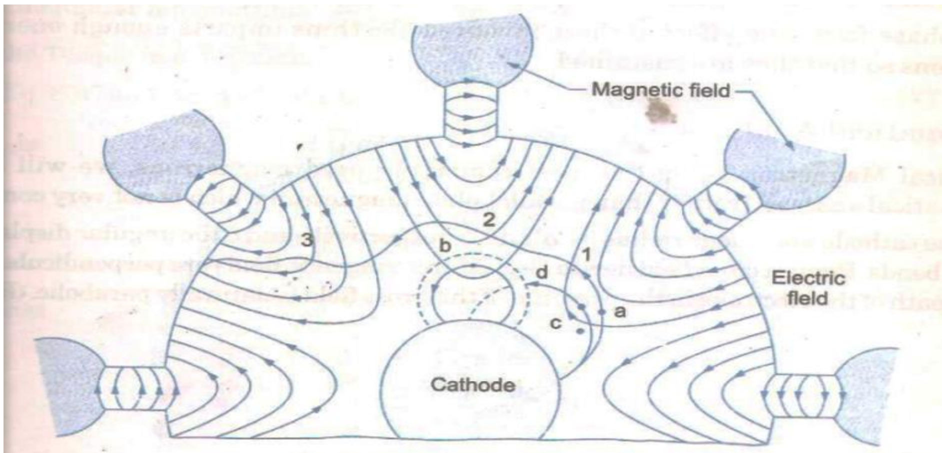
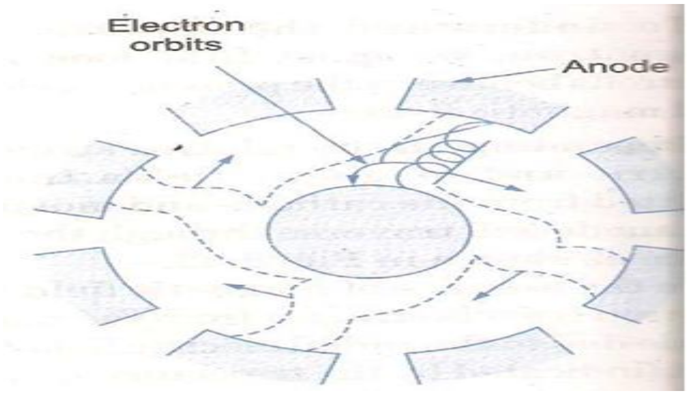


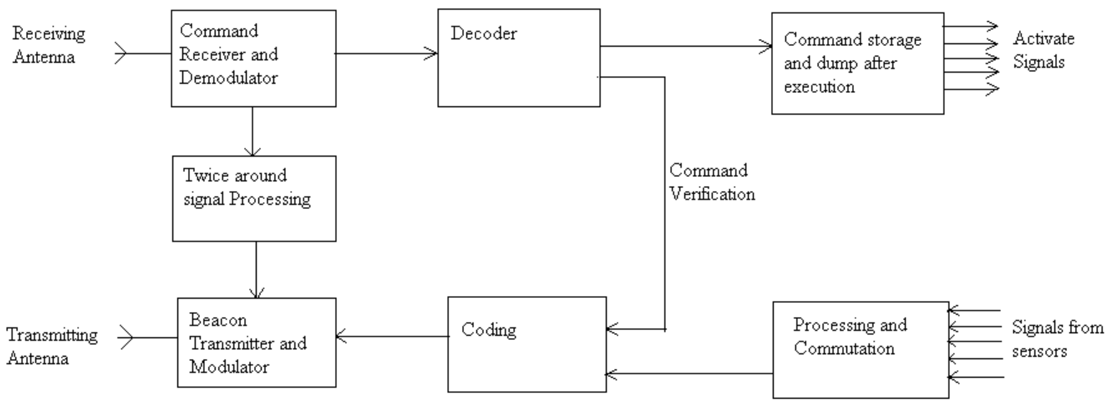
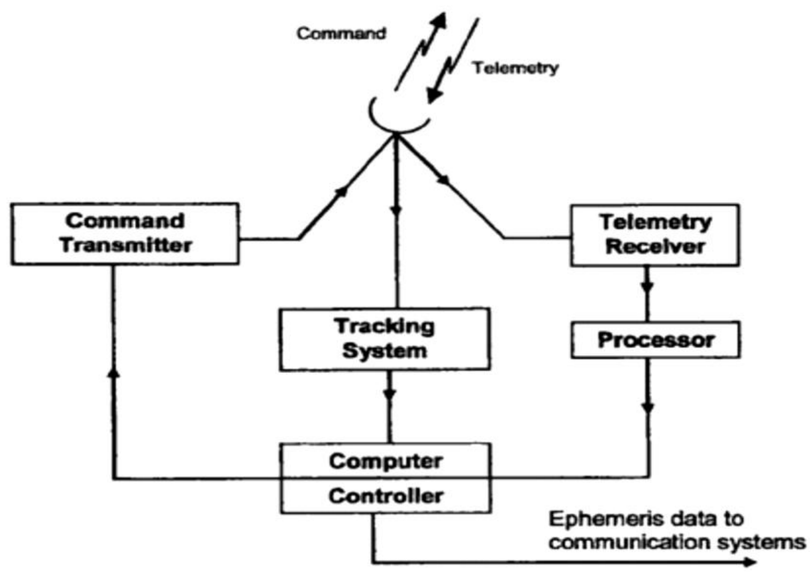
Fig. 8.33 π-mode of magnetron

