MODEL ANSWER

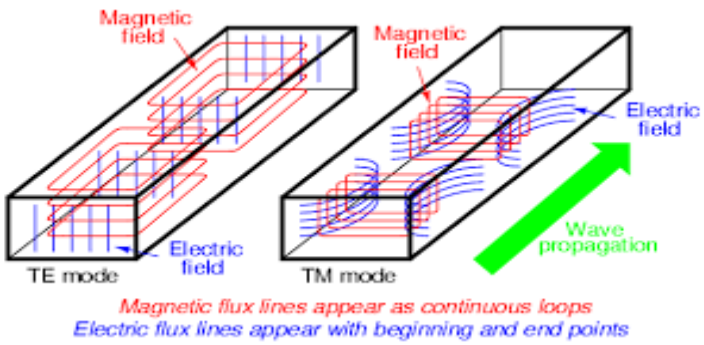
SUMMER– 19 EXAMINATION

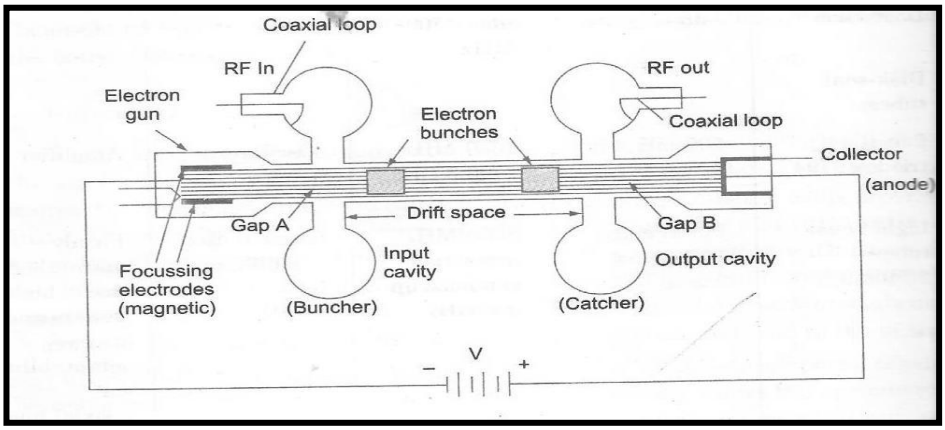
Subject Title: Microwave Communication System

Subject Code: 17670

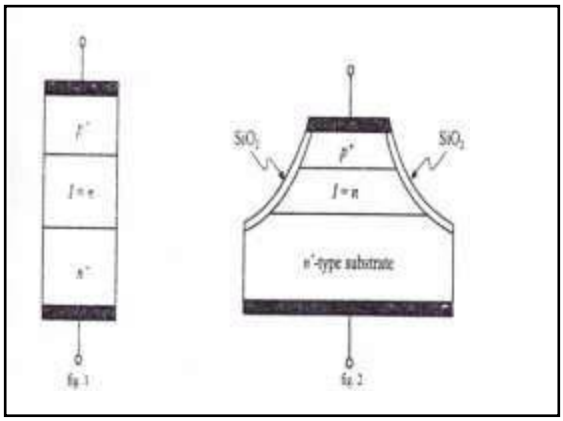
Important Instructions to examiners:

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.

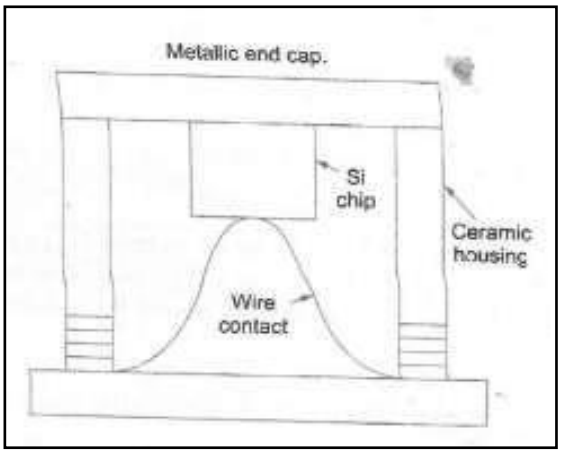
Q. No.	Sub Q.N.	Answer	Marking Scheme
Q.1		**Attempt any Five :**	**20- Total Marks**
	a)	**Explain the TE&TM modes in rectangular wave guide.**	**4M**
	Ans:	**Transverse electric (TE) modes:--** No electric field in the direction of propagation. These are sometimes called *H modes* because there is only a magnetic field along the direction of propagation (*H* is the conventional symbol for magnetic field). **Transverse magnetic (TM) modes:--** No magnetic field in the direction of propagation. These are sometimes called *E modes* because there is only an electric field along the direction of propagation.  *Magnetic flux lines appear as continuous loops* *Electric flux lines appear with beginning and end points*	**TE modes 1M, TM modes 1 M, Diagram:2 M**

	b)	**With neat schematic, explain operation of two Cavity Klystron amplifier.**	**4M**
	Ans:	**Diagram:--**  **Operation:--** The two-cavity klystron utilizes an electron source (heater), an anode, and a cathode like a conventional vacuum tube. It also utilizes a collector element at the end of the electron stream. The heater boils off electrons when heated and the electrons are ejected from the cathode and accelerate towards the anode due to the high dc potential between the two elements. A focused beam of electrons is thus produced. In the case of the two-cavity klystron, the electron beam passes through a central hole in the first toroid-shaped cavity and through a similar second cavity, terminating at the collector. On each side of the cavity hole is a grid that the electrons pass through. It is the interaction of the cavities with the beam that provides the high levels of amplification that the device can produce. Electrons in a beam leaving a source at high velocity all have a roughly equal velocity in the direction of travel. With no applied interaction along the path, the electrons in the beam will continue this way until terminating at the collector. If, however, there exists a structure along the path that can oppose the movement of the electrons, it can cause some of them to reduce their velocity. This occurs when the left side grid is negative.	**Dia 2M, Expla in 2M**
	c)	**Draw neat sketch and explain working of PIN diode as on microwave component.**	**4M**

Ans:



OR



Dia 2M, Expla in 2M

Working:

The PIN diode has following modes of operation:

1. Forward biased:

When the diode is forward biased, it behaves as if it possesses a variable resistance controlled by the applied current.

1. When a PIN diode is forward biased, holes and electrons are injected from the P and N regions into the region.

2. 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.

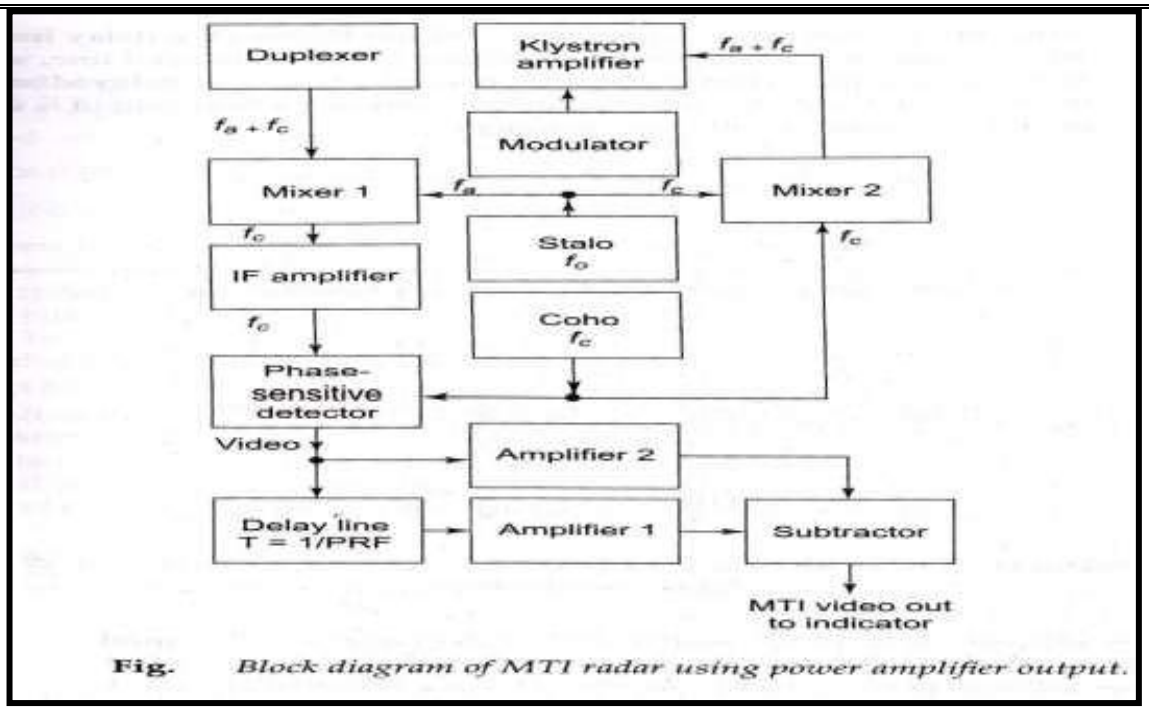
3. The high-frequency resistance is inversely proportional to the DC bias voltage applied to the diode. A PINdiode, suitably biased, therefore acts as a variable resistor. This high-frequency resistance may vary over awide range from 0.1Ω to 10 kΩ.

