T.Y. Diploma : Sem. VI
[EJ/ET/EN/EX]

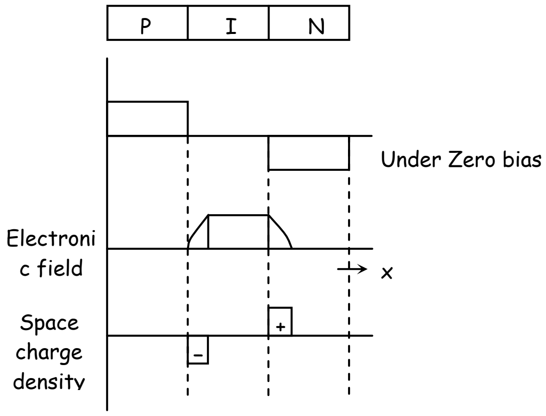
Advanced Communication System

Time: 3 Hrs.] Prelim Question Paper Solution **[Marks : 100**

Q.1(a) Attempt any THREE questions. **[12]**

Q.1(a) (i) Give the working principle of PIN diode with construction. **[4]**

Ans.: 2 marks]



Zero bias [1 mark]

- At zero bias the diffusion of the holes and electrons across the junction cause space charge region of thickness inversely proportional to the impurity concentration.
- An ideal '1' layer has no depletion region i..e. P layer has a fixed negative charge and N layer has a fixed positive charge.

Reverse Biased

- As Reverse bias is applied, the space charge region in the P and n layer will becomes thicker. The reverse resistance will be high and almost constant.

Forward Biased [1 mark]

- With forward biased carrier will be injected into the i layer and p and n space charge regions will becomes thinner.
- So, the electrons and holes are injected into 'i' layer from p and n layer respectively.
- This increase the carrier concentration into 'i' layer above equilibrium.
- Thus resistivity decrease as increase in forward biased.
- Therefore low resistance is altered in the forward direction.

Q.1(a) (ii) Define the terms w.r.t. waveguide : **[4]**
(1) Cut-off frequency **(2) Cut-off wavelength**

Ans.: [Each definition 1 marks, Formula 1 mark each]

(1) Cut off frequency of a waveguide:

It is the frequency of the signal above which propagation of waves occur.

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

Where m & n are integers, a is broader dimension and b is narrower dimension

(2) Cut–off wavelength of a waveguide:

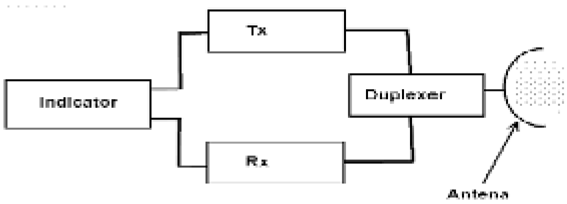
It is defined as the distance travelled by the wave in order to undergo a phase shift of 2π radians.

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

where λ = wavelength of the signal, λc = cut off wavelength

Q.1(a) (iii) Draw block diagram of Radar System and explain it. **[4]**

Ans.: [Diagram 2 marks, Explanation 2 marks]



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

Q.1(a) (iv) Define following terms w.r.t. satellite : **[4]**
(1) Azimuth angle **(2) Elevation angle**

Ans.: [2 marks for each]

