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 judgment 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.

Q1. (A) Attempt any THREE:

a) Define the term with respect to waveguide:

i) Group velocity

ii) Cut-off wavelength

Ans: (2M each Definition)

i) **Group velocity:** It is defined as the rate at which the wave propagates through the waveguide and is given by

$$v_g = \frac{d\omega}{d\beta}$$

Group velocity is always less than speed of light. Group velocity in waveguide is the speed at which electromagnetic wave travels in a waveguide.

ii) **Cut-off wavelength:** The cut-off wavelength is the free space wavelength at which signal is just unable to propagate in the waveguide.

OR

The cut-off wavelength is defined as the smallest free-space wavelength that is just unable to propagate in the waveguide.

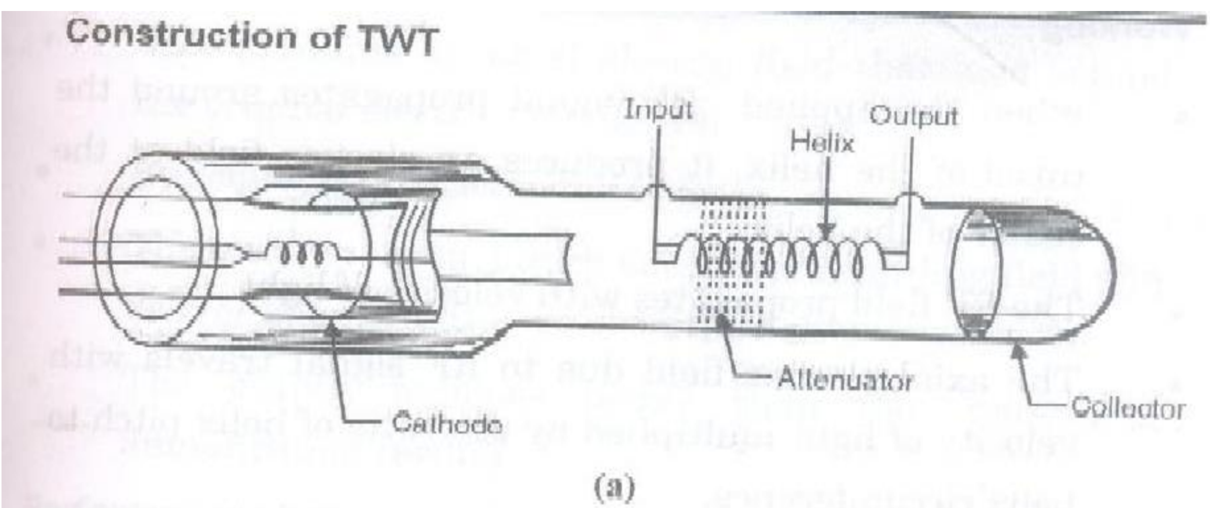
Mathematically it is given by,

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

b) Draw well labeled schematic of TWT & Give its any two application.

Ans: (Diagram-2M, Application -2M)

[***Note: Any other relevant diagram or application can be considered.]***



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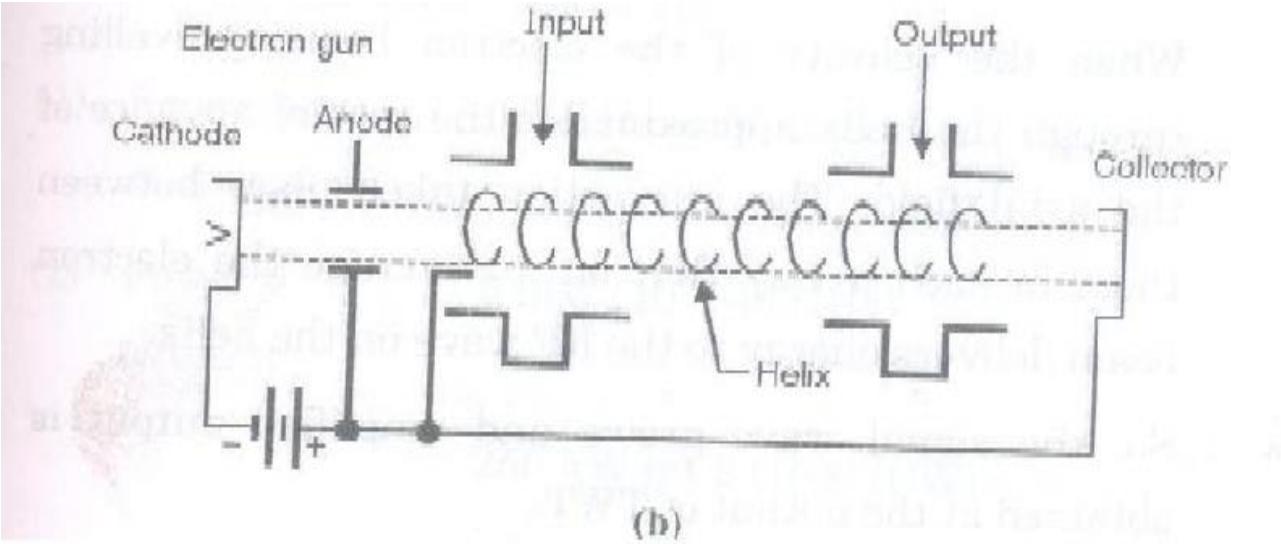


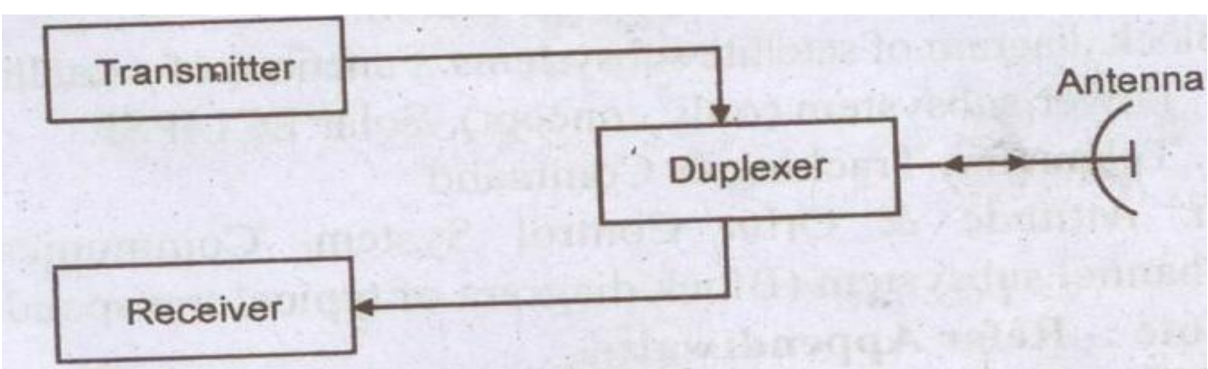
Application: [any 2, list is enough]

- TWT are commonly used as amplifiers in satellite transponders
- TWT transmitters are used extensively in radar, particularly in airborne fire-control radar systems, in electronic warfare and self-protection systems
- TWT is use for the electromagnetic compatibility (EMC) testing industry for immunity testing of electronic devices.

c) Draw basic block diagram of RADAR system & describe its working principle.

Ans: (Diagram-2M, Explanation-2M)

[***Note: Any other relevant diagram can be considered.]***



Explanation:

- **Basic principle:** Rader consist of a transmitting receiver each connected to a directional antenna. The transmitter is capable of large UHF and microwave power through the antenna. The receiver collects as much as energy possible from the echoes reflected in its direction be the target. The received signal is then displayed of suitable fashion on displayed information of.

- **Devices:** In a radar system a master timer controller exists which controls the pulse repetition Rate (PRR) (PRF gives the occurrence of continuous wave train these are transmitted by a highly directional parabola antenna. Antenna has been switched between antenna & receiver by a diplexer. The reflected energy is received and The time measurement are made to determine the distance of the target.

d) Define the following terms with respect to satellite:

i) Look angle

ii) Foot print

Ans: (2M each Definition)

i) **Look angle:** To orient an earth station antenna towards a satellite so that transmission and reception can be maximized, it is necessary to know the elevation and azimuth angle. These are called as look angles. Azimuth angle and elevation angle are jointly referred to as the antenna look angle.

ii) **Foot print:** The geographical representation of a satellite antenna radiation pattern is called footprint. The footprint of a satellite is the earth area that the satellite can receive from and transmitted to.

Q 1 B)Attempt any ONE:

a) With neat diagram describe the wave propagation through rectangular waveguide. Also, give the condition when propagation in dominant mode.

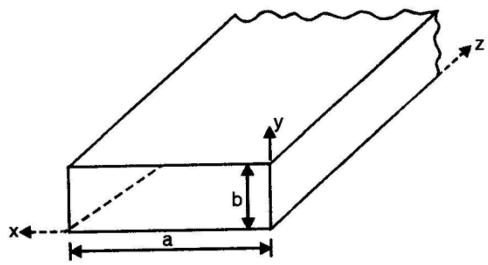
Ans: (Explanation 3M, Diagram 1M, Condition when propagates in dominant mode-2M)

Note: Any other relevant diagram can be considered.