2. Self-oscillations will be obtained if the phase difference between adjacent anode poles is $n\pi/4$ ($N=8$), where n is an integer. n=4 results in π mode. Here the anode poles are π radians apart.
3. The dotted lines refer to the path of electrons in case of static field. The solid lines refer to the electron trajectories in the presence of RF oscillations in the interaction space.
4. The electron 'a' is seen to be slowed down in the presence of oscillations thus transferring energy to the oscillations during its longer journey from cathode to anode. Such electrons which participate in transferring energy to the RF field are called as favored electrons and these electrons are responsible for bunching effect.
5. An electron 'b' is accelerated by the RF field. Instead of imparting energy to the oscillations, it takes energy from the oscillations resulting in increased velocity. Hence bends more sharply, spends very little time in the interaction space and is returned back to the cathode. Such electrons are called un-favored electrons which do not participate in the bunching process; rather they are harmful as they cause back heating.
6. Similarly electron 'c' which is emitted little later to be in correct position moves faster and tries to catch up with electron 'a' and an electron emitted at d will be slowed down to fall back in step with the electron 'a'.
7. This result in all favored electrons like a,c,d to form a bunch and are confined to electron clouds or spokes as shown in fig below. This process is called **phase focusing effect** corresponding to the bunch of favored electrons around the reference electron 'a'. The spokes so formed in the π-mode rotate with an angular velocity corresponding to2 poles/cycle.



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

c)	**How doppler effect can be used to measure speed?**	**4 Marks**
Ans:	To find the relative speed between RADAR unit and observed object, we have to measure the amount of the frequency difference between the transmitted signal & Reflected signal. If the R is the distance between RADAR & Target, the total number of wavelengths λ contained in two way path is $$\frac{\mathbf{2R}}{\boldsymbol{\lambda}}$$ One wavelength corresponds to angular excursion of 2π radian. The total angular excursion ϕ made by electromagnetic wave is $\frac{4\pi R}{\lambda}$ Radians. If the target is in motion R and Phase are continuously varying. Change in phase w.r.t. time is equal to frequency. $$\frac{d\phi}{dt} = Wd$$ i.e. Doppler frequency $Wd = 2\,\pi f_d$ $= \frac{d\ (4\pi R)}{dt\ (\lambda)}$ There for, $Wd = \frac{4\pi}{\lambda} V_r$ **OR** The frequency shift that occurs, when there is a relative motion between the transmitting station and a remote object is known as Doppler effect. By measuring the amount of frequency, difference between the transmitted and the reflected signal, It is possible to determine the relative speed between the RADAR unit and the observed object	**4 marks Explanation**

		$V = 1.1\ f \times \lambda$ Where v = relative speed between the two objects (m/s) F = frequency difference between the transmitted and reflected signals (Hz) λ = wavelength of transmitted signal (m) d. State the reason for difference in uplink and downlink frequency in satellite communication.	
	d)	**Illustrate how telemetry tracking and command system is used in satellite.**	**4 Marks**
	Ans:	 **OR** 	**01 Mark for diagram and 1½ Marks for each uses**

<table>
<tr><td></td><td></td><td>Telemetry, Tracking and Command (TT&C) Subsystem
These systems are partly on the satellite and partly at the control earth station. They support the functions of the spacecraft management. The main functions of a TTC system are