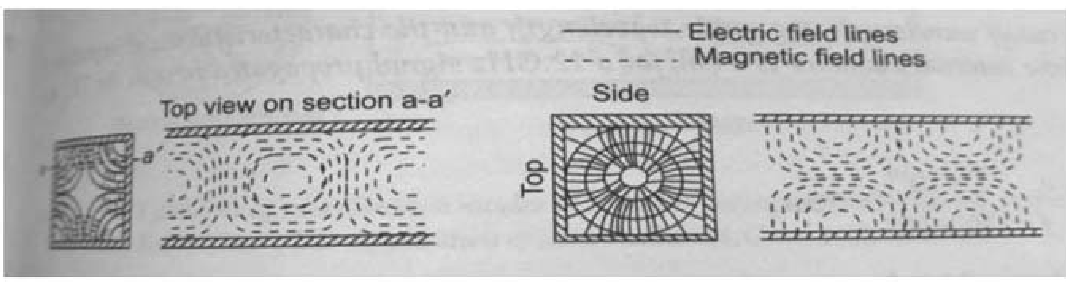
(1) Azimuth angle: Azimuth is the horizontal angular distance from a reference direction, either the southern or northern most point of the horizon.
Azimuth angle is defined as the horizontal pointing angle of the earth station antenna. For navigation purpose, azimuth angle is usually measured in clockwise direction in degrees from true north. However for satellite earth stations in the northern hemisphere and satellite vehicles in geosynchronous orbits, azimuth angle is generally referenced to true south.

(2) Elevation angle: Elevation angle is the vertical angle formed between the direction of travel of electromagnetic wave radiated from an earth station antenna pointing towards a satellite and horizontal plane.
The smaller the elevation angle, the greater the distance a propagated wave must pass through earth's atmosphere. If the angle of elevation is too small, and the wave travels through earth's atmosphere is too long, the wave degrades the transmission quality.

Q.1(b) Attempt any ONE questions. **[6]**

Q.1(b) (i) Justify TE_{110} mode in rectangular waveguide is the dominant mode. Draw the field pattern for TE_{110} and TE_{210} mode. **[6]**

Ans.: [3 marks for justification and 3 marks for diagram of field pattern]



TE_{11} mode TE_{21} mode

- The electric and magnetic field patterns for the dominant mode are shown in fig. the electric field exist only at right angles to the direction of propagation, whereas the magnetic field has component in the direction of propagation as well as normal component.

- The electric field is maximum at the center of waveguide for this mode and drops off sinusoidal to zero intensity at the walls.
- The magnetic field is in the form of loops, which lie in planes normal to the electric field. This magnetic field is the same in all these planes, regardless of position of such a plane along y axis, as evidenced by the equidistant dashed lines in the end view. This applies to all modes.

Q.1(b) (ii) Differentiate between TE m, n and TM m, n modes. (6 points) [6]

Ans.: [6 Point - 1 mark each]

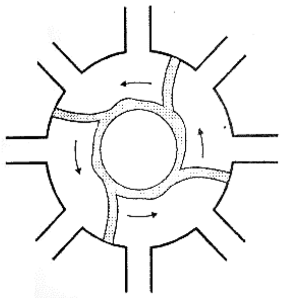
Sr. No.	TE m n	TM m n
(1)	It is Transverse electric mode	It is transverse magnetic mode
(2)	Ez = 0 that means energy transmission is done by Hz.	Hz = 0 that means energy transmission is done by Ez
(3)	Dominant mode is TE_{01} mode	Dominant mode is TE_{11} mode
(4)	Cutoff frequency of dominant mode is less than TE_{11} mode	Cutoff frequency of dominant mode is more than TE_{10} mode
(5)	TE_{01} and TE_{10} mode exist	TM_{01} and TM_{10} mode does not exist
(6)	Cutoff wavelength for dominant mode = 2a	Cutoff wavelength for dominant mode = $2ab/\sqrt{a^2 + b^2}$

Q.2 Attempt any FOUR questions. [16]

Q.2(a) Describe, how bunching is formed in Magnetron-with neat diagram. [4]

Ans.: [Diagram 2 marks, Description 2 marks]

- **Bunching is formed in Magnetron:** Bunching takes place in magnetron like Klystrons which is known as phase focusing effect. This effect is useful for the favored electron to maintain the phase. Since such electron are retarded at each interaction with RF field.
- Diagram shops the wheel spoke bunches in the cavity magnetron. These bunches rotates counter clockwise with the correct velocity to keep up with RF phase changes between adjoining anode poles.