- Rectangular waveguide is a hollow metallic tube with a rectangular cross section. It has width a and height b. Commonly used rectangular guide has an aspect ratio of 0.5 approx (b/a).
- The physical dimension of waveguide determines the cut off frequency for each mode. The walls of waveguide have infinite conductivity and medium is ideal dielectric having permittivity Є, permeability

μ and σ=0

- The dominant mode in particular waveguide is the mode having lowest cut off frequency or highest cut off wavelength.
- In a rectangular waveguide TEM mode does not exist
- For rectangular waveguide dominant mode is TE10 mode



- Above figure shows the direction of propagation of two different electromagnetic wave fronts of different frequencies being radiated into waveguide by a probe.
- The age of incidence and angle of reflection of wave fronts vary in size with the frequencies of the input energy. The angle of reflection is equal to each other in waveguide. Arrow shows the direction of propagation.
- The cut off frequency in the waveguide is the frequency that causes angles of incidence and reflection to be perpendicular to the wall of guide.
- If the frequency is below the cut off frequency, the wave fronts will be reflected back and forth across the waveband and no energy will be conducted down the waveguide.
- The velocity of propagation of wave along a waveguide is less than its velocity through free space. This lower velocity is caused by zigzag path taken by wave front in a waveguide

Condition when propagates in dominant mode:

- It signifies all electric fields are transverse to the direction of propagation and no longitudinal electric field is present.
- The electric field is maximum at the center of the waveguide and drops off sinusoidally to zero intensity at the walls.

b) Write Radar maximum range equation in noise free atmosphere and state how different parameters affecting the RADAR range.

Ans: (Equation-2M, Parameters-4M)

The maximum range R_{max} will be obtained when the received power is equal to the maximum receivable power of the receiver ,P_{min}

$$R_{max} = \left(\frac{P_t A^2{}_0 S}{4\pi r^4 \lambda^2} \right)^{1/4}$$

<u>Factors:</u>

1. Transmitter Power:

In case the radar range is to be doubled, we have to increase the transmitter power 16 times since $R_{max} \alpha (Pt)^{1/4}$

2. Minimum Detectable Signal:

Rmax $\alpha (1/S_{min})^{1/4}$; thus reducing S_{min}, the receiver has to be very sensitive and gain of the Receiver should be high. But Rx is more susceptible to interference as it now amplifier weak signals rather than amplifying low power received signals.

3. Frequency and Effective Area of Antenna:

- $R_{max} \alpha 1/\sqrt{\lambda}$ or $R_{max} \alpha \sqrt{f}$ (=c/f).this implies that increase in frequency increases the range. But, in a parabolic antenna, the beamwidth is given by λ/D where D is the diameter of the parabola.
- If λ is reduced, beamwidth becomes very narrow which reduces the tracking range of the radar. This is particularly is in case of a search radar where the sweep of the antenna that covers a portion of the sky will require a longer time.
- If the lobe beam width is very narrow. Thus, radar frequency cannot be increased far too much as the radar becomes ineffective although range may increase.
- Also, $R_{max} \alpha \sqrt{A_e}$. Hence, range can be increased if effective area of antenna is increased. In order to increase effective area diameter D of parabolic antenna must be increased,which in turn reduces the beam width.

4. Target cross sectional area(S):

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

Q.2. Attempt any FOUR: [16M]

(a) Differentiate between waveguide and two wire transmission line (any four point)

Ans: (Any four points, 1M each)

[NOTE: If diagram drawn that can be considered as point]

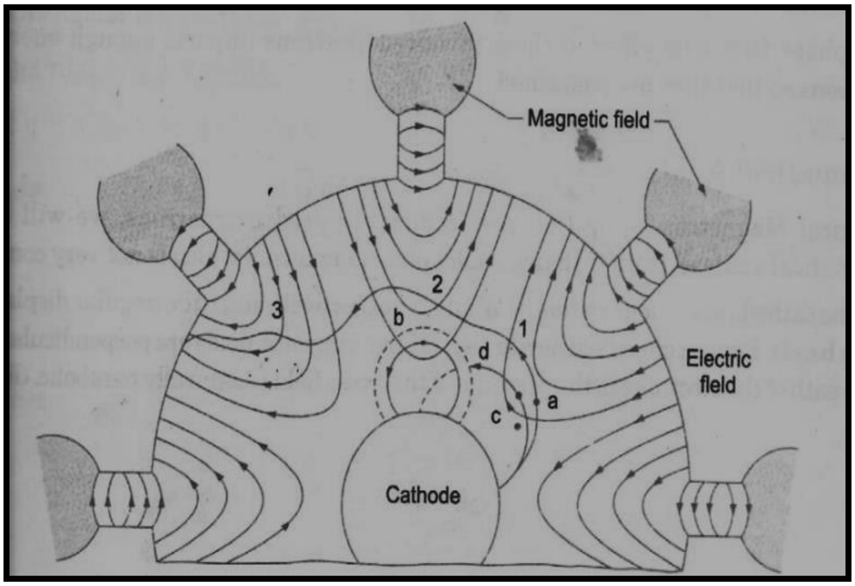
SR NO.	WAVEGUIDES	TRANSMISSION LINES
1.	It acts as a High Pass Filter	All frequencies can pass through.
2.	It is one conductor transmission system. The whole body of the waveguide acts as ground. The wave propagates through multiple reflections from the walls of waveguide (WG).	It consists of two conductors.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

(b) Describe working of magnetron as an oscillator.

Ans: (Working-2 M, Diagram -2 M)

Working of Magnetron:

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



2. Self-oscillations will be obtained if the phase difference between adjacent anode poles is nπ/4 (N=8), where n is an integer. n=4 results in π mode. Here the anode poles are π radians apart.
3. The dotted lines refer to the path of electrons in case of static field. The solid lines refer to the electron trajectories in the presence of RF oscillations in the interaction space.
4. The electron 'a' is seen to be slowed down in the presence of oscillations thus transferring energy to the oscillations during its longer journey from cathode to anode. Such electrons which participate in transferring energy to the RF field are called as favored electrons and these electrons are responsible for bunching effect.
5. An electron 'b' is accelerated by the RF field. Instead of imparting energy to the oscillations, it takes energy from the oscillations resulting in increased velocity. Hence bends more sharply, spends very little time in the interaction space and is returned back to the cathode. Such electrons are called un-favored electrons which do not participate in the bunching process; rather they are harmful as they cause back heating.

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

(c) Write the operation of pulse RADAR to detect the object.

Ans:(Diagram-2M,Explanatiom-2M)

Diagram: **[2M]**

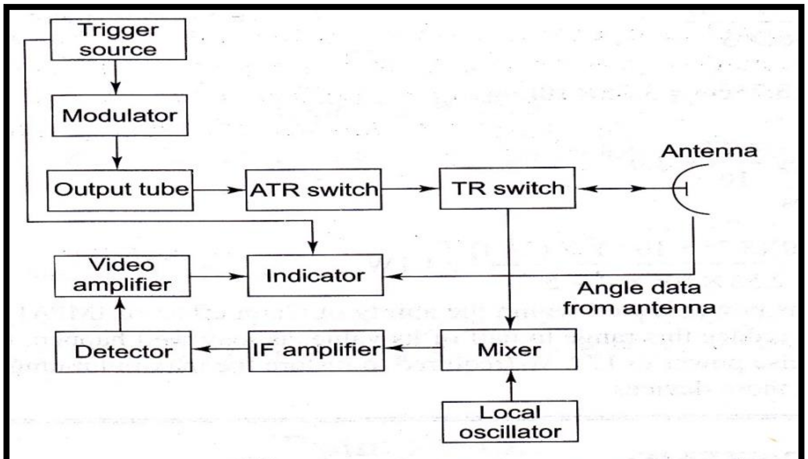


Fig. *Pulsed radar block diagram.*

Explanation:- **[2M]**

- **Triggering Source**: It provides pulses for the modulator which establishes the rate at which the pulses are to be transmitted.

- **Modulator**: The modulator provides rectangular voltage pulses which are used as the supply voltage for the output tube, thus switching it ON and OFF as required. The modulation process is at high power level, because the peak transmitted power is generally of the order of 500KW, although the average power over a cycle is less than 500 watts. The modulator should therefore be capable of supplying three to four times the carrier power to the power tube.

- **Output tube**: Magnetron is commonly used output tube because it can develop large power.