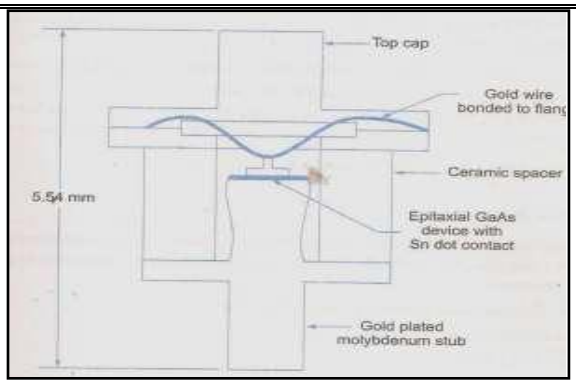
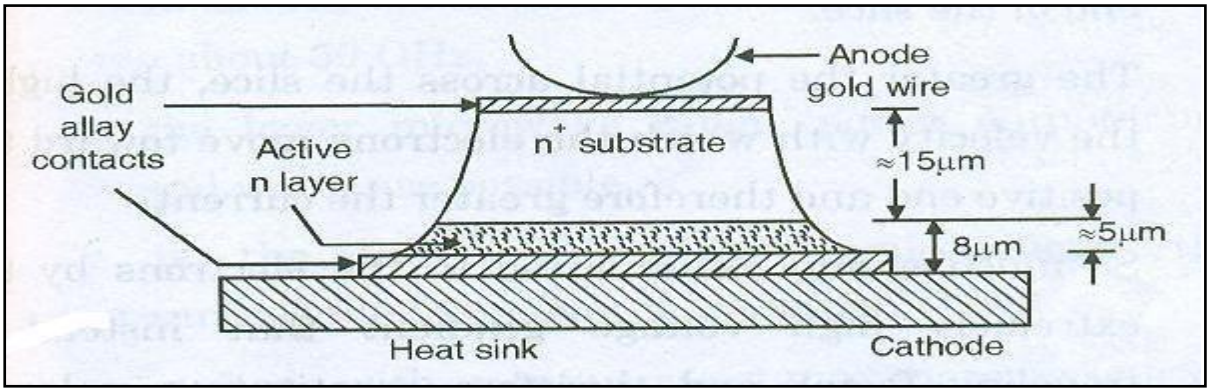
2. Reverse biased:

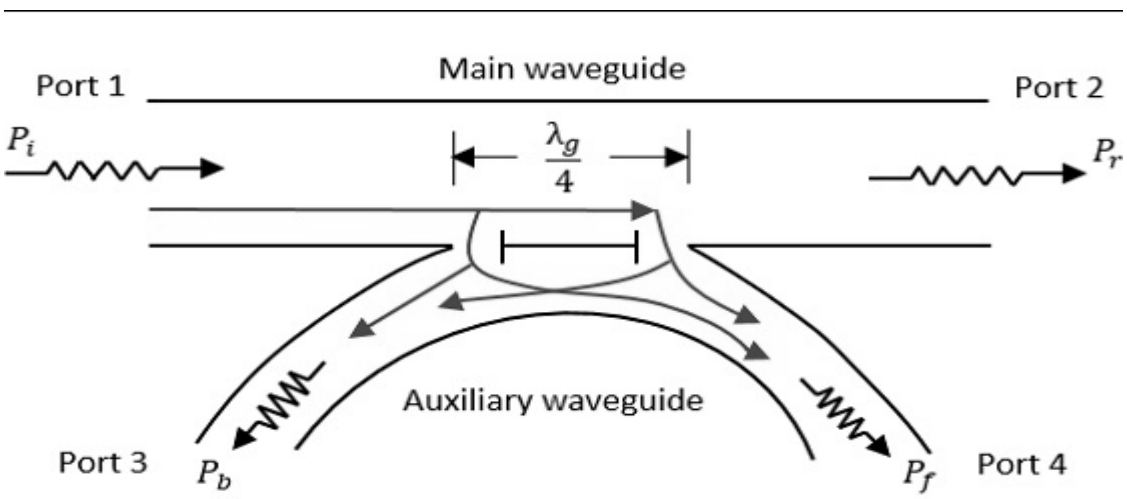
When the diode is reversed biased the space charge regions in the p and n layers will become thicker. The reverse resistance will be very high and almost constant.

3. Zero Bias:

4. 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.

	d)	**Draw neat block diagram of MTI Radar system. State its working principle.**	**4M**
	Ans:	 **Fig.** *Block diagram of MTI radar using power amplifier output.* **Working principle:** • When it is desired to remove the clutter due to stationary targets an MTI radar is employed. • The basic principle of MTI radar is to compare a set of received echoes with those received during the previous sweep. • Moving targets will give change of phase and are not cancelled. Thus clutter due to stationary targets both manmade and natural is removed from the display and this allows easier detection of moving targets.	**Dia 2M, Expla in 2M**
	e)	**Describe station keeping in Satellite Communication System.**	**4M**
	Ans:	i. Once a satellite is in orbit, the forces acting on it tend to keep it in place. If the	**2M for**

		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. The process of firing the rockets underground control to maintain or adjust the orbit is referred to as station keeping.	**each pt.**
	f)	**Draw constructional diagram of gunn diode and list its application.**	**4M**
	Ans:	 **OR**  **Application:** 1. Police Radar, CW dopler Radar 2. As an Oscillator used in transponder for air traffic control 3. Broadband linear amplifier 4. Low and medium power oscillator in microwave receiver 5. As pump sourse in par amplifier	**Dia 2M, Application 2M**

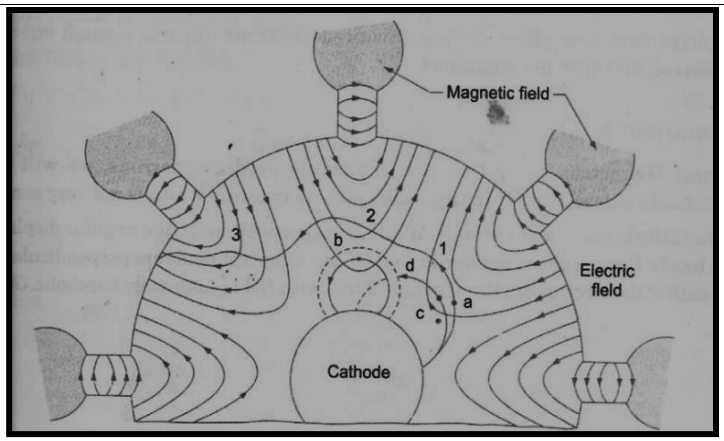
	g)	**Draw two hole directional coupler and explain its operation.**	**4M**
	Ans:	 Two-hole directional coupler A **Directional coupler** is a device that samples a small amount of Microwave power for measurement purposes. The power measurements include incident power, reflected power, VSWR values, etc. Directional Coupler is a 4-port waveguide junction consisting of a primary main waveguide and a secondary auxiliary waveguide. The following figure shows the image of a directional coupler. Directional coupler is used to couple the Microwave power which may be unidirectional or bi-directional • All the terminations are matched to the ports. • When the power travels from Port 1 to Port 2, some portion of it gets coupled to Port 4 but not to Port 3. • As it is also a bi-directional coupler, when the power travels from Port 2 to Port 1, some portion of it gets coupled to Port 3 but not to Port 4. • If the power is incident through Port 3, a portion of it is coupled to Port 2, but not to Port 1. • If the power is incident through Port 4, a portion of it is coupled to Port 1, but not to Port 2. Port 1 and 3 are decoupled as are Port 2 and Port 4. Ideally, the output of Port 3 should be zero. However, practically, a small amount of power called **back power** is observed at Port 3. The following figure indicates the power flow	**Dia 2M, Expla in 2M**

	in a directional coupler.	
Q.2	**Attempt Any Four:**	**16 Total Marks**
a)	**Compare waveguide and transmission line.(any 4 points)**	**4M**