Bunching Process of Magnetron

Q.2(b) A rectangular waveguide measures 3 × 4.5 cm internally and has a 9 GHz signal propagated in it. Calculate the cut off wave length, the guide wavelength, phase velocity and the characteristic wave impedance for TE_{110} mode. [4]

Ans.: [Formula 2 marks and Proper answer 2 marks]

Calculating the free space wavelength gives

$$\lambda = \frac{v_c}{f} = \frac{3\times10^{10}}{9\times10^{9}} = 3.33 \text{ cm}$$

(a) The cutoff wavelength will be

$$\lambda_0 = \frac{2a}{m} = \frac{2\times4.5}{1} = 9 \text{ cm}$$

Calculating ρ, for convenience, gives

$$\rho = \sqrt{1-\left(\frac{\lambda}{\lambda_0}\right)^2} = \sqrt{1-\left(\frac{3.33}{9}\right)^2} = \sqrt{1-0.137} = 0.93$$

Then the guide wavelength is

$$\lambda_p = \frac{\lambda}{\rho} = \frac{3.33}{0.93} = 3.58 \text{ cm}$$

The group and phase velocities are simply found from

$$v_g = v_c\rho = 3 \times 10^8 \times 0.93 = 2.79 \times 10^8 \text{ m/s}$$

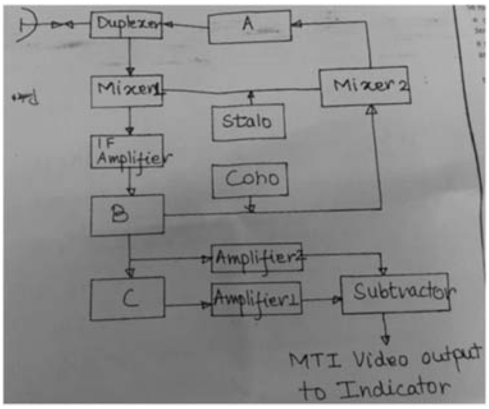
$$v_\rho = \frac{v_c}{\rho} = \frac{3\times10^8}{0.93} = 3.23 \times 10^8 \text{ m/s}$$

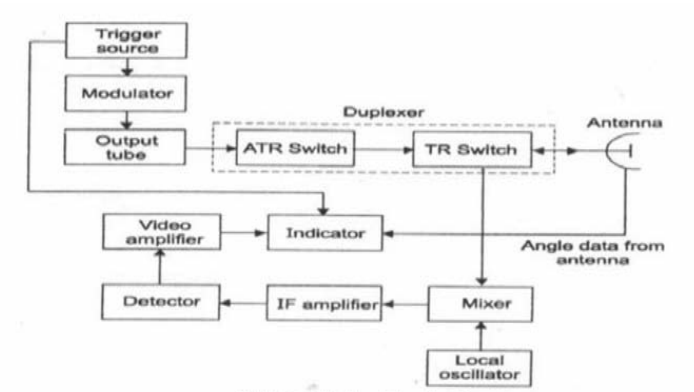
The characteristic wave impedance is

$$Z_0 = \frac{L}{\rho} = \frac{120\pi}{0.93} = 405\ \Omega$$

Q.2(c) Write the operation of pulsed radar to detect the object. **[4]**

Ans.: [Diagram 2 marks and Explanation 2 marks]





Pulsed Radar Block Diagram

There are four basic subsystem: The antenna, the transmitter, receiver and display unit.

- **Transmitter:** The transmitter in pulsed radar is a magnetron. (The magnetron is special a high power vaccum tube oscillator that operates in microwave region.) The cavity size of magnetron sets the operating frequency. It can produce many megawatts of power.
- **Master timing generator:** The timing generator sets pulse duration, PRT and duty cycle. The pulses from timing network trigger the magnetron into oscillations and the magnetron emits short burst of microwave energy.
- **Duplexer:** Duplexer is special device that allows transmitter and receiver to share single antenna.
- **Antenna:** The horn antenna with parabolic reflector used to produce very narrow beam width. The same antenna is used for reception.
  During the pulse off time, the received signal passes through the antenna, the associated waveguide and duplexer to receive.
- **Receiver:** The receiver is a standard high gain super heterodyne type.
  Display: CRT display is known as type p or plan position indicator.
  PPI display is that it shows both range and azimuth of the target.