- **ATR & TR switch**: It acts as duplexer is a circuit designed to allow the same antenna for radar transmission and echo reception, such that it will neither allow the transmitter output into the receiver nor the echo input into the transmitter
- **Video amplifier**: The video amplifier has the same band width as that of IF amplifier. It amplifies the detector output.
- **Indicator**: The output of the radar receiver is presented to the operator in the form of visual indication, using a cathode ray tube. Presentation may be deflection modulated or intensity modulated, depending on whether the trace is deflected or brightened by the presence of an echo. Since a radar is rang measuring instrument, one-coordinate displays range.
- **Detector:** Since vaccume tubes or transistors do not function at microwave frequency due to transmit time, the detector is often a schottky – barrier diode or crystal diode.
- **IF amplifier**: The IF amplifier section usually consists of five or six amplifiers to ensure high gain and approximately 10MHz bandwidth. In addition, all the amplifiers are also synchronous, that is, all stagger tuned to the same frequency to obtain a pass band within the broad selectively.
- **Local Oscillator**: Local oscillator in radar receiver is reflex klystron with a narrow band filter at the output to reduce its noise.
- **Mixer**: Mixer is fed a signal from RF amplifier as well as local oscillator signal. The local oscillator operates at frequency higher than the RF signal and required a special high frequency tube. The output from the mixer is selected as the difference frequency at about 30 MHz.

(d) Justify selecting uplink frequency higher than downlink frequency in satellite communication system.

Ans: (Explanation -4M)

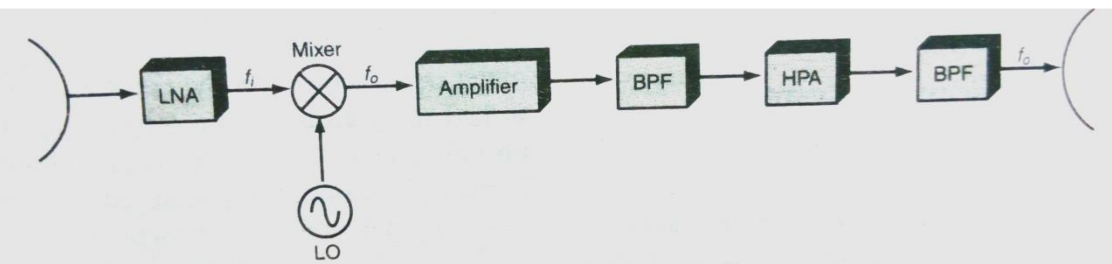
- Two separate frequencies are used for uplink and downlink signals in satellite communication so that one cannot interfere with the other and full duplex communication is possible.
- The Power required to transmit a signal is proportional to the frequency of the signal. And more power requirement more would be the weight of the system. As there are constraints on the load that can be carried with the satellite, mainly down linking frequency is lower than the up linking one.

- The satellite gets power from solar cell. So, the transmitter is not being of higher power. On the other hand the ground station can have much higher power. As we want less attenuation and better signal-to-noise ratio, lower frequency is more suitable for downlink and higher frequency is commonly used for uplink.

(e) Describe transponder with basic block diagram.

Ans: (Block diagram- 2M, Explanation- 2M)

Note: Any other relevant diagram to be considered



A single-conversion transponder.

- In this transponder only a single-frequency translation process takes place
- First uplink frequency signal is picked up by the receiving antenna and is routed to LNA (Low Noise Amplifier)
- The signal is very weak at this point, so LNA amplifies the signal
- Once the signal is amplified, it is translated in correct frequency by mixer.
- The output of mixer is then amplified again and fed to band pass filter (BPF1)
- BPF1 allows only a desired down-link signal of 4 GHz
- At last, the down-link signal is amplified by high power amplifier (HPA) usually TWT (Travelling wave tube)
- Again output of BPF2 is fed to the down-link antenna
- If common antenna is used for transmission or reception then diplexer is used to share the antenna.

(f) Give frequency bands used for satellite communication with uplink and downlink frequency range.

Ans: (Each Band-1M)

SR. NO.	BAND	UPLINK FREQUENCY (GHZ.)	DOWNLINK FREQUENCY (GHZ.)
1	UHF	0.29-0.31	0.25-0.27
2	C	5.9-6.4	3.7-4.2
3	X	7.9- 8.4	7.25-7.75
4	Ku	14-14.5	11.7-12.2
5	Ka	27-30 30-31	17-20 20-21

Q.3. Attempt any FOUR : [16M]

a) Give advantages of circular waveguide over rectangular waveguide.

Ans : (Any relevant point consider – 1M)

Advantages of circular waveguide over rectangular waveguide are

- Circular waveguide is easier to manufacture than rectangular waveguide.
- Easier to join together.
- Propagate both vertically and horizontally polarized waves in the same waveguide.
- It has lowest attenuation per unit length so suitable for long distance waveguide transmission.

b) Describe the operation of Gunn diode with well labeled diagram.

Ans : (Diagram-2M , Operation-2M)

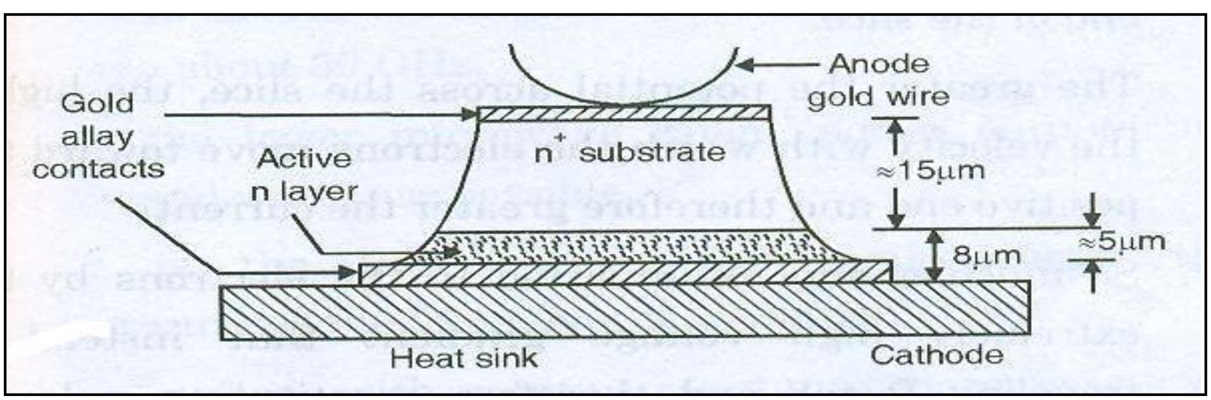


Fig: Gunn Diode

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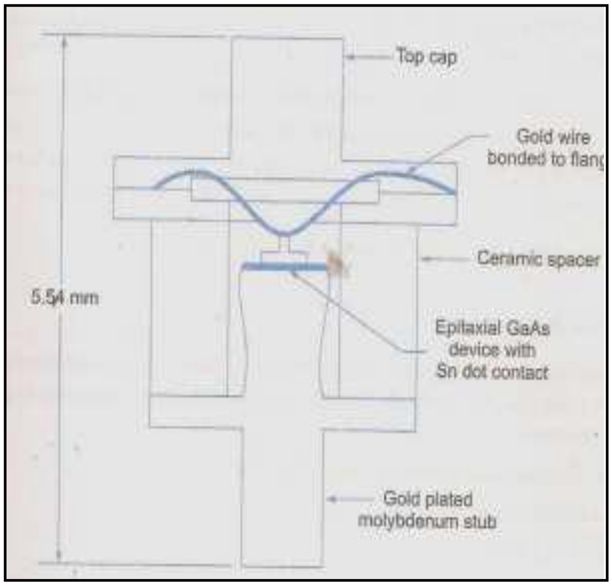

Fig: Gunn Diode

Operation:

- When a DC bias of value equal or more than threshold field (of about 3.3KV/cm) is applied to an n-type GaAs sample, the charge density and electric field within the sample become non- uniform creating domains that is electron in some region of the sample will be first to experience the inter valley transfer than the rest of the electrons in the sample. The EF inside the dip[ole domain will be greater than the fields on either side of the dipole so the electrons in that region or domain will move to upper- valley and hence with less mobility. This creates a slight deficiency of *e*-1 s in the region immediately ahead. This region of excess and efficient *e*-1 s form a dipole layer.
- As the dipole drifts along more *e*-1 s in the vicinity will be transferred to the U-valley until the electric field outside the dipole region is depress below the threshold EF. This dipole continues towards the anode until it is collected upon collector, the EF in the sample jumps immediately to its original value and next domain formation begins as soon as the field values exceeds the threshold values and this process is repeated cyclically.

c) Describe different display methods used in RADAR system.

Ans:

[Types: 1M]

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

- Automatic target detection

A-scope Display: **(1.5M)**

- A beam is made to scan the CRT screen horizontally by applying a linear saw tooth voltage to the horizontal deflection plates in synchronism with the transmitted pulses.
- The demodulated echo signals from the receiver is applied to the vertical deflection plates so as to cause vertical deflections from the horizontal lines.
- In the absence of any echo signal, the display is simply a horizontal line(as in a ordinary CRO)
- As indicated in the diagram, A-scope displays range v/s amplitude of the received echo signals.
- The first 'blip' is due to the transmitted pulse, part of which is deliberately applied to the CRT for reference.
- In addition to this there are blips corresponding to:

i. Ground clutter i.e., echoes from various fixed objects near the transmitter and from the ground.
ii. Grass noise i.e., an almost constant amplitude and continuous receiver noise.
iii. Actual targets. These blips are usually large.