Ans:

SR NO.	WAVEGUIDES	TRANSMISSION LINES	1M for each point
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)	**Draw neat sketch of magnetron. Explain its operation in brief.**	**4M**

	Ans:	 **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.	**Dia 2M, Expla in 2M**
	c)	**Draw and explain basic pulse Radar system.**	**4M**

Ans:

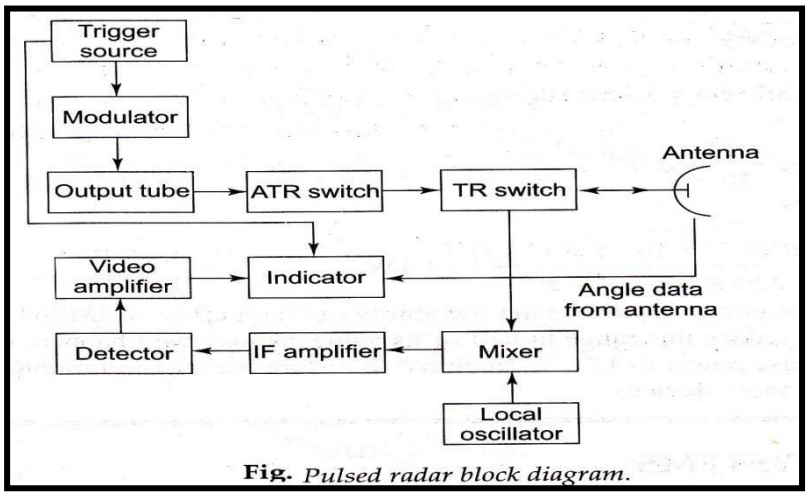


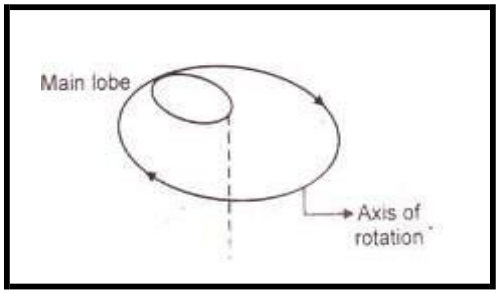
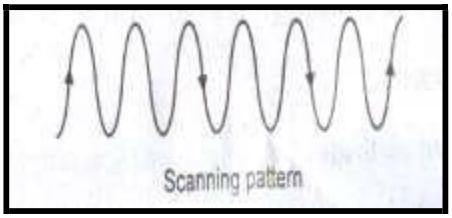
Fig. *Pulsed radar block diagram.*

Dia 2M, Expla in 2M

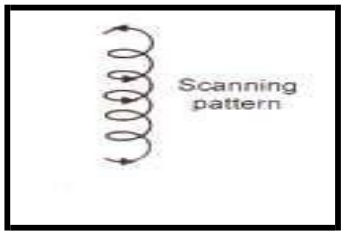
Explanation:-

- **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.

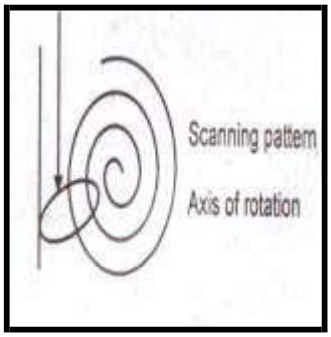
	d)	**Describe any two antenna scanning methods used in Radar with neat sketches of scanning patterns.**	**4M**
	Ans:	**1. <u>Horizontal Scan Pattern</u>:** This has the drawback of scanning in the horizontal plane as shown in fig. but, this type of scanning is useful in searching the horizon. E.g. ship to ship radar.  **2. Elevation/Vertical/Nodding scan Pattern:** Nodding scan is an extension of horizontal scanning. The antenna now moves rapidly in elevation while it rotates more slowly in azimuth as shown in fig. thus scanning in both planes is obtained.  **3. Helical Scanning:**	**2 M for any one method**

This scanning helps searching over the complete hemisphere as shown in fig. here the elevation of the antenna is raised slowly while it is rotated more rapidly in azimuth. The antenna is returned to the starting point at the completion of the scanning cycle.

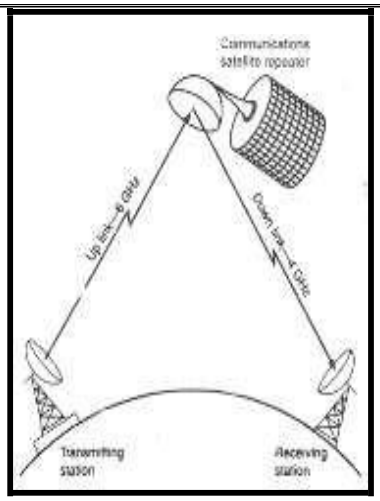


2. Spiral Scanning:

If limited area of more or less circular shape is to be covered, spiral scan may be used as shown in fig. the area to be covered may be in horizontal plane or vertical plane. The separation between adjacent sweep does not exceed half the width of the beam. This insures that the search embraces all possible directions in space.