Q.2(d) Differentiate between waveguide and two wire transmission line. [4]

Ans.: [Any four 1 mark each]

Sr. No.	Waveguide	Two wire Transmission line
(1)	A waveguide is a hollow metallic pipe design to carry microwave energy from one place to another	Transmission on line is a conductor or wire designed to carry electrical energy below microwave range from one place to another.
(2)	Used for Microwave frequency above 1 GHz	Used for RF up to 500 in GH_2 upto 18 GHz. For short distance.
(3)	Power handling capacity is high	Power handling capacity is low
(4)	Wave theory is considered in waveguide analysis	Circuit theory considered in Transmission line
(5)	The large surface area of waveguide reduces copper losses	Two wire transmission line have large copper losses due to small surface area
(6)	Dielectric losses are less in waveguide	Dielectric losses are more in two wire Transmission line
(7)	If the other end is also closed, then the hollow box so formed can support a signal which can bounce back and forth between two shorting plates resulting in resonance.	If one of the end of the waveguide is closed using a shorting plate, there will be a reflection and hence standing waves will be formed.

Q.2(e) List the specifications of two cavity klystron amplifier and give it's applications. [4]

Ans.: [4 Specification - 2 marks, Application - 2 marks]

Two cavity Klystron:

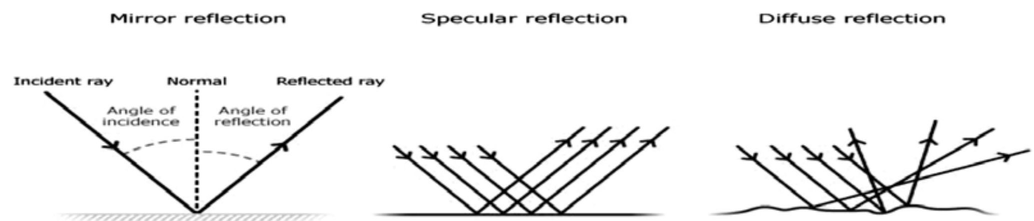
- Frequency: 250 MHz to 100 GHz (60 GHz nominal).
- Power: 10 KW – 500 KW (CW) 30 MW (pulsed).
- Power gain: 15 dB – 70 dB (60 dB nominal).
- Bandwidths: Limited (because cavity resonators are being used) 10–60 MH_z- generally used in fixed frequency applications.
- Noise figure: 15–20 dB (sometimes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

Applications:

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

Q.2(f) Define :(i) Reflection [4]
(ii) Refraction
(iii) Absorption in scattering w.r.t light theory.

Ans.: (i) Reflection [1 mark]



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

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

(ii) Refraction: [1 mark]

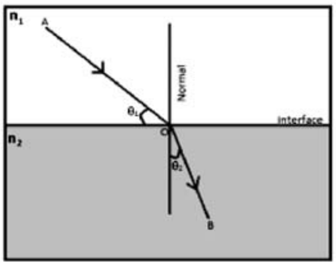


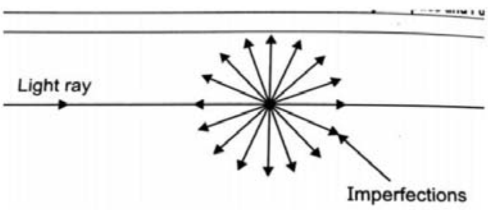
Figure 1

Reflection is the bending of the wave when it enters a medium where the speed is different. The refraction of light when it passes from a fast medium to a slow medium bends the light ray towards the normal to the boundary between the two media.