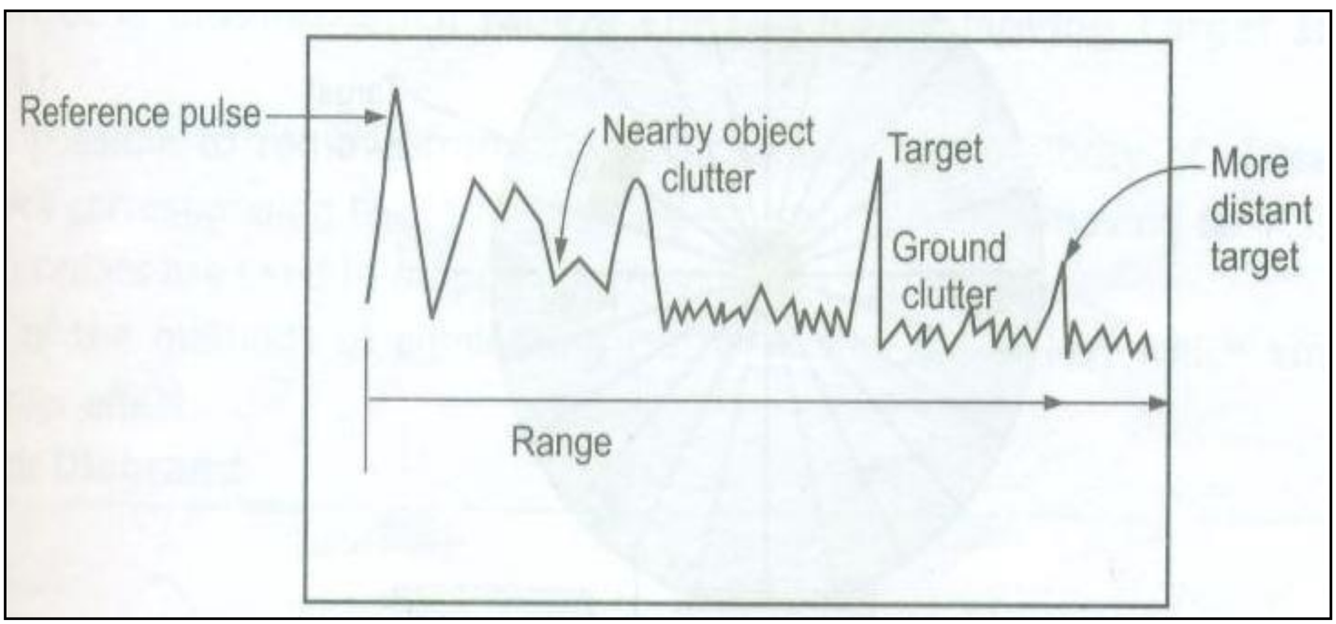

Fig :A-scope Display

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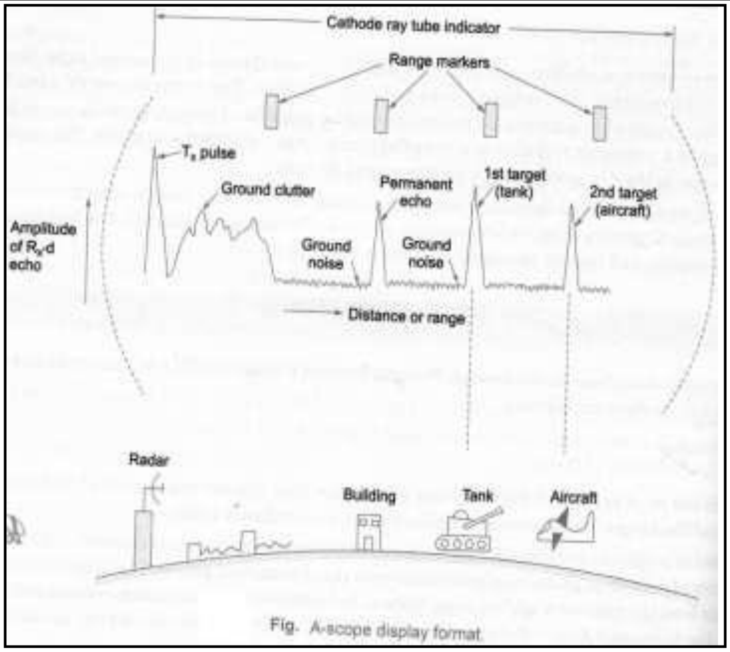

Fig :A-scope Display

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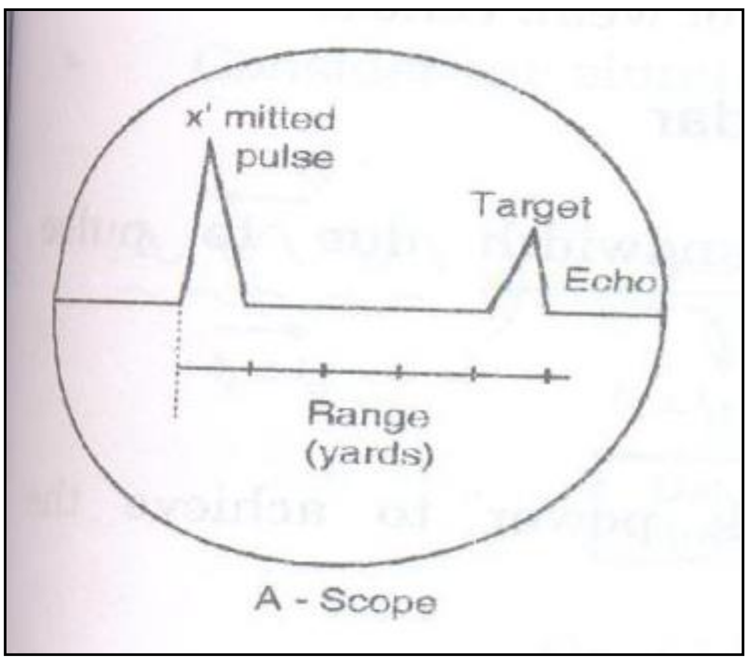

Plan-Position indicator (PPI): **(1.5M)**

- 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.

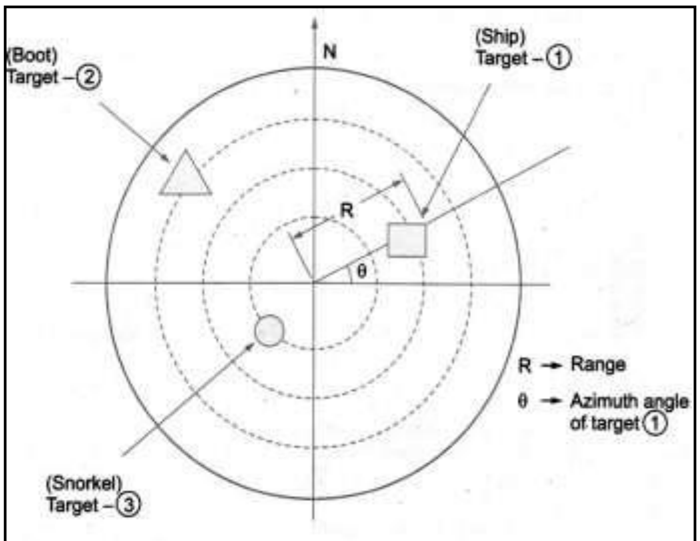

Fig. PPI display

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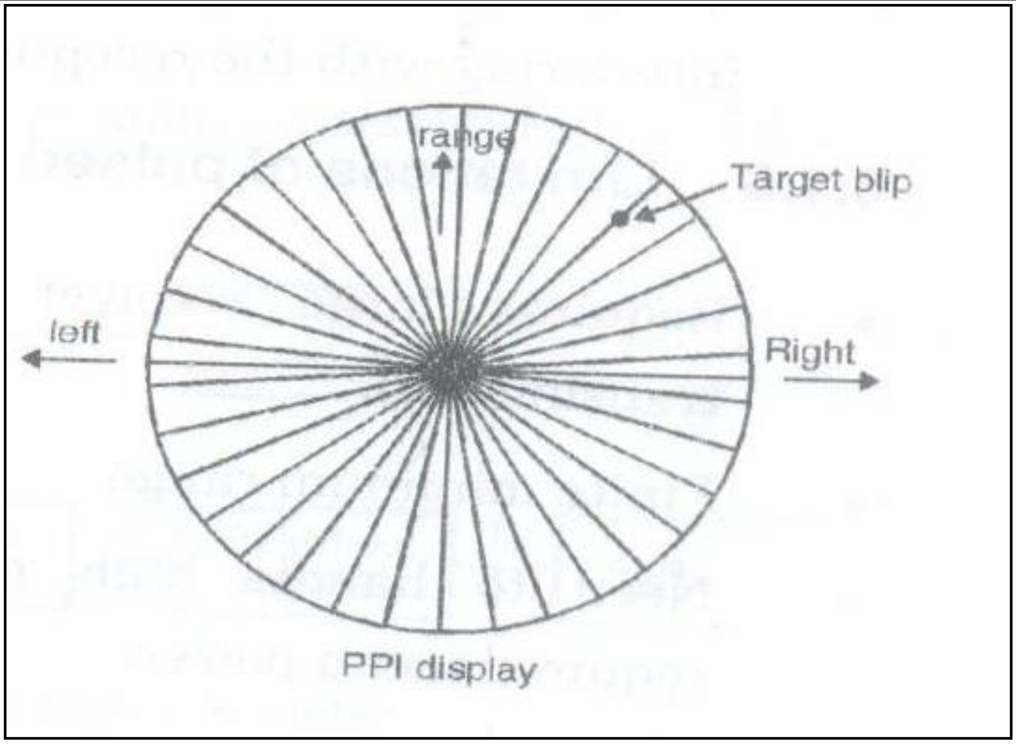


Automatic Target Detection: **(1M)**

- For automatic target detection an appropriate threshold should be there so that noise pulses are eliminated and only the signal pulses are shown up.
- So to set threshold two pulse threshold technique or method or multiple pulse detection techniques are used.
- In M out of N Detection i.e. multiple pulse detection binomial probability is used.
- A threshold is set up and an event will be based on whether this threshold is crossed.
- Minimum number of crossings is required for a detection.