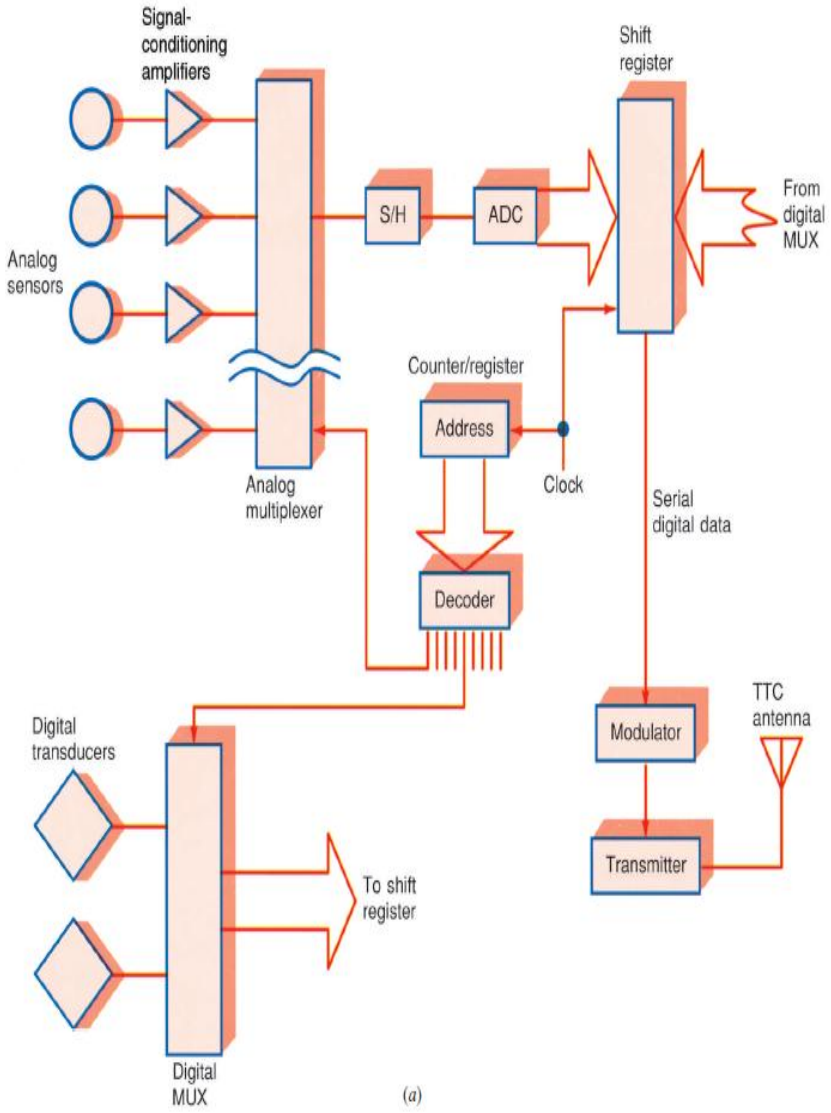


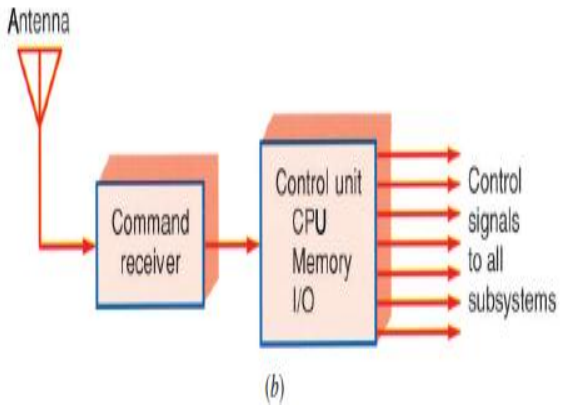
	e)	**Expalin concept of uplink and downlink frequencies in satellite communication.**	**4M**
	Ans:	**Uplink frequency:** The frequency at which the earth station transmitter beams its signal towards the satellite is known **as uplink frequency.** **Downlink frequency*:*** The frequency at which the satellite transponder beams its signal to the earth station receiver is called **as downlink frequency.**	**2 M uplink, 2 M downlink**

			
	f)	**Draw neat block diagram of TTC and state the function of each block.**	**4M**

Ans:

Figure 17-16 (*a*) General block diagram of a satellite telemetry unit. (*b*) The command receiver and controlle

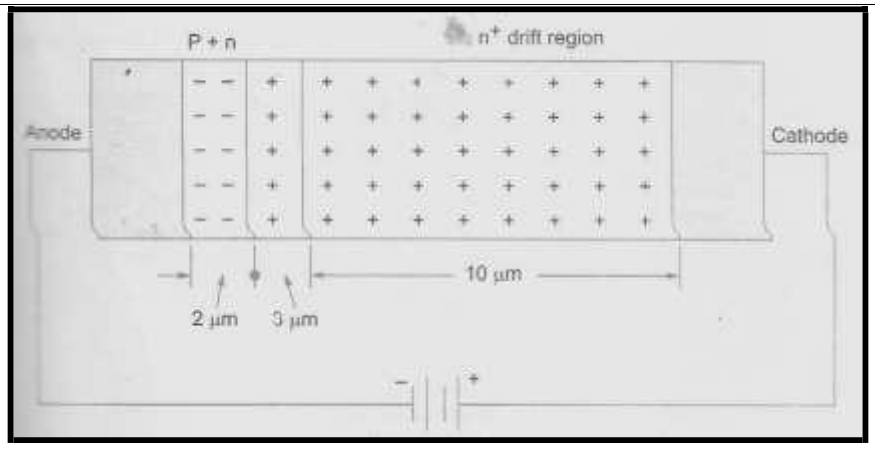




Dia 2M, Explain 2M

Telemetry, Command, and Control Subsystems:

1. All satellites have a *telemetry, command, and control (TC&C) subsystem that allows a* ground station to monitor and control conditions in the satellite.
2. The telemetry system is used to report the status of the onboard subsystems to the ground station **(see Fig. 17-16).**
3. The telemetry system typically consists of various electronic sensors for measuring temperatures, radiation levels, power supply voltages, and other key operating characteristics. Both analog and digital sensors may be used. The sensors are selected by a multiplexer and then converted to a digital signal, which then modulates an internal transmitter.
4. The transmitter sends the telemetry information back to the earth station where it is recorded and monitored. With this information, the ground station then determines the operational status of the satellite at all times.
5. Command and control system permits the ground station to control the satellite. The satellite contains a command receiver that receives control signals from an earth station transmitter.
6. The control signals are made up of various digital codes that tell the satellite what to do.
7. Various commands may initiate a telemetry sequence, activate thrusters for altitude correction, reorient an antenna, or perform other operations as required by the special equipment specific to the mission. Usually, the control signals are processed by an onboard computer.

Q.3		**Attempt any Two:**	**16- Total Marks**
	a)	**Describe the operation of IMPATT diode with the help of well labelled sketches.**	**4M**
	Ans:		**Dia 2M, Expla in 2M**

<u>Operation Of impatt diode</u> :

1. 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.
2. 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.
3. This kind of negative resistance is exhibited by IMPATT diode.
4. 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.

5.An extremely high-voltage gradient is applied to the IMPATT diode, of the order of 400kV/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.

6.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.

7.These additional carriers continue the process at the junction and it now snowballs into an avalanche.

8.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.

9.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.

10.A 90° phase shift or phase difference between voltage and current has then been achieved.

11.The current pulse as shown in figure below is situated at the junction. It does not stay there but moves towards the cathode due to applied reverse bias at a drift velocity dependent upon the presence of high dc field.

12.The time taken by the pulse to reach the cathode depends on this velocity and on the thickness of the highly doped n^+"layer. The thickness is adjusted such that time taken for current pulse to move from *V*=0 position to *V*=negative maximum RF cycle is exactly 90°.

13.Hence voltage and current are 180° out of phase and a dynamic RF negative resistance has been proved to exist. Hence IMPATT diode is useful both as an oscillator and as an amplifier.

14.The resonant frequency of IMATT diode is given by: $f = \frac{V_d}{2L}$; where, V_d = carrier drift velocity and *L* = length of drift space charge region.