Due to change in speed of light when it travels from different medium as air, water, glass and other transparent material.

(iii) Absorbtion in scattering [2 marks]

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



Q.3 Attempt any FOUR questions. **[16]**

Q.3(a) When the mean optical power launched into an 8km length of fiber is 120 μW, the mean optical power at the fiber output is 120 μW. Determine the overall signal attenuation or loss in decibels through the fiber, assuming there are no connector or splices. **[4]**

Ans.: [Equation 1 mark and Calculation 3 marks]

$L = 8$ Km

$P_i = 120\ \mu W$
$= 10 \log 120 \times 10^{-6}$
$P_i = -39.208$ dB

$P_O = 3\ \mu W$
$= 10 \log 3 \times 10^{-6}$
$P_O = -55.228$ dB.
$P_i = P_O + (\alpha f_C + \alpha j)\ L + Ma + \alpha_{Cr}$

Assumed

$\alpha_{Cr} = \alpha_j = 0$
$Ma = 6$ dB (Safety margin)

$\therefore \quad P_i = P_O + \alpha f_C L + Ma$
$-39.208 = -55.228 + \alpha f_C L + 6$
$\alpha f_C L = -39.208 - 6 + 55.228$
$\alpha f_C L = 10.02$ dB

Overall signal attenuation $\alpha f_C L = 10.02$ dB.

Q.3(b) State the advantages and applications of circular waveguide (2 points each). **[4]**

Ans.: Note: any other relevant application and advantages can be considered

Advantages: (Any 2 application) [2 marks]

1. The circular waveguide are easier to manufacture than rectangular waveguides and are easier to join.
2. The TM01 modes are rotationally symmetrical and hence rotation of polarization can be overcome.
3. TE01 mode in circular for long distance waveguide transmission.

Applications of Circular waveguide: (Any 2 application) [2 marks]

1. It is used where the transmission or reception is in the range of microwave frequencies.
2. It is also used for handling the high power of energy.
3. It is mostly used in the airborne radar.
4. The circular waveguide is mostly used in the ground radar to transmit or receive the energy from antenna. This revolves in 360 degree bearing continuously.
5. The waveguide is also used in communication system.
6. It can also use in the devices of navigation aids.
7. The circular waveguides are also used with the cavity resonators to carry the input and output signals.

Q.3(c) Explain advantages of satellite communication (4 points). **[4]**

Ans.: [Any 4 advantages 1M each]

Note: Any other relevant advantage can be considered

Broadcast property : Wide coverage area. Satellites, by virtue of their very nature, are an ideal means of transmitting information over vast geographical areas. This broadcasting property of satellites is fully exploited in point-to-multipoint networks and multipoint interactive networks. The broadcasting property is one of the major plus points of satellites over terrestrial networks, which are not so well suited for broadcasting applications.

Wide bandwidth : high transmission speeds and large transmission capacity. Over the years, satellites have offered greater transmission bandwidths and hence more transmission capacity and speeds as compared to terrestrial networks. However, with the introduction of fiber optic cables into terrestrial cable networks, they are now capable of providing transmission capabilities comparable to those of satellites.

Geographical flexibility : independence of location. Unlike terrestrial networks, satellite networks are not restricted to any particular configuration. Within their coverage area, satellite networks offer an infinite choice of routes and hence they can reach remote location shaving rudimentary or nonexistent terrestrial networks. This feature of satellite networks makes them particularly attractive to Third World countries and countries having difficult geographical terrains and unevenly distributed populations.

Easy installation of ground stations: Once the satellite has been launched, installation and maintenance of satellite Earth stations is much simpler than establishing a terrestrial infrastructure, which requires an extensive ground construction plan. This is particularly helpful in setting up temporary services. Moreover, one fault on the terrestrial communication link can put the entire link out of service, which is not the case with satellite networks.