(d) List different orbits used for satellite communication. Also specify one application of each.

Ans: (Types-1M and consider any relevant Application-1M each)

Types of orbit satellite:

1. Synchronous orbit or geostationary orbit
2. Polar Orbit
3. Inclined Orbit

Applications of Synchronous orbit or geostationary orbit:

1. Synchronous orbit or geostationary orbit is applicable for GPS.

2. Provide reliable telecommunications service, and even beam television signals directly to your house.

Applications of polar orbit:

1. It is used to put remote sensing satellite and for navigation.
2. Typical applications of polar orbit satellites are for observation of the Earth and reconnaissance.

Applications of Inclined orbit:

1. It is used for domestic communication in some countries.
2. Geostationary orbit (GEO) communication satellites can be extended in lifetime by switching to inclined- orbit operations

e) Compare satellite communication system with fiber optic communication system (Any four points).

Ans: (Consider any relevant points-1M)

SR.NO.	SATELLITE COMMUNICATION SYSTEM	FIBER OPTIC COMMUNICATION SYSTEM
1	Bandwidth is limited for satellite communication for example 75 MHz for each transponder.	Unlimited bandwidth is available (50 THz) for optical fiber.
2	It require high power transmitter and low noise amplifier (LNA).	No such requirement.
3	Satellite communications suffers from propagation delays.	No such delays.
4	It is possible to jam the satellite.	No jamming possible.
5	Satellite communication is more suitable to the remote areas where fiber optics cannot be used.	Suitable for sea or flat terrain both.
6	Communications is affected by storm/EMI	Not affected

4. (A) Attempt any THREE: [12M]

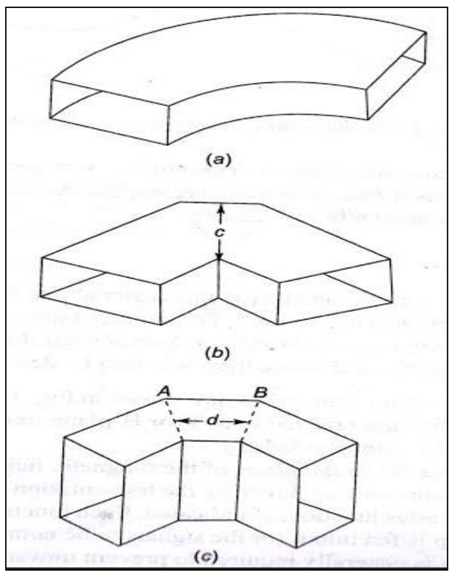
(a) Describe the function of bends and corners; taper and twist in microwave system.

Ans: (2 M Each)

Functions:

Bends and corners: Waveguide bends are useful for changing the direction of the guide by a desired angle. Corner is one of waveguide component used to change the direction of the guide through an arbitrary angle.

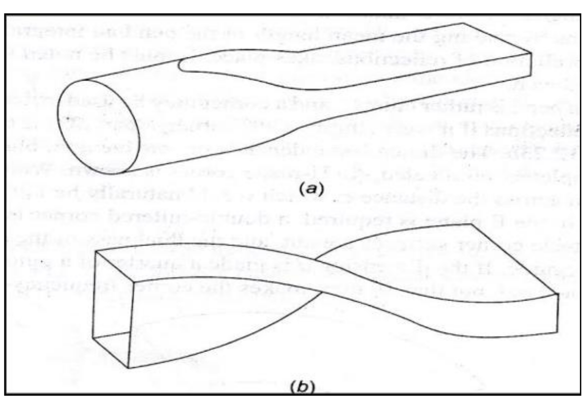
Diagram:



Taper and Twist:

Taper is used to couple the WGs having different dimensions or cross sectional shapes. The twist section is used to change between horizontal and vertical polarization.

Diagram:



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

Ans: (Diagram-2M , Working-2M)

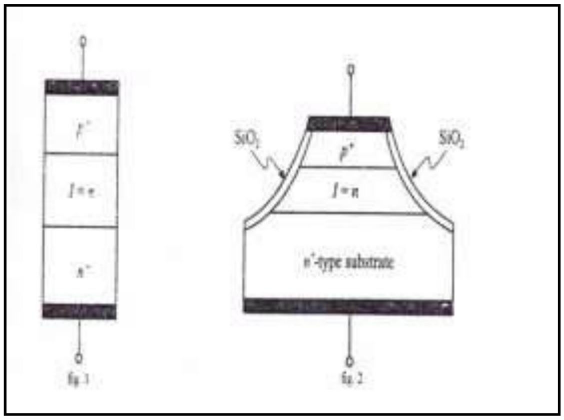


Fig: PIN Diode

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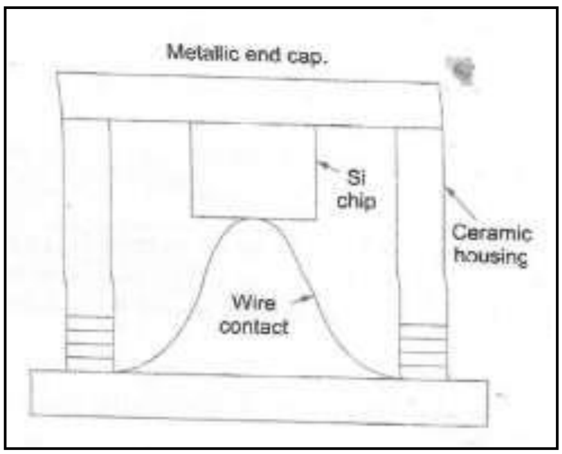


Fig: PIN Diode

Working:

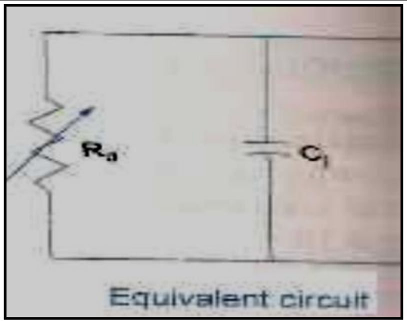
The PIN diode has following modes of operation:

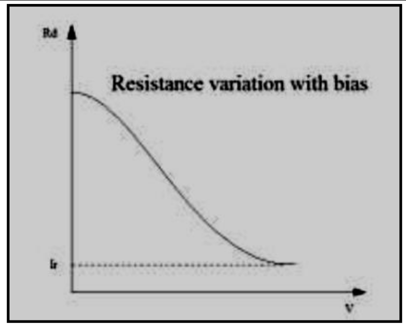
1. Forward biased:

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 region.

3. This results in the carrier concentration in the I layer becoming raised above equilibrium levels and the resistivity 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 PINdiode, suitably biased, therefore acts as a variable resistor. This high-frequency resistance may vary over awide 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.

(c) Describe the working principle used in CW Radar system.

Ans: (Diagram-2M, Working-2M)

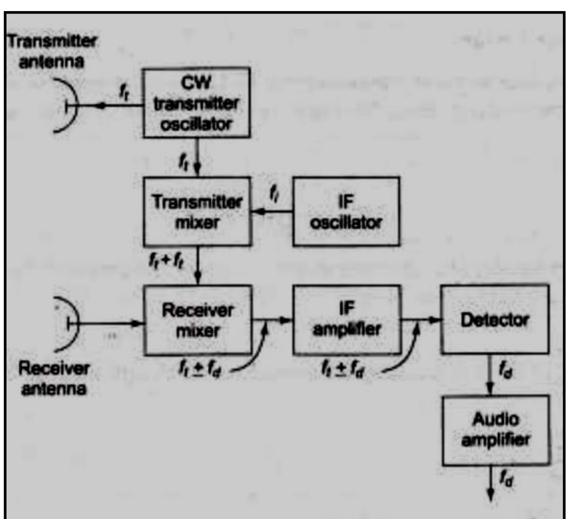


Fig. *CW Doppler radar with IF amplification.*

Working:

- CW Doppler radar makes use of Doppler effect for target speed measurement. It transmit continuous sine wave rather than pulses.
- As CW radar transmission is continuous, there is no point to use duplexer, Instead od duplexer circulator is used to provide isolation between the transmitter and the receiver.
- The isolation provided by typical circulator is of the order of 30 dB, so that some of the transmitted signal leaks into receiver.
- This signal is mixed in the detector with echo signal from the target and the difference is doppler frequency .This doppler frequency is usually in the audio range, hence it is amplified by audio amplifier.
- The output of the audio amplifier is then applied to the frequency counter, whose output is displayed in terms of Km/hr or miles/hr, rather than actual frequency in hertz.
- The main dis-advantage of this system is its low sensitivity. The type of diode detector that is 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. The figure shows the block diagram of CW doppler radar with IF amplifier, which is improved version in that regard.