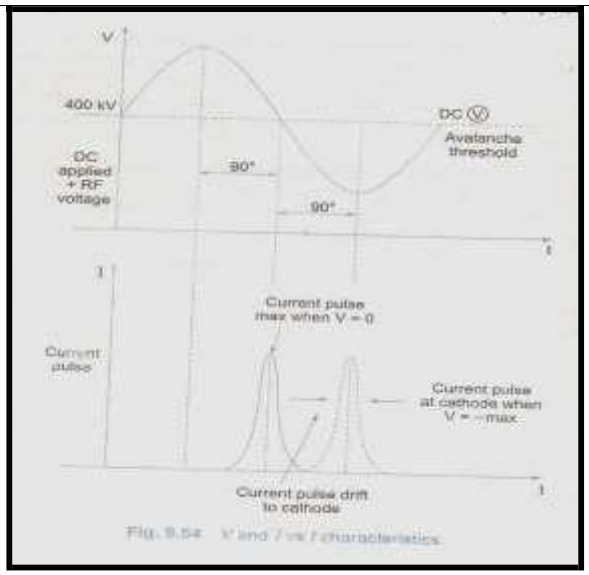
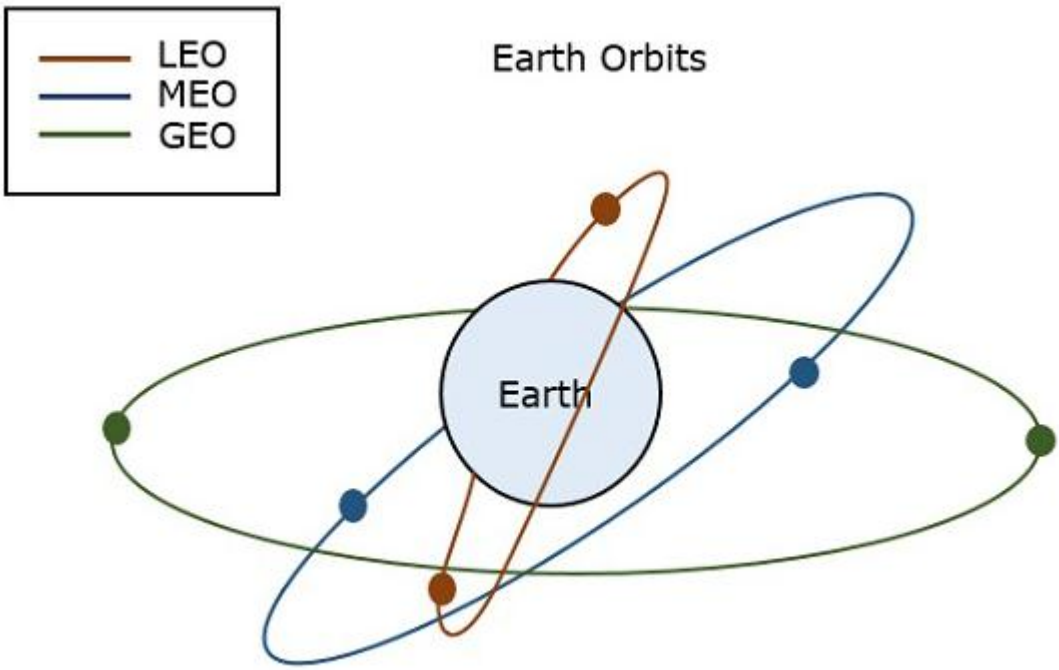


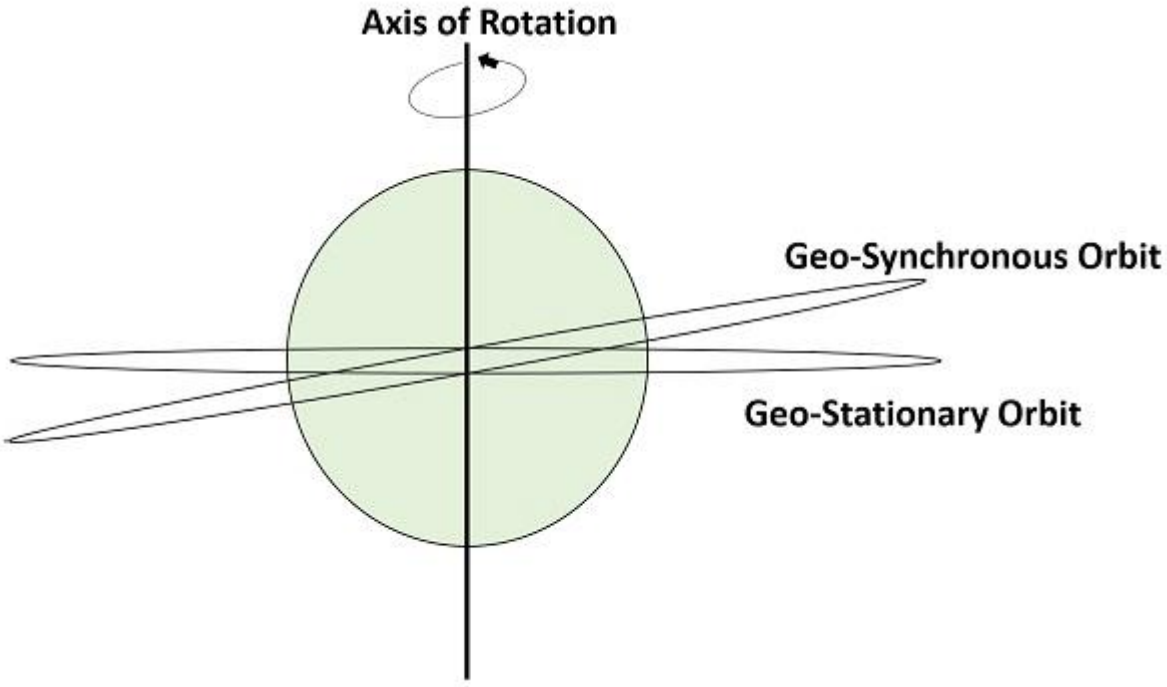
Fig. 9.54 V and I vs t characteristics

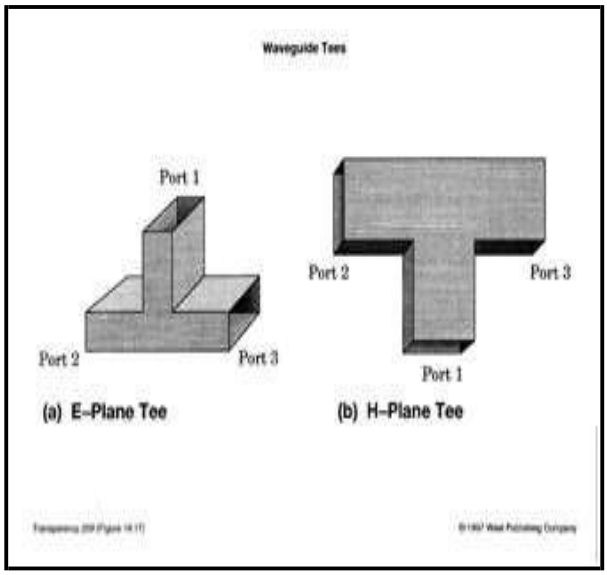
b)	**Define Rader beacons. Describe their typical usages.**	**4M**
Ans:	***(a)* <u>Definition</u>*:*** A radar beacon is small radar consisting of a receiver, a separate transmitter and an antenna which is often Omni-directional. **<u>Typical usage of radar beacons</u>*:*** i) One of the functions of a beacon may be to identify itself. The beacon may be installed on a target (aircraft) and will transmit a specific pulse code when interrogated these pulses then appear on the PPI of the interrogating radar and inform it of the identity of the target. The system is used in airport traffic control and also for military purpose, where it is called identification, friend or foe (IFF). ii) Another use is similar to that of lighthouses, except that radar beacons can operate over much larger distances.	**Definition 1 M, Usages: 3M**
c)	**Explain the concept of orbit and its different types with neat sketch.**	**4M**
Ans:	**Concept of orbit** • Satellite should be properly placed in the corresponding orbit after leaving it in the space. It revolves in a particular way and serves its purpose for scientific, military or commercial. • The orbits, which are assigned to satellites with respect to earth are called as **Earth Orbits**. The satellites present in those orbits are called as **Earth Orbit Satellites**.	**Concept 1M, Types of orbit 3M**

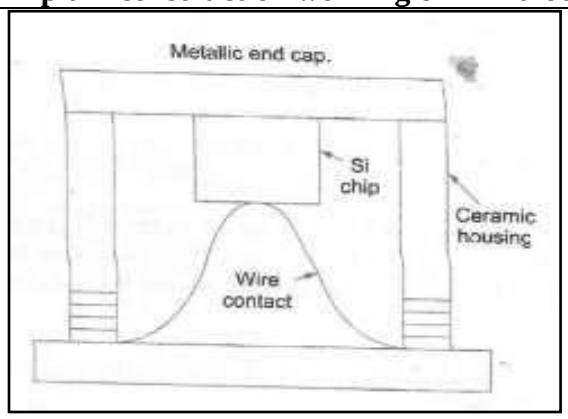
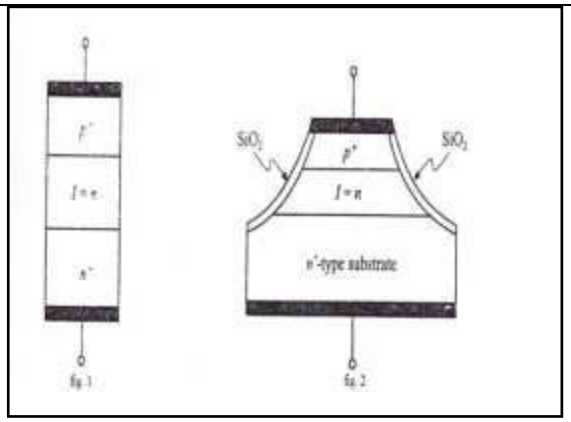
Types of Orbit:

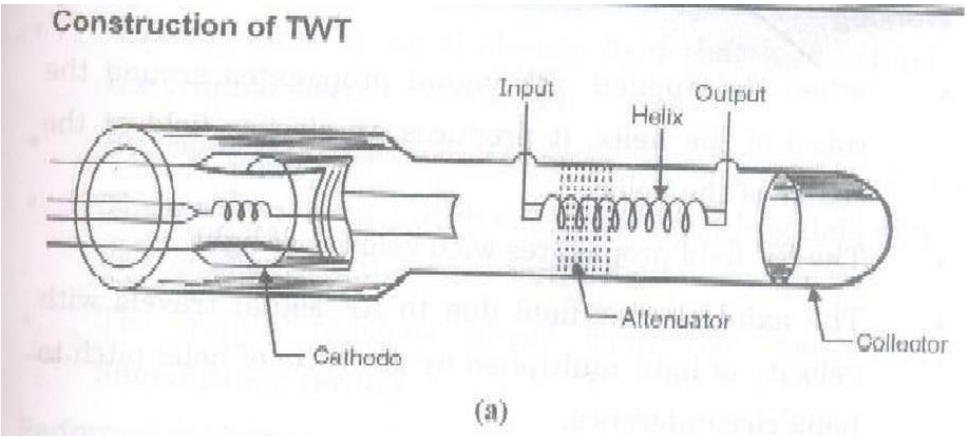
- Geosynchronous Earth Orbit Satellites
- Medium Earth Orbit Satellites
- Low Earth Orbit Satellites



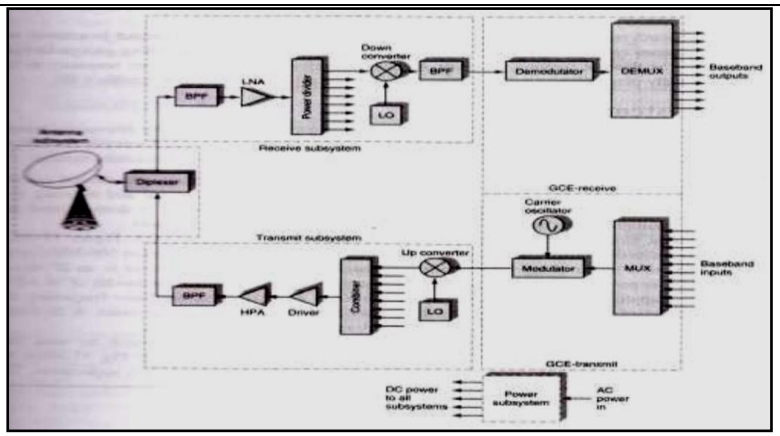


Q.4	**A)**	**Attempt any FOUR :**	**16- Total Marks**
	a)	**Explain H-plane Tee with respect to wave guide.**	**4M**
	Ans:	 **H - PLANT TEE** H - Plane Tee is shunt type T - junction for use in conjunction with VSWR meters, frequency - meters and other detector devices. Like in E-plane tee, the signal fed through first port of H - plane Tee will be equally divided in magnitude at second and third ports but in same phase	**Dia 2M, Explain 2M**
	b)	**Define cut-off frequency & phase velocity with respect to wave guide.**	**4M**
	Ans:	• Cut- off frequency: Although the exact mechanics for the cut-off frequency of a waveguide vary according to whether it is rectangular, circular, etc, a good visualisation can be gained from the example of a rectangular waveguide. This is also the most widely used form. • Signals can progress along a waveguide using a number of modes. However the dominant mode is the one that has the lowest cut-off frequency. For a rectangular waveguide, this is the TE10 mode. • **Phase Velocity :** It is the velocity which the electromagnetic waves changes it phase in the waveguide during propagation. Its symbol is Vph. Group velocity and phase velocity of the electromagnetic waves is the same in free space. ***OR***	**2M each**

		The velocity of propagation for a TEM wave (plane wave or transmission line wave) is referred to as the phase velocity (the velocity at which a point of constant phase moves). The phase velocity of a TEM wave is equal to the velocity of energy transport.	
	c)	**Explain construction working of PIN diode.**	**4M**
	Ans:	  **Working:** The PIN diode has following modes of operation: **1. Forward biased:** 5. When the diode is forward biased, it behaves as if it possesses a variable resistance controlled by the applied current. 6. When a PIN diode is forward biased, holes and electrons are injected from the P and N regions into the region. 7. 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. 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. **5. 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.	**Dia 2M, Expla in 2M**
	d)	**Draw labeled schematic of TWT and describe its working as amplifier.**	**4M**
	Ans:		**Dia 2M, Expla**

		 **Working:** The anode plates, when at zero potential, which means when the axial electric field is at a node, the electron beam velocity remains unaffected. When the wave on the axial electric field is at positive antinode, the electron from the electron beam moves in the opposite direction. This electron being accelerated, tries to catch up with the late electron, which encounters the node of the RF axial field. At the point, where the RF axial field is at negative antinode, the electron referred earlier, tries to overtake due to the negative field effect. The electrons receive modulated velocity. As a cumulative result, a second wave is induced in the helix. The output becomes larger than the input and results in amplification.	**in 2M**
	e)	**Define the term: look angles, foot print in Satellite Communication System.**	**4M**
	Ans:	**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. **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	**2 M each**
	f)	**Draw block diagram of Satellite earth station transmitter and state function of each block.**	**4M**

Ans:



Dia 2M, Expla in 2M

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:

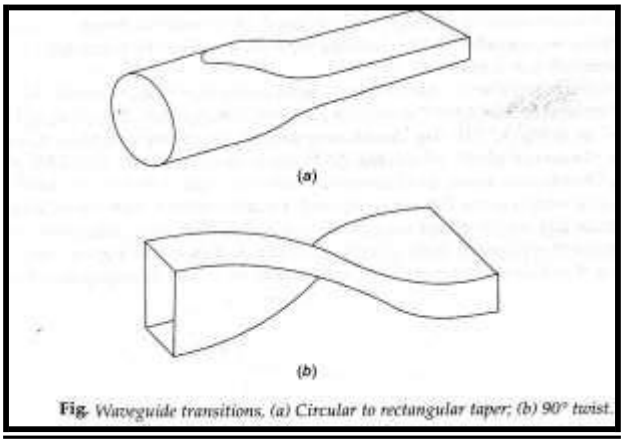
This comprises of control circuit and drive which are necessary to keep the antenna pointed at the satellite. Tracking system keeps antenna pointing in the direction of the satellite in spite of relative movement of the satellite and the station.