Uniform service characteristics: Satellites provide a more or less uniform service within their coverage area, better known as a 'footprint'. This overcomes some of the problems related to the fragmentation of service that result from connecting network segments from various terrestrial telecommunication operators.

Immunity to natural disaster. Satellites are more immune to natural disaster such as floods, earthquakes, storms, etc., as compared to Earth-based terrestrial networks.

Independence from terrestrial infrastructure: Satellites can render services directly to the users, without requiring a terrestrial interface. Direct-to-home television services, mobile satellite services and certain configurations of VSAT networks are examples of such services. In general, C band satellites usually require terrestrial interfaces, whereas Ku and Ka band systems need little or no terrestrial links.

Cost aspects: low cost per added site and distance insensitive costs. Satellites do not require a complex infrastructure at the ground level; hence the cost of constructing a receiving station is quite modest – more so in case of DTH and mobile receivers. Also, the cost of satellite services is independent of the length of the transmission route, unlike the terrestrial networks where the cost of building and maintaining a communication facility is directly proportional to the distances involved.

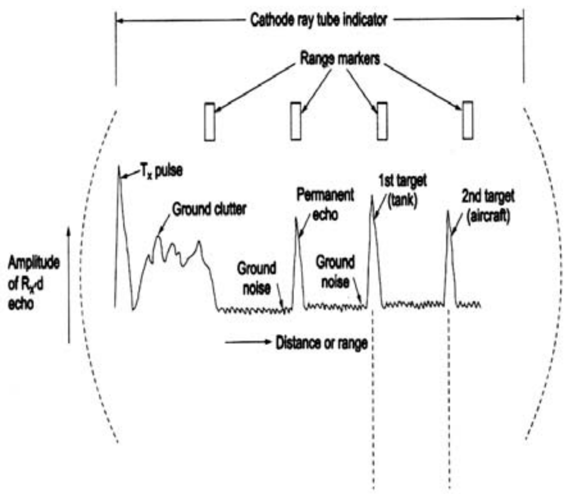
Q.3(d) Compare Non synchronous and synchronous satellite based on : [4]
(i) Orbit (ii) Visibility (iii) Altitude (iv) Footprint

Ans.: **[1 mark for each]**

Sr.No.	Parameter	Synchronous satellite	Non-synchronous satellite
1.	Orbit	Circular	Elliptical and parabolic
2.	Visibility	Periodic	Visibility changes
3.	Altitude	Constant (36000KM) from earth surface	Changes according to orbit
4.	Footprint	Big Coverage of earth	Small coverage of earth

Q.3(e) Explain A–scope Display Method with diagram, used in Radar System. [4]

Ans.: [Diagram 1 mark and Explanation 3 marks]



Explanation:

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

Q.4(a) Attempt any THREE questions. [12]

Q.4(a) (i) Draw the frequency spectrum for communication and show the region for Fiber optic communication. [4]

Ans.: [Diagram 2 marks and Table and explanation 2 marks]

This electromagnetic spectrum is shown in figure 1

We know that the energy contained by the photons is given by,

$$E = h\upsilon = hc/\lambda$$

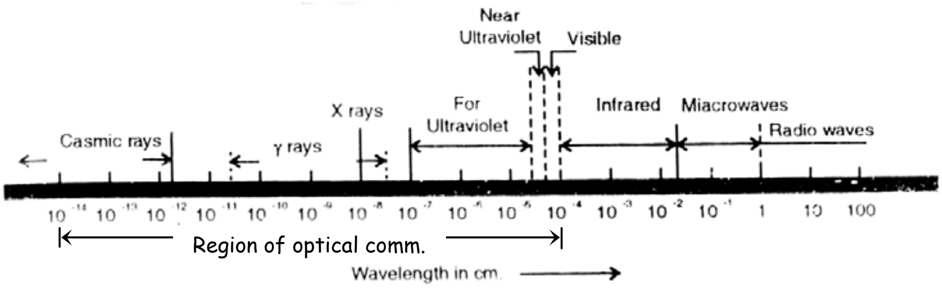


Fig. 1 : Electromagnetic spectrum.