(d) Describe the function of Attitude control subsystem in satellite communication system.

Ans: Function: 4M

i) Attitude control subsystem provides stabilization in orbit and senses the changes in orientation of satellite.

ii) With built-in jet thruster it makes the necessary corrections to the alttitude of satellite.

iii) When this subsystem senses the change in position of satellite from the desired.

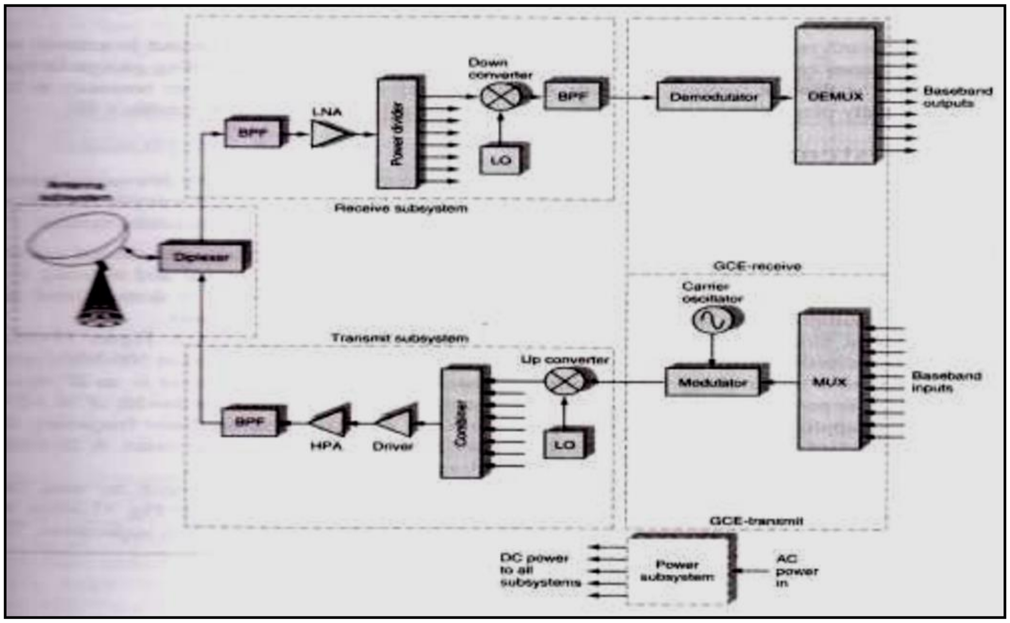
iv) It receives signal from command and control system and that fires the appropriate thruster at proper time.

v) This subsystem provides stabilization of the satellite and controls its orbit. It fires jet thrusters to perform attitude adjustments and station keeping man oeuvres that keep the satellite in its original orbital position with correct orientation.

(B) Attempt any ONE: [6M]

(a) Describe the function of satellite earth station with neat block diagram.

Ans: (Diagram-2M , Function-4M)



Note: Or Any other relevant Diagram

(Explanation-4M)

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.

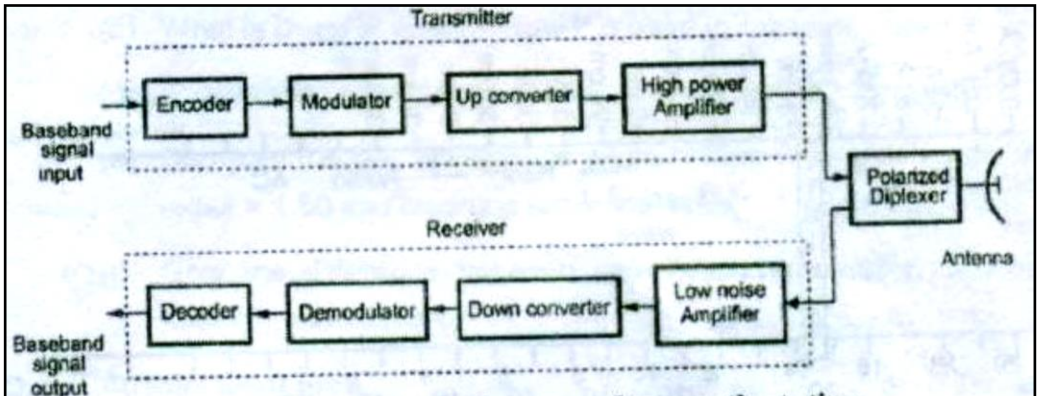
Power Subsystem:

This system includes the primary sources (the standard AC lines) for running the earth station. The subsystemoperates 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.

OR



Basic block diagram of an earth station

Note : Any relevant explanation to be considered

<u>Transmitter Side</u>

- 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 up converted 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.

Receiver Side

- The signal received from the antenna is of different frequency (downlink frequency) and is very weak signal.
- This signal is amplified by the low noise amplifier.
- It is then down converted to the intermediate frequency by the down converter.
- This signal is then demodulated and decoded to get baseband signal.

b) Describe different antenna tracking methods with neat diagrams.

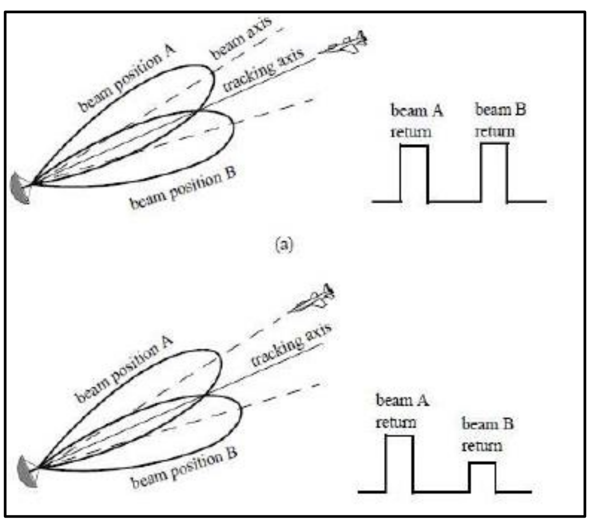
Ans: 2M Each

Types:

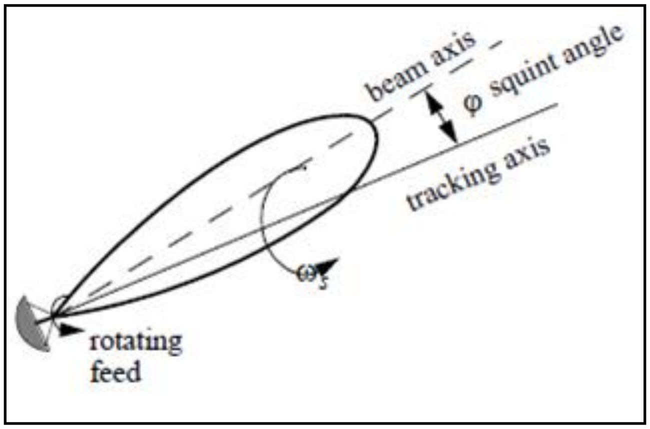
a) Sequential tracking or Lobe switching tracking
b) Conical tracking
c) Monopulse tracking

a) Lobe switching

- Here the direction of antenna being rapidly switch between two positions. Hence the name role switching or sequential switching is given.
- The echo signal from the target will fluctuate at the switching rate unless the target is exactly centered between the two directions. Once the target reached the midway of antenna positioning the strength of echo signal will be the same. But the angular or tracking error should be determined.
- Tracking error is the angle difference between the reference axis target axis and axis of antenna. This angular error is applied to the server mechanism which attempts to position the antenna beam on the target. When this angular error is zero the target is located along the reference direction. Thus sequential lobing is used for tracking a target only in one plane.