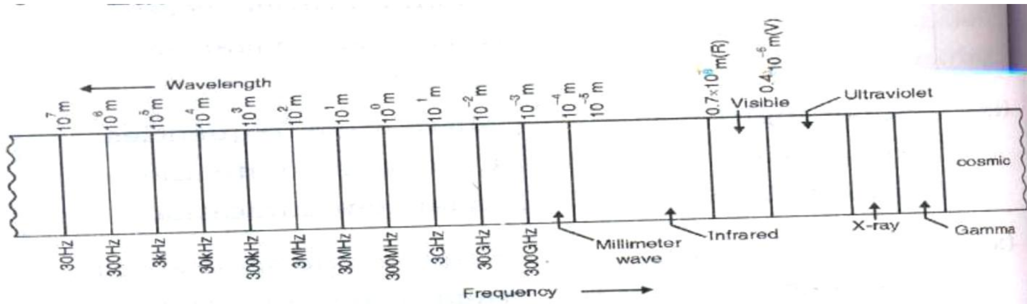
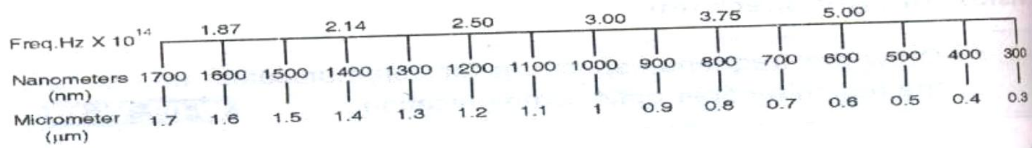
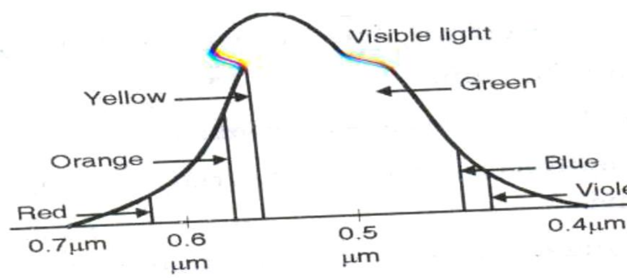
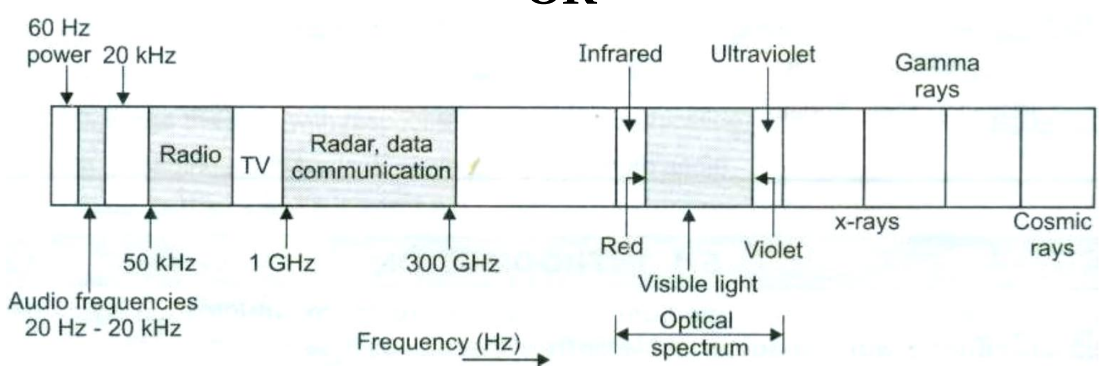
To monitor the performance of all satellite subsystems and transmit the monitored data to the satellite control center via a separate Telemetry link.
To support the determination of orbital parameters.
To provide a source to earth station for tracking.
To receive commands from the control center for performing various functions of the satellite.
Typical functions include:
To correct the position and attitude of the satellite.
To control the antenna pointing and communication system configuration to suit current traffic requirements.
To operate switches on the spacecraft.

TELEMETRY:

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

TRACKING:

By using velocity and acceleration sensors, on spacecraft the orbital position of satellite can be detect from earth station.
For accurate and precise result number of earth stations can be used.
</td><td></td></tr>
<tr><td></td><td>e)</td><td>Draw frequency spectrum of optical communication with band name and its range.</td><td>4 Marks</td></tr>
<tr><td></td><td>Ans:</td><td>Note: any relevant correct diagram can be considered.</td><td>4 marks diagram</td></tr>
</table>

		 **Fig. 4.1.3 : Electromagnetic spectrum**  **Fig. 4.1.4 : Light wave spectrum (visible and nonvisible)**  **OR** 	
Q. 4	**A)**	**Attempt any THREE:**	**12 Marks**
	a)	**Write uplink and downlink frequencies for C-Band, X-Band, Kn-Band&Ka-Band.**	**4 Marks**
	Ans:		**1 Marks Each**

Band	Uplink (GHz)	Downlink (GHz)
C – Commercial	5.9 – 6.4	3.7 – 4.2
X – Military	7.9 – 8.4	7.25 – 7.75

Ku - Commercial	14 – 14.5	11.7 – 12.2
Ka – Commercial	27.5 – 30	17.7 – 21.2
Ka – Military	43.5 – 45.5	20.2 – 21.2

b) **State two advantages and two applications of continuous wave Radar.** **4 Marks**

Ans: **Advantages :**

2 Marks Advantage 2 Marks application

- Single frequency transmission and hence narrow receiver bandwidth
- Duty cycle is unity, so mean power can be as high as transmitters will permits.
- Ability to see moving targets in presence of large number of echoes from stationary target to which it is blind.
- Target velocity can be measured using Doppler shift.
- Zero minimum range.
- Simple to design and construct.

Applications:

- Measurement of the relative velocity of a moving target.
- Human Gait Recognition
- In Doppler Radar.

c) **Describe working of directional coupler with neat diagram.** **4 Marks**

Ans:

2 mark diagram 2 mark explanation

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

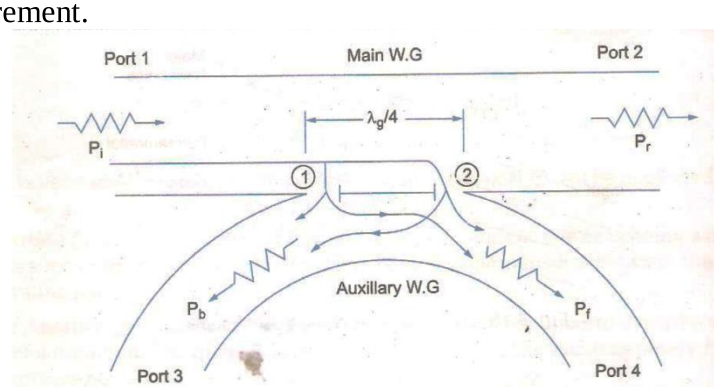


Fig. 6.19 Two hole directional coupler.