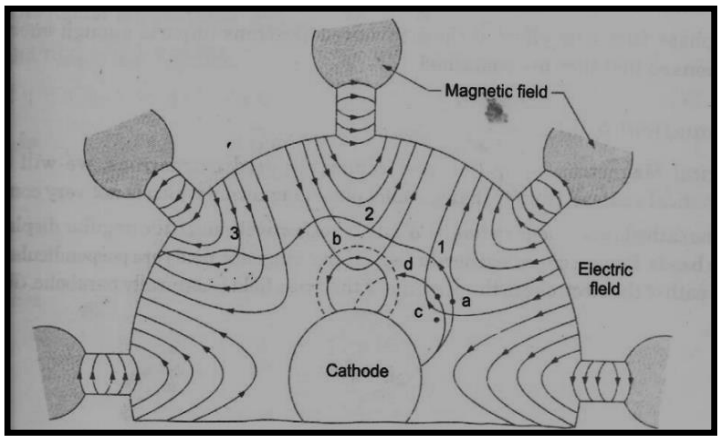
Terrestrial Interface:

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.	
Q.5		**Attempt any FOUR:**	**16- Total Marks**
	a)	**Describe function of following microwave components with the help of neat sketch: (i) Flanges, (ii) Taper & Twist**	**4M**
	Ans:	**Flanges:** A waveguide flange is a connector for joining sections of waveguide.  **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.  **Fig.** *Waveguide transitions, (a) Circular to rectangular taper; (b) 90° twist.*	**Flanges: 1.5 M, Taper and Twist: 2.5 M**

	b)	**Describe working of magnetron with neat diagrams. List any two applications of it.**	**4M**
	Ans:		**Dia 1M, Explain 2M, Application 1M**

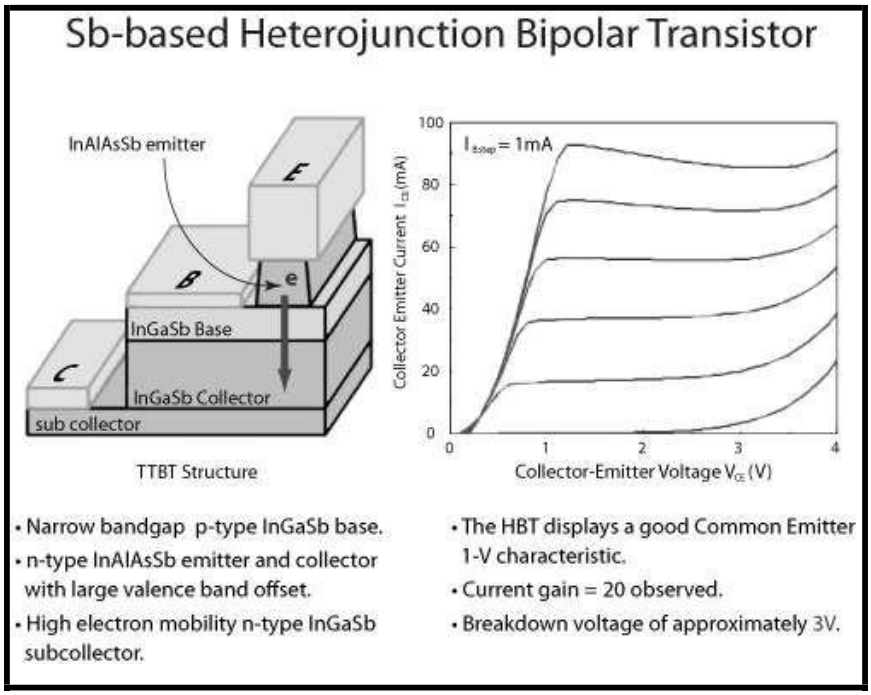
Working of Magnetron:

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

1. 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.
2. 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.
3. 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.
4. 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.
5. 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".
6. 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.

Applications:

Magnetron is used in Microwave oven, Radar Transmitter, Induction heating

	c)	**Describe working of microwave bipolar transistor with characteristics curve.**	**4M**
	Ans:		**Dia 2M, Expla in 2M**
		a) <u>Working</u>: AlGaAs/GaAs hetero junction bipolar transistors (HBTs) are used for digital and analog microwave applications with frequencies as high as Ku band. HBTs can provide faster switching speeds than silicon bipolar transistors mainly because of reduced base resistance and collector-to-substrate capacitance. HBT processing requires less demanding lithography than GaAs FETs, therefore, HBTs can cost less to fabricate and can provide improved lithographic yield. This technology can also provide higher breakdown voltages and easier broad-band impedance matching than GaAs FETs. In comparison with Si bipolar junction transistors (BJTs), HBTs show better performance in terms of emitter injection efficiency, base resistance, base-emitter capacitance, and cutoff frequency. They also offer good linearity, low phase noise and high power-added efficiency. characteristics between AlGaAs/GaAs HBTs and Si BJTs. HBTs are used in both commercial and high- reliability applications, such as power amplifiers in mobile telephones and laser drivers	
	d)	**List any four factors influencing maximum range of Radar.**	**4M**
	Ans:	**<u>Factors:</u>**	**1 M**

Transmitter Power:

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

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.

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.

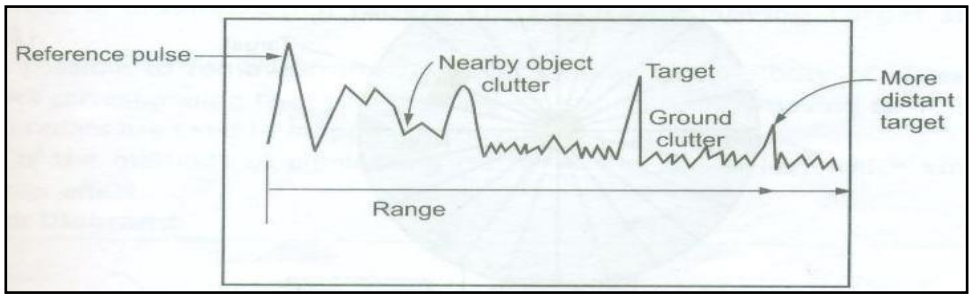
Target cross sectional area(S):

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.

each for factor

e) Describe A-scope display method used in Radar system. **4M**

Ans:



Dia 2M, Expla in 2M

A-scope Display:

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

f) **Draw the block diagram of communication subsystem of satellite.** **4M**

Ans:

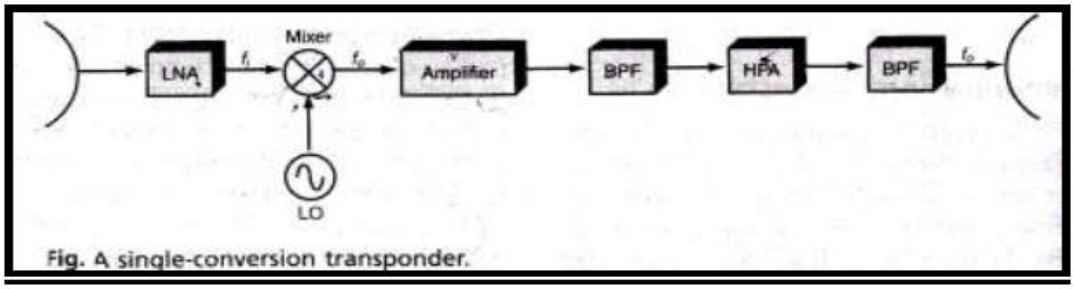


Fig. A single-conversion transponder.