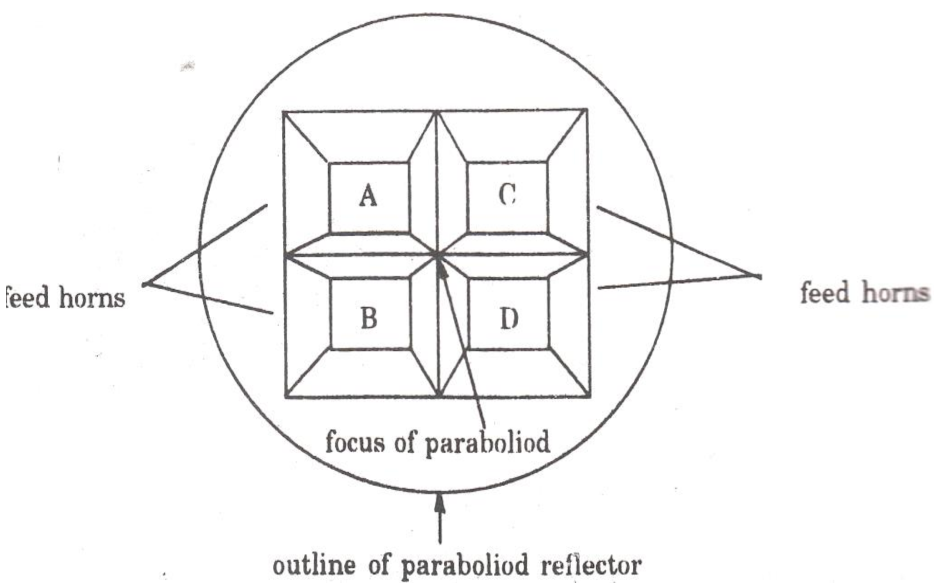


b) Conical Switching:



- In conical switching parabolic antenna is mounted slightly off centre and rotate continuously about it's axis. The rotation is slow as compared to PRF. The surface described by the beam in space is conical. Since the revolution of solid is a cone as the tip of the pattern moves in a circle so the name is given conical tracking. The angle between the antenna is called as squint angle conical switching is accurate in elevation as well as in azimuth. Whereas sequential lobing is accurate only in one plane.

c) Monopulse tracking: In an amplitude system four feeds are u horn antennas and the central focus of the reflector. The transmitter feeds the horns simultaneously so that a sum signal is received by the receiver using ring or rat race to provide the following signal.



- Each of the four field produces a slightly different beam from the reflection so that during transmission four individual beams are projected into the space beam centered on the direction could have a signal beam placed at the 4 of reflector. As a conical and sequential lobing, no differences will be recorded if the target is precisely in the actual axis direction of the antenna. However, once acquired any deviation from the central position will be shown by presence of vertical and horizontal difference. The O/P of the sum signal is generally used to provide the data obtained at the receiver while the difference signals feeds the servo motors & amplifier to drive the antenna so that it keep pointing exactly at the target.

Q.5 Attempt any FOUR: [16M]

a) Draw schematic of two cavity klystron amplifier and list its specifications.

Ans: (Schematic Diagram-2 M & Specifications-2M)

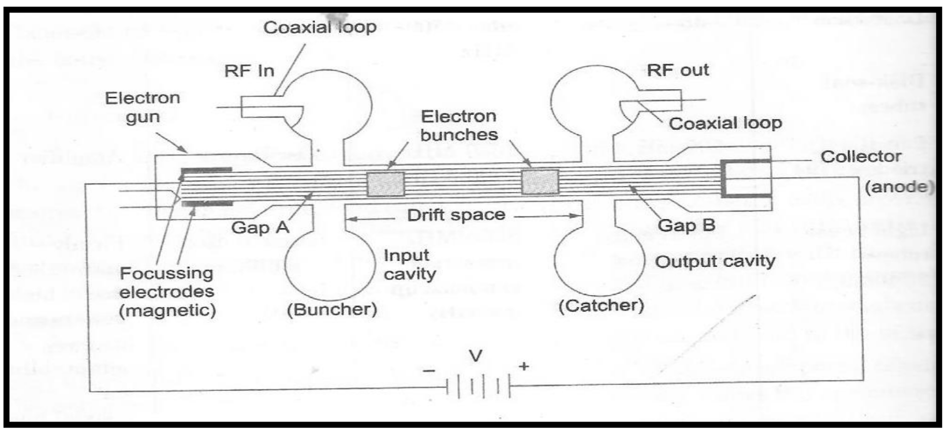


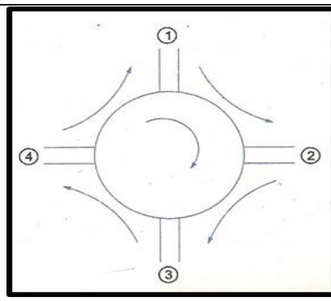
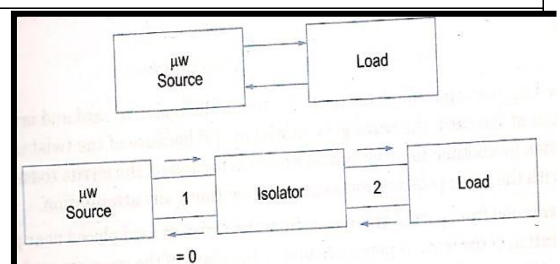
Figure: Two cavity Klystron amplifier

<u>Specification</u>:(Any Four)

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

b) Distinguish microwave circulator and isolator on the basics of function, construction, application and number of parts.

Ans: (1M for each point)

SR. NO.	PARAMETER	CIRCULATOR	ISOLATOR
1	**Function**	Function It has peculiar property that each terminal is connected tonext clockwise terminals. That means port 1 is connected to port 2 only and not to port 3 and port4.	It uses property of faradays rotation in the ferrite material.It provides very small attenuation for transmission from port 1 to 2. But provides very high attenuation for transmission from port 2 to 1.
2	**Construction**		
3	**Application**	Circulators are used in parametric amplifiers, tunnel diode amplifiers and duplexers in radars.	Isolators are used in the output of an amplifier that is sensitive to its load conditions. In UHF or VHF transmitters. In Radio Transmitters.
4	**Number of parts**	Circulator is usually (more than 2) 4 port microwave device.	Isolator is a 2 port microwave device.

c) Describe station keeping in satellite communication system.

Ans: : Explanation:4M

i. Once a satellite is in orbit, the forces acting on it tend to keep it in place. If the satellite's height and speed during launch are accurately controlled, the satellite will enter the proper orbit and remain there. However, even with a very good launch, the satellite will drift somewhat in its orbit. This drift is particularly undesirable in a geosynchronous satellite whose position is supposed to remain fixed for reliable continuous communications.

ii. Because of this drift, the orbits of the satellite contain small rockets or thruster jets for that purpose. These rockets placed at various positions on the satellite, can be used to speed up or slow down the satellite for the purpose of compensating for orbital drift.

iii. The process of firing the rockets underground control to maintain or adjust the orbit is referred to as station keeping.

d) List advantages of microwave tube over vacuum tubes.

Ans: (Any four, 1M each)

Advantages:

1. Conventional tubes such as triodes, tetrodes and pentodes are useful only at low microwave frequencies.
2. These tubes cannot operate at high frequencies due to their limitations at those frequencies. The conventional tubes become less effective at microwave frequency range when these are used as an amplifier and oscillator. The limitations of conventional tubes at high frequencies is due to :

a. Inter-electrode capacitance effect

b. Lead Inductance effect

c. Transit Time effects.

3. Large life span
4. Large transit time
5. This loading is due to the dissipation of the power at the grid. The effect of loading is such that the noise in the circuit increases
6. RF loses effect.
7. Gain bandwidth limitations.

e) Calculate maximum radar range of a RADAR system which operates at 3cm with peak pulse power of 500KW, its minimum receivable power is 10^{-13}W, capture area of antenna is $5m^2$ and radar cross sectional area of target is $20m^2$.

Ans: Given data: [1M]

Given: Transmitted power (P_t) = 500KW

Antenna capture area (A_0) = $5m^2$

Target cross section area (S) = $20m^2$

Wavelength (λ) = 3cm =0.03 m

Minimum receivable power (P_{min}) = 10^{-13}W

Maximum Range (r_{max}) =?

Formula- [1M]

Calculation- [1M]

Correct answer- [1M]

$$r_{max} = \left(\frac{P_t A_0^2 S}{4\pi\lambda^2 P_{min}}\right)^{1/4} = \left[\frac{5\times10^5\times5^2\times20}{4\pi\times(0.03)^2\times10^{-13}}\right]^{1/4} = \left(\frac{25}{3.6\pi}\times10^{24}\right)^{1/4}$$

$$= 10^5\times\sqrt[4]{2,210} = 6.86\times10^5 \text{ m}$$

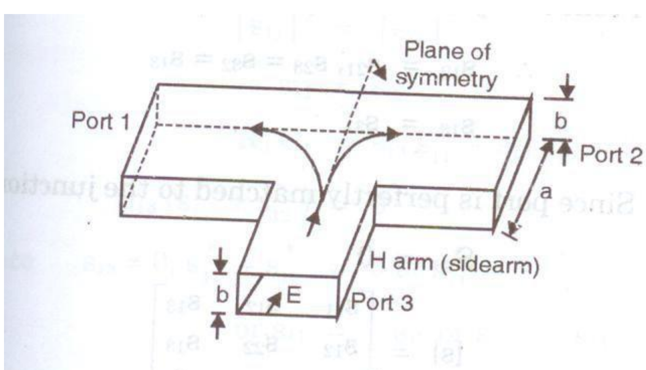
$$= 686 \text{ km}$$

Q.6 Attempt any FOUR: [16]

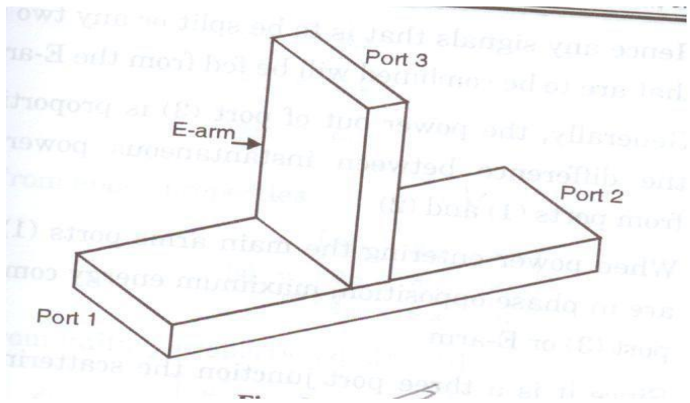
a) Draw the sketches of E plane and H plane tee.Give function of Hybrid Tee.