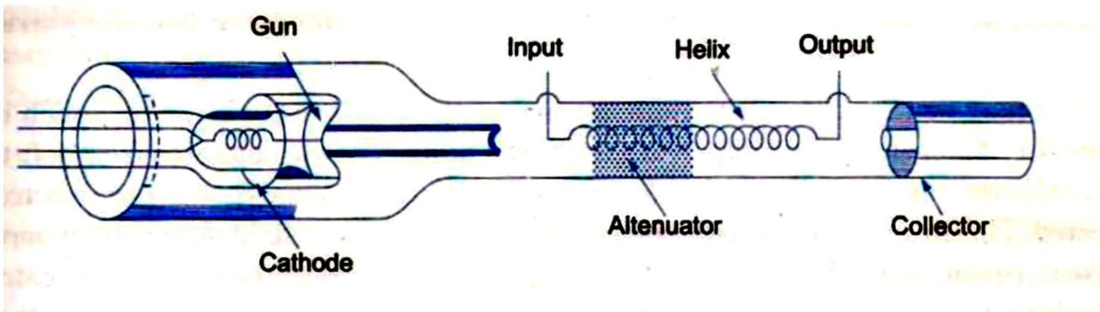
i. The principle of operation of a two-hole directional coupler is shown in figure above. It consists of two guides; the main and the auxiliary with two tiny holes common between them as shown.

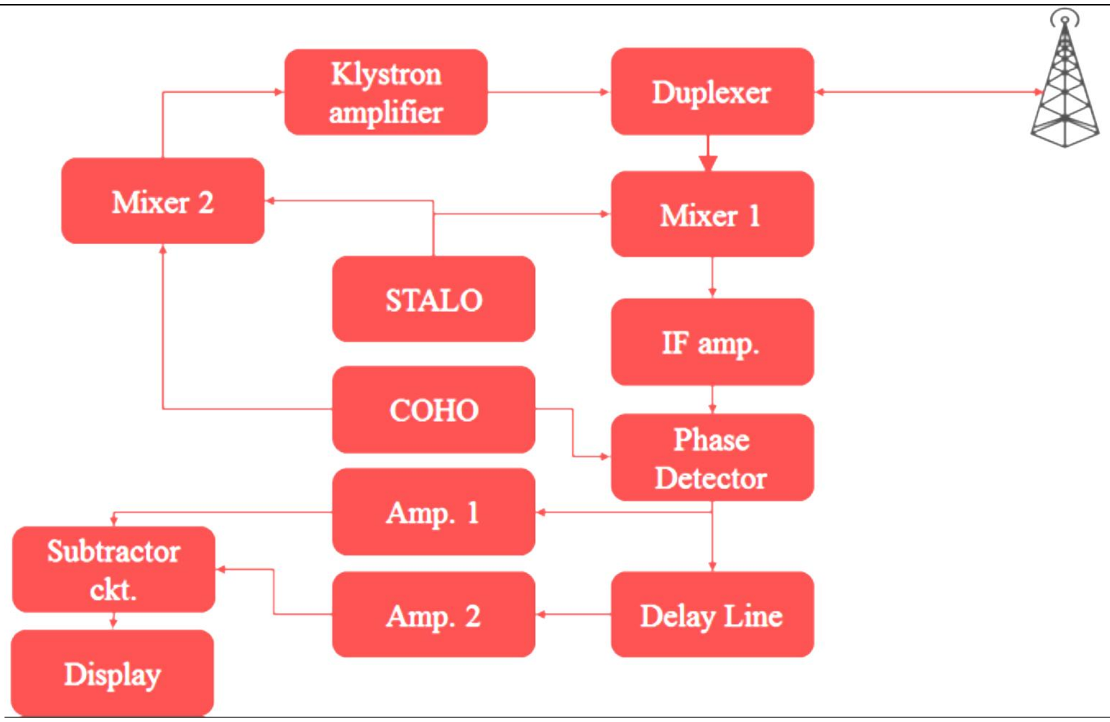
ii. The two holes are at a distance of $\frac{\lambda_g}{4}$ where λ_g is the guide wavelength.

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

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

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

		two holes as a fraction of the wavelength.	
	d)	**Describe the working of TWT as an amplifier.**	**4 Marks**
	Ans:	 • 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.	**2 mark diagram** **2 mark explanation.**
	B)	**Attempt any ONE :**	**06 Marks**
	a)	**A glass clad fiber is made with core glass of refractive index 1.5 and the cladding is dopped to give fractional index difference of 0.0005. Find** **(i) The cladding index, (ii) The critical internal reflection angle,** **(iii) The Numerical aperture.**	**06 Mark**
	Ans:	**Solution:** Given, $n_1 = 1.5, \Delta = 0.0005$ (*i*) Let the refractive index of cladding be n_2. So we have $$\Delta = \frac{n_1 - n_2}{n_1}$$ $$\therefore \quad 0.0005 = \frac{1.5 - n_2}{1.5}$$ $$n_2 = 1.5 - 1.5 \times 0.005 = \mathbf{1.4925}$$ **2) sin $\Theta c = n2/ n1$** **$\Theta c = \sin^{-1} (n2/ n1)$** **$= \sin^{-1} (1.4925/ 1.5)$** **$= 84.268^o$**	**2 Marks each for all finding.**