1M

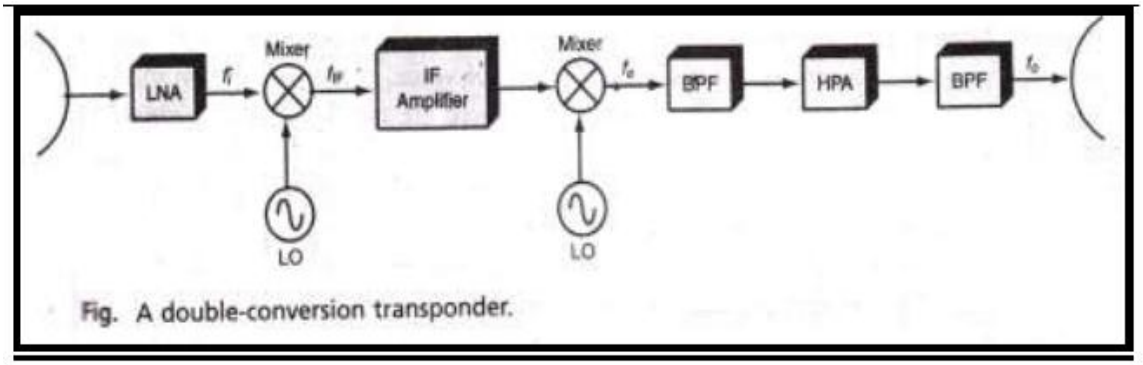
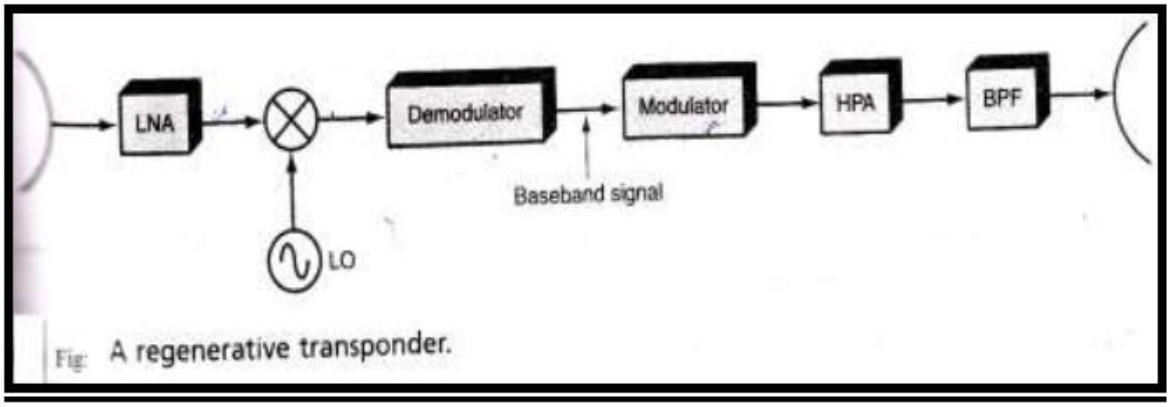
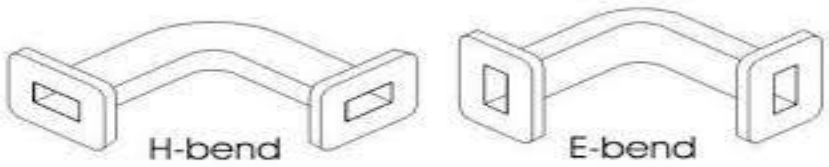
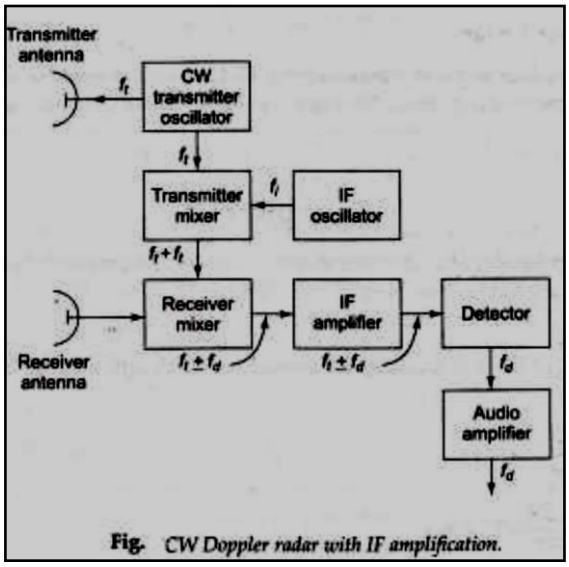


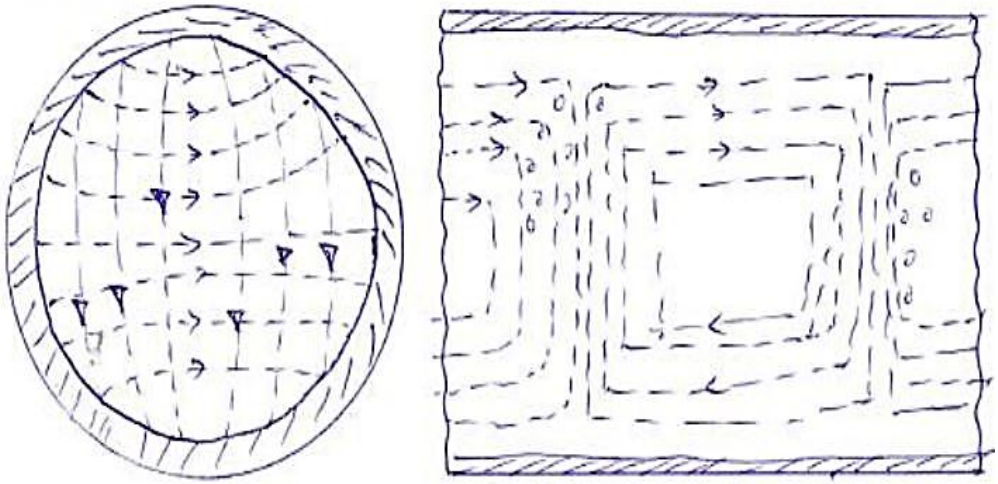
Fig. A double-conversion transponder.

1M

		 Fig: A regenerative transponder.	**2M**
Q.6		**Attempt any FOUR:**	**16- Total Marks**
	a)	**Enlist different types of bends. Draw the diagram of each type.**	**4M**
	Ans:	**Types of bend:** **1)H bend** **2) E bend** **Diagram:** **H bend and E bend** 	**Types 2M, Diagram 2M**
	b)	**List advantages of microwave tubes over conventional vacuum tube.(any four)**	**4M**
	Ans:	**1.**Works on higher frequency(>100MHz) 2.Less transits time 3.Low power consumption 4.High efficiency	**1 M for each**
	c)	**Give specification and application of TRAPATT diode**	**4M**
	Ans:	**Specification:** **1**.CW power: 1-3 between 8 Ghz to 0.5 Ghz 2.Pulse power: 1.2 kW at 1.1 Ghz 3.Operating voltage: 60-150 V 4.Efficiency 15 to 40% 5.Noise fihure: >30db 6. Frequency : 3 to 50 Ghz **Application:** **1.**Used in low power Doppler radar 2.As a local oscillator for radar 3. microwave beacon landing system	**Any four specification :2M, Any four Application 2M**

		4. Radio altimeter 5. Phased array radar	
	d)	**Describe the working of CW Doppler Radar system with the help of block diagram.**	**4M**
	Ans:	 **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.	**Dia 2M, Expla in 2M**
	e)	**Describe the function of propulsion subsystem and antenna subsystem in satellite.**	**4M**

	Ans:	**Propulsion sub-system**: (a) ropulsion sub-system is the reaction control sub-system carried by the satellite in the geostationary orbit so as to generate forces on it whenever needed. (b) It moves satellite to its assigned position in orbit, to maintain in that position (station keeping) and to maintain the direction of spin axis and attitude control. (c) Usually propulsion subsystem has three units. i) Low thrust (10^{-3} to 20N) actuators (Reaction control system, RCS) ii) High thrust (400 to 50,000 N) motor (Apogee kick motor: AKM or Apogee Boost Motor (ABM) which provides velocity increment) to inject satellite into geostationary orbit from transfer orbit apogee. iii) Perigee kick motor (PKM) which provides velocity increments required to inject the satellite into the transfer orbit. Low thrust actuators (RCS) are of much importance as these are responsible for keeping the satellite in orbit with its perfect attitude till its life end. They are either chemical or electrical thrusters. **Antenna Sub-system**: Antenna on board serves as an interface between the earth on the ground and various satellite subsystems during operations. • Receive uplink signals. • Transmit downlink signals. • Provides signal link for satellite telemetry, command and ranging systems. • Provide signal link for attitude control subsystem. • Provide becon tracking signals for precise pointing of the antenna towards the earth area.	**2M** **2M**
	f)	**State any two advantages and application of circular waveguide and also draw the field patterns for dominant mode.**	**4M**
	Ans:	**Advantages** 1)Easier to manufacture and Join 2)Lowest attenuation per unit length and hence suitable for long distance communication 3)Rotation of polarization can be overcome **Application** 1)Rotating joints in radars to connect to horn antenna feeding a paraboloid reflector 2) TE01 mode is suitable for long distance wavelength transmission above 10 Ghz 3) Short and medium distance broad band communication **Field patterns for dominant mode.**	**Advantages: 1M, Application 1M, Field pattern:2M**

		Dominant mode (TE_{11}).  TE_{11} mode.	