Ans: (E plane tee-1M, H plane tee-1M, functions of Hybrid Tee-2M)

H plane tee:



E plane tee:



Hybrid Tee:

- The four part hybrid Tee junction combines the power dividing properties of both H-plane Tee and E-plane Tee as shown in Fig. (b) and has the advantage of being completely matched to all its ports.

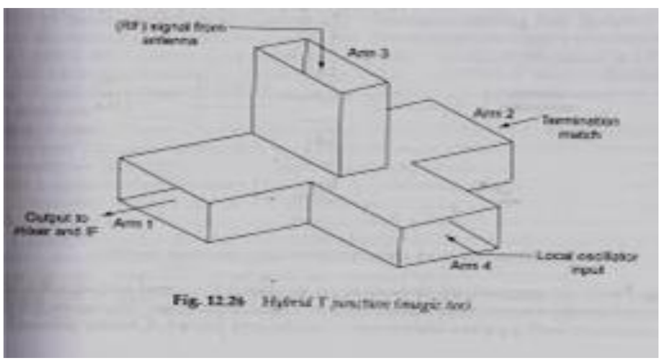
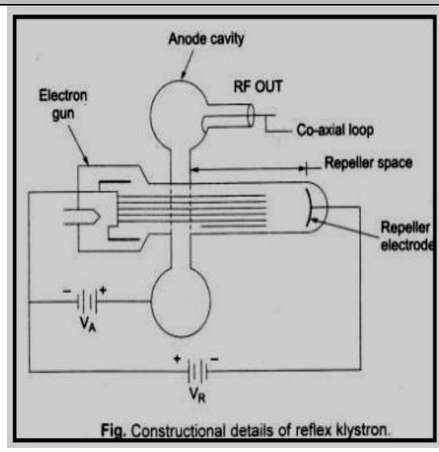
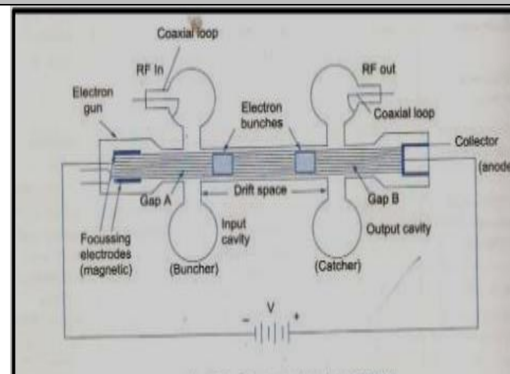


Fig. 12.26 Hybrid T junction (magic tee)

- Ports (1) and (2) are perfectly matched to the junction. Hence in any fore port junction, if any two ports are perfectly matched to the junction, then the remaining two ports are automatically matched to the junction.
- Such a junction where in all the four ports are perfectly matched to the junction is called a magic Tee.
- When power is fed into ports (1), nothing comes out (2) even though they are collinear ports. Hence port (1) and (2) are called isolated ports.
- Similarly an input at port (2) cannot came out of (1). Similarly ‘E’ and ‘Ports are isolated ports.
- Equal input at ports (3) and (4) result in an output at port (1) (in phase and equal in amplitude). This is called additive property. Equal input at port (1) and (2) result.

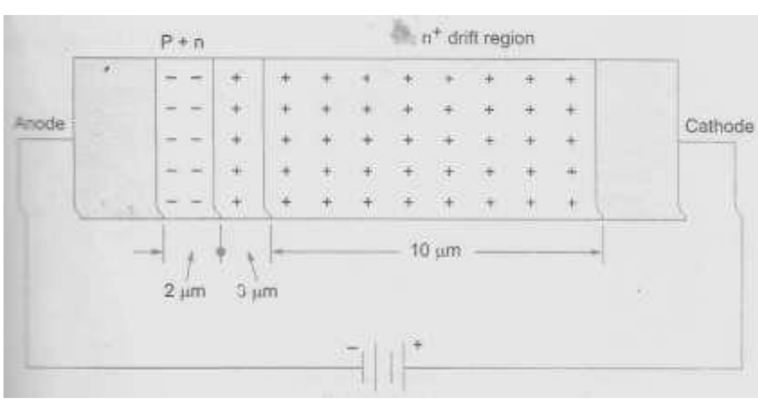
b) Compare Reflex Klystron with two cavity Klystron amplifier (any two points)

Ans:(2M each Point)

SR NO	PARAMETERS	REFLEX KLYSTRON	TWO CAVITY KLYSTRON AMPLIFIER
1	**Diagram**	 Fig. Constructional details of reflex klystron.	 Fig. 8.9 Two cavity klystron amplifier.
2	**Frequency Range**	4-200GHz	250MhHz-100GHz
3	**Power holding Capacity**	1.0MW to 2.5W	10KW to 500KW
4	**Efficiency**	10-20%	58%
5	**Application**	1.Portable Microwave 2.Pump Oscillator	1.RADAR Satellite 2.Acts as Power oscillator

c) Draw schematic of IMPATT diode and explain its working.

Ans: ((2M, Diagram, 2M Working)



Operation Of IMPATT diode:

- Any device which exhibits negative resistance for dc will also exhibit for ac i.e. if an ac voltage is applied current will rise when voltage falls at an ac rate.
- Hence negative resistance can also be defined as that property of a device which causes the current through it to be 180° out of phase with the voltage across it.
- This kind of negative resistance is exhibited by IMPATT diode.
- A combination of delay involved in generating avalanche current multiplication together with delay due to transit time through drift space provides the necessary 180° phase difference between applied voltage and resulting current in an IMPATT diode.
- The cross section of the active region of this device is shown in figure above. It is a diode with the junction between the P^+ and n layers.
- An extremely high-voltage gradient is applied to the IMPATT diode, of the order of 400 kV/cm, eventually resulting in a very high current. A normal diode would very quickly breakdown under such conditions, but the IMPATT diode is constructed so as to be able to withstand such conditions repeatedly.
- Let us consider application of a RF ac voltage superimposed on top of the high dc voltage. Increased velocity of electrons and holes result in additional electrons and holes by knocking them out of the crystal structure by so called impact ionization.
- These additional carriers continue the process at the junction and it now snowballs into an avalanche.
- If the original dc field was just at the threshold of allowing this situation to develop, his voltage will be exceeded during the whole of the RF positive cycle and the avalanche current multiplication will be taking place during this entire time.
- Since it is a multiplication process avalanche is not instantaneous. This process in fact takes a time such that current pulse maximum at the junction occurs at the instant when RF voltage across the diode is zero and going negative.

d) Give applications of TRAPATT diode & PIN diode

Ans: (2M each) ***Note: Any other relevant application can be considered***

Applications of TRAPATT diode:

- In low power Doppler radars or as local oscillators for radar system.
- Microwave beacon landing system.
- Radio altimeter.

- Phased array radar system.

Applications of PIN diode:

- RF Switches
- Attenuators
- Photo detectors
- Phase Shifters
- Limiters

e) List specifications & 2 applications of TWT

Ans: (2M specifications & 2M applications)

Note: Any other relevant Application & Specification can be considered.

Specifications: (Any 4)

- Frequency of Operation: 3.1 – 3.5 GHz (minimum)
- Output Power (watts): 150,000 (minimum)
- Duty Cycle (%): greater than 15
- Gain (dB): greater than 40
- Pulse Width (milliseconds): greater than 1
- Modulation: non-intercepting grid pulsed
- RF Input connector: Type N, coaxial
- RF Output connector: CPR 284 waveguide
- Solenoid Voltage (volts DC): No greater than 250
- Solenoid Current (amps): No greater than 26
- Cathode Voltage (kilovolt DC): No greater than 45
- Cathode Current (Amps): No greater than 20

Applications: (Any 2)

- TWT are commonly used as amplifiers in satellite transponders
- TWT transmitters are used extensively in radar, particularly in airborne fire-control radar systems, in electronic warfare and self-protection systems
- TWT is use for the electromagnetic compatibility (EMC) testing industry for immunity testing of electronic devices.