		3) NA = $\sqrt{n1^2 - n2^2}$ $= \sqrt{(1.5)^2 - (1.4925)^2}$ $= \sqrt{2.25 - 2.2275}$ $= \sqrt{0.02244}$ $= 0.1498 = 0.15$	
	b)	**Explain the working of MTI radar with the help of block diagram and with suitable waveforms.**	**06 Mark**
	Ans:	 **Explanation :** • The echo pulse from the target is received by MTI radar antenna. If echo is due to moving target, the echo pulse undergoes a Doppler frequency. • The received echo pulses then pass through mixer 1 of the receiver. Mixer 1 heterodynes the received signal of frequency (Fo+Fc) with the output of the stalo at Fo. Mixer 1 produces a difference frequency Fc at its output. • This difference frequency signal is amplified by an IF amplifier. Amplifies output is given to phase detector. The detector compares to IF amplifier with reference signal from the COHO oscillator. • The frequency produced by COHO is same as IF frequency so called coherent frequency. The detector provides an output which depends upon the phase difference between the two signals. • Since all received signal pulses will have a phase difference compared with the transmitted pulse. The phase detector gives output for both fixed and also moving targets. Phase difference is constant for all fixed targets but varies for moving targets. • Doppler frequency shift causes this variation in the phase difference. A change	**3 Marks Diagram** **2 Marks Explanation** **1 Marks Waveform**

of half cycle in Doppler shift would cause an output of opposite polarity in the phase detector output.

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

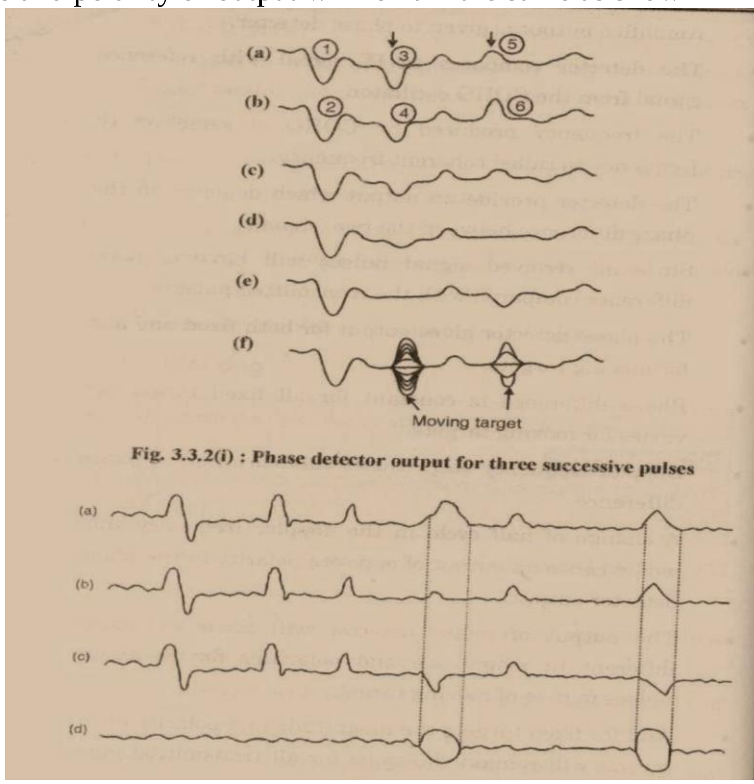
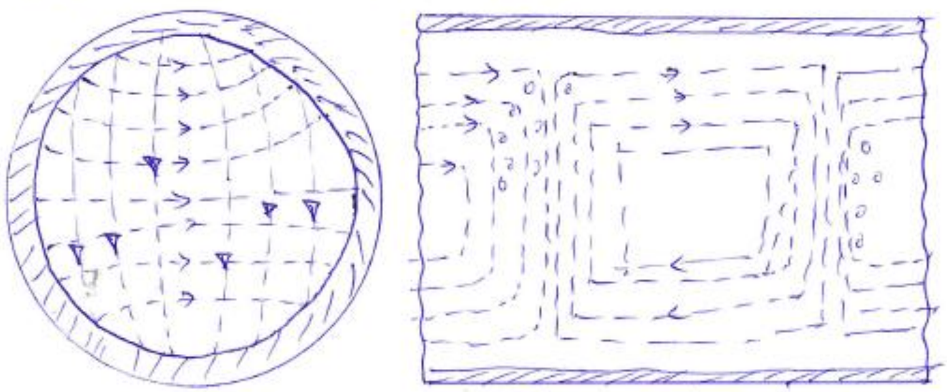
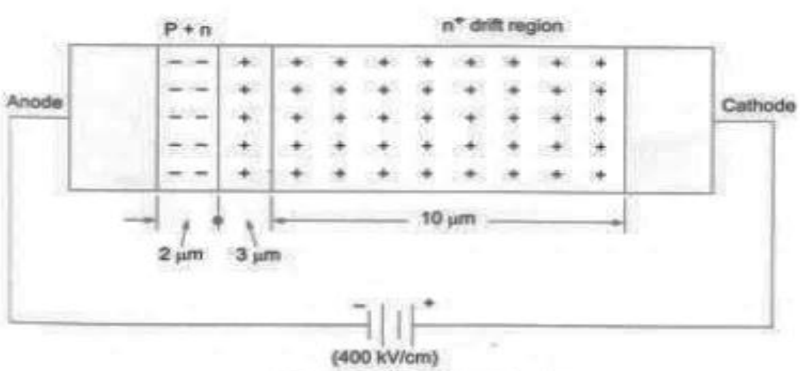
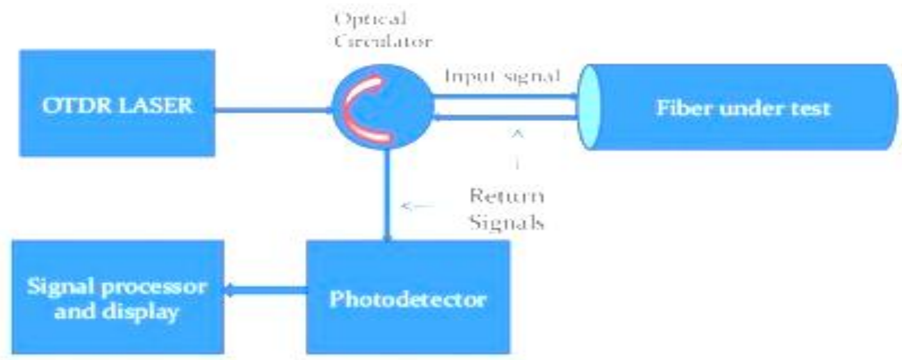


Fig. 3.3.2(i) : Phase detector output for three successive pulses

Q.5	**A)**	**Attempt any FOUR :**	**16 Marks**
	a)	**Draw the field patterns of circular waveguide for its dominant mode.**	**4 Marks**

	Ans:	In Circular waveguide dominant mode is TE_{11} because in this mode lowest cut-off frequency is obtained for $n=1$ & $m=1$. Field pattern: (4marks diagram) Dominant mode (TE_{11}).  TE_{11} mode.	**4 Marks diagram.**
	b)	**With neat sketch describe the operation of IMPATT diode.**	**4 Marks**
	Ans:	 **Fig.** IMPATT 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 180^0 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	**02 marks diagram + 02 marks explanation.**

		necessary 180^0 phase difference between applied voltage and the resulting current in an IMPATT diode.	
	c)	**Draw block diagram of OTDR and explain its working.**	**4 Marks**
	Ans:	 • An Optical time domain reflectometer (OTDR) is a versatile portable instrument that is used widely to evaluate the characteristics of an installed optical fiber link. • In addition to identifying and locating faults or anomalies within a link, this instrument measures parameters such as fiber attenuation, length, optical connector and splice losses and light reflectance levels An OTDR is fundamentally optical radar. • As shown in fig, the OTDR operates by periodically launching narrow laser pulses into one end of fiber under test by using either a directional coupler or a circulator. The properties of the optical fiber link then are determined by analyzing the amplitude and temporal characteristics of the waveform of the reflected and back-scattered light. • A typical OTDR consists of a light source and receiver, data-acquisition and processing modules, an information-storage unit for retaining data either in the internal memory or on an external disk, and display. Figure shows a portable OTDR for making measurements in the field.	**02 marks diagram + 02 marks explanation.**
	d)	**Define geostationary orbit and the geostationary satellite.**	**4 Marks**
	Ans:	**Geostationary Orbit:** A **geostationary orbit**, **geostationary Earth orbit** is a circular geosynchronous orbit 35,786 kilometres (22,236 mi) above the Earth's equator . **Geostationary satellite:** A geostationary satellite is an earth-orbiting satellite, placed at an altitude of approximately 35,800 kilometers (22,300 miles) directly over the equator, that revolves in the same direction the earth rotates .At this altitude, one orbit takes 24 hours, the same length of time as the earth requires to rotate once on its axis. The term geostationary comes from the fact that such a satellite appears nearly stationary in the sky as seen by a ground-based observer.	**02 marks each.**
	e)	**Calculate critical angle of incidence between two substances with different refractive indices n_1 = l.5 and n_2 = 1.46.**	**4 Marks**

Ans:

Given:

$n_1 = 1.5$

$n_2 = 1.46$

formula:

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

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

$$\theta_c = 76.74^{\circ}C$$

OR

$= 1.339$ radians.

1 Marks Formula
3 Marks Answer.

f) Differentiate between LED and LASER (any eight points). **4 Marks**

Ans:

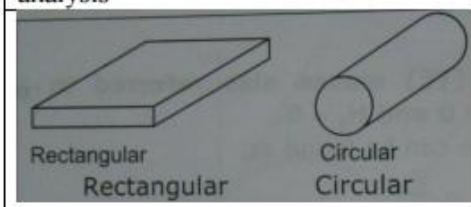
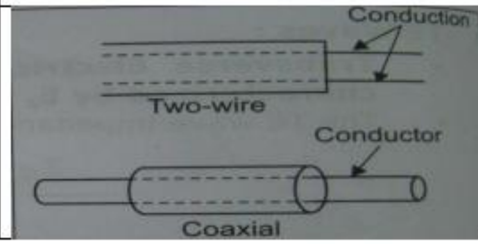
Sr. No.	Parameter	LED	LASER
1	Principle operation	Spontaneous emission	Stimulated emission
2	Output beam	Non-coherent	Coherent
3	Spectral width	Broad (20 – 100 mm)	Narrow (1 – 5 mm)
4	Data rate	Low	Very high
5	X'mission distance	Smaller	Greater
6	Temperature sensitivity	Less sensitive	More sensitive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

½ marks each point (Any 08 points)

Q.6 A) Attempt any of following: **16 Marks**

a) Differentiate between waveguide and two wire transmission line. **4 Marks**

Ans:

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

01 mark each point (any four point)

b) **Describe working and principle of avalanche photodiode with neat sketch.** **4 Marks**

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

02 marks diagram + 02 marks explanation.

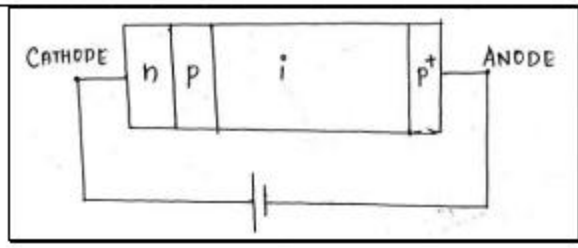


Fig. Avalanche photodiode

Or

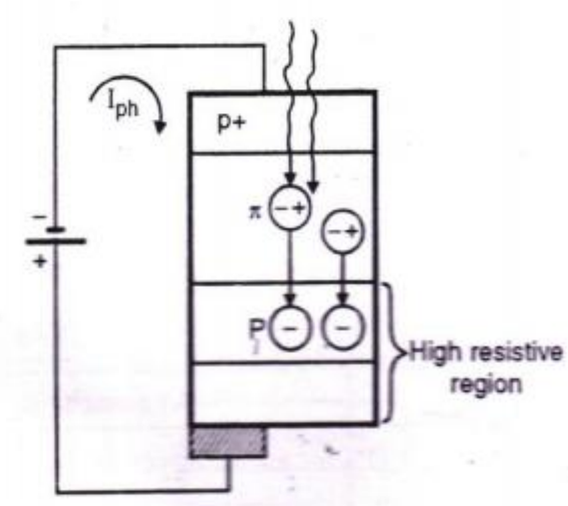
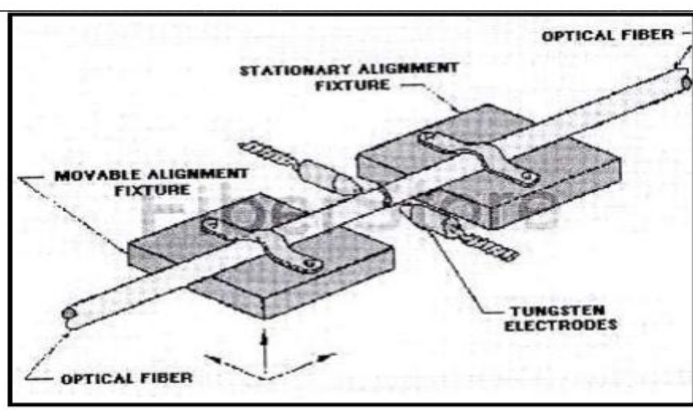


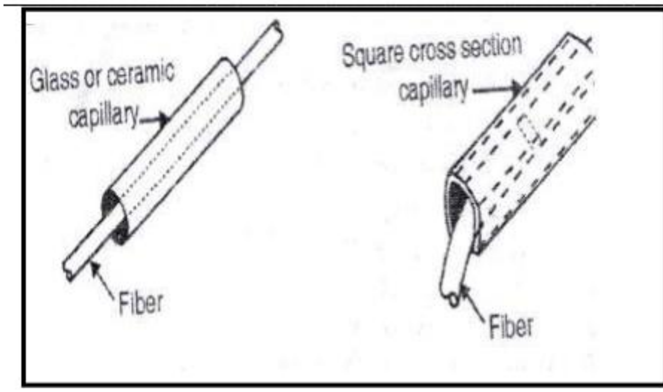
Fig. Avalanche photodiode

Working:

- Light enters the diode & absorbed by the P+ material. This causes high electric field intensity developed across the i-p-n junction.
- This provides reverse biased & causes impact ionization. During ionization carrier can gain sufficient energy to ionize other electrons.
- This process is continues like an avalanche.
- It is effectively equivalent to an internal gain or carrier multiplication.
- APD's are more sensitive than PIN diodes and requires less additional amplification.

	c)	**A step index fiber has a numerical aperture of 0.16, a core refractive index of 1.45 and core diameter of 90 mm, calculate** **(i) The acceptance angle øa.** **(ii)The refractive index of cladding.**	**4 Marks**

	Ans:	Given: $N.A = 0.16$, $n_1 = 1.45$ A) $N.A = \sqrt{n_1^2 - n_2^2}$ $0.16 = \sqrt{(1.45)^2 - n_2^2}$ $n_2^2 = (1.45)^2 - 0.0256$. (02 marks). $\therefore n_2 = 1.441$ $\boxed{n_2 = 1.441}$ refractive index of cladding = 1.441 B) $\sin\theta_a = \frac{N.A}{n_o}$ $= \frac{0.16}{1}$ (02 marks) $\theta_a = \sin^{-1}(0.16)$. $\theta_a = 9^\circ 12'$ $\boxed{\text{Acceptance angle } \theta_a = 9^\circ 12'}$	**2 Marks The acceptance angle** **2 Marks The refractive index of cladding.**
	d)	**Draw the diagram of fusion splice and rigid alignment tube splice.**	**4 Marks**
	Ans:	Different types of splicing are: 1. Fusion splicing or welding 2. Mechanical splicing 3. Elastic tube splicing  **Fig. FUSION splicing** FUSION splicing:- It is accomplished by applying localized heating i.e by a flame or an electrical arc at an interference between two butted, pre aligned fiber ends. This technique involves heating of two prepared fiber ends to their fusing point by applying sufficient axial pressure between the two optical fibers. For heating most widely source is electric arc. Following are steps for fusion process PREFUSION: It is a technique, which involves the rounding of the fiber ends with a low energy discharge before pressing the fibers together. By moving movable block, with proper pressure two fibers are pressed together Then there will be accomplishment of splice.	**02 marks each splice (01 marks diagram + 01 marks explanation)**

		MECHANICAL splicing: Using rigid alignment tube. In this method accurately produced rigid alignment tube is used to bond the prepared fiber ends permanently Figure shows the snug tube splicing  **Fig. MECHANICAL splicing** In snug tune splicing technique uses a glass or ceramic capillary tube with an inner diameter just large enough to accept the optical fibers. Transparent adhesive is injected through a transverse bore in capillary to give mechanical sealing and index matching of the splice. Average insertion losses as low as 0.1dB have been obtained. Figure shows the loose tube splice. In this splice an oversized square section metal is used to accept the prepared fiber ends. Transparent adhesives are first inserted into the tube followed by the fibers.The splice is self-aligned, when fibers are curved in a same plane.Mean splice insertion losses of 0.73dB have been achieved.	
	e)	**How power is generated in satellite? Describe how it is distributed to other subsystem of satellite.**	**4 Marks**

Ans:

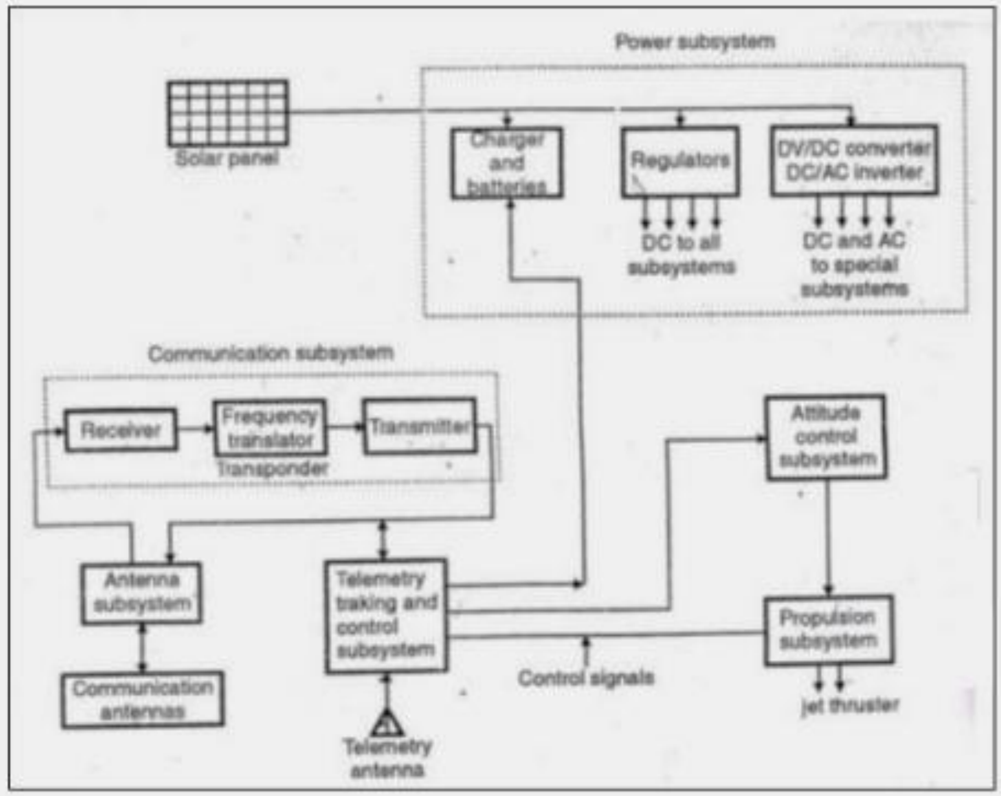


Fig. Block diagram of satellite subsystem

Figure shows the distribution of power in other subsystem.
Explanation(02 marks)

1. The solar panels generate a direct current which is used to operate the various components of the satellite. The DC power is typically used to charge Ni-Cd batteries that act as a buffer. At times when the satellite goes into an eclipse or when solar panels are not properly positioned, the batteries take over temporarily and keep the satellite operating. These batteries are not large enough to power the satellite for a long period of time. They are simply used as a backup system for eclipses, initial satellite orientation and stabilization or emergency conditions.
2. The basic DC voltage from the solar panels is then conditioned in various ways –
   a) It is typically passed through voltage regulators before being used to power individual electronic circuits. Most electronic equipment works best with fixed stable voltages and therefore regulators are incorporated in most satellite systems.
   b) Some parts of the satellite require higher voltage than those produced by the solar panels. The TWT amplifiers in most communication transponders require thousands of volts for proper operation. Special DC to DC converters are used to translate the lower DC voltage of the solar panels to the higher DC voltage required by the TWTs.

		c) Some circuits of the satellite require Ac voltage so inverters (DC to AC) are used to generate AC voltage.	