Thus energy and wavelength are inversely proportional to each other. So as shown in Figure 1, as the wavelength goes on increasing, the energy goes on decreasing.

The construction of two hole directional coupler is as shown in Figure 2.

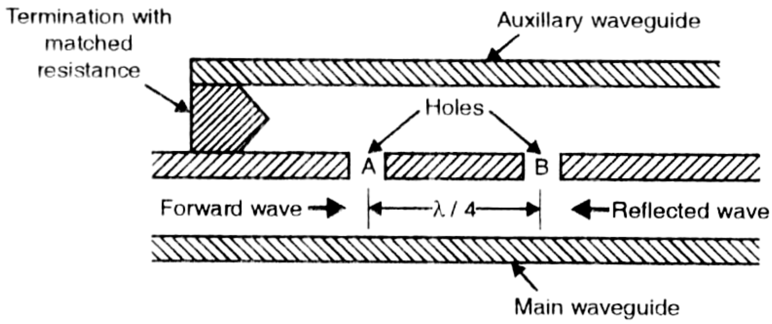


Fig. 2 : Two hole directional

It consists of two waveguides. Auxiliary waveguide and main waveguide. Two gaps (holes) are present between these two waveguides. One end of an auxiliary waveguide is terminated with the matched resistance as shown in Figure 2. So that any backward wavecomponents will be absorbed by this matched resistance termination.

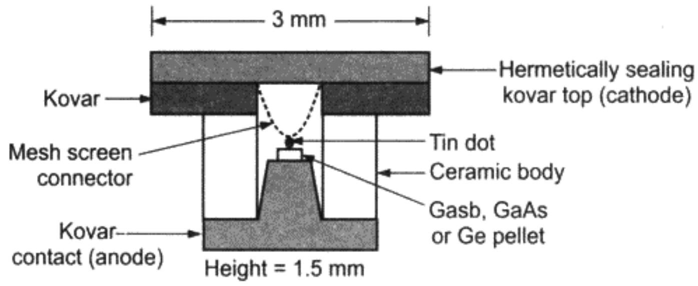
Working :

As shown in figure 2, the two holes namely A and B are separated by the distance of $\lambda/4$. The forward wave travelling through main waveguide enters into auxiliary arm at A. Some portion of this wave enters into auxiliary arm at B. These two wave components entering at A and B get added and passes in the auxiliary waveguide. The direction in auxiliary waveguide for these wave components is from left to right.

The portion of reflected wave is small. Some portion of reflected wave passes through main waveguide from right to left and enters in auxiliary wave guide through gap A. While some portion of reflected waves enter into auxiliary waveguide through gap B. The portion of reflected wave entering through A in auxiliary Waveguide has to travel double distance as compared to the portion entering through B. Now the portion entering through A and reaching to gap B in auxiliary waveguide has travelled an extra distance of $2 \times \lambda/4 = \lambda/2$. Thus these two reflected waves meeting at B are 180° out of phase. So they cancels each other.

Q.4(a) (ii) Draw the construction of Tunnel diode and give its working as microwave component. **[4]**

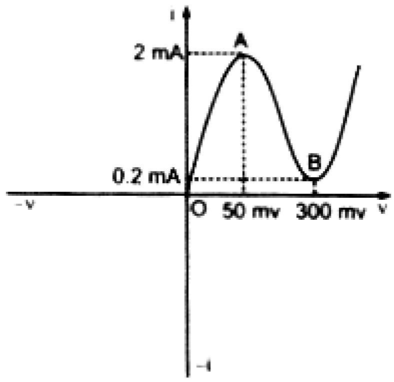
Ans.: [Diagram 2 marks, Working 2 marks]



Tunnel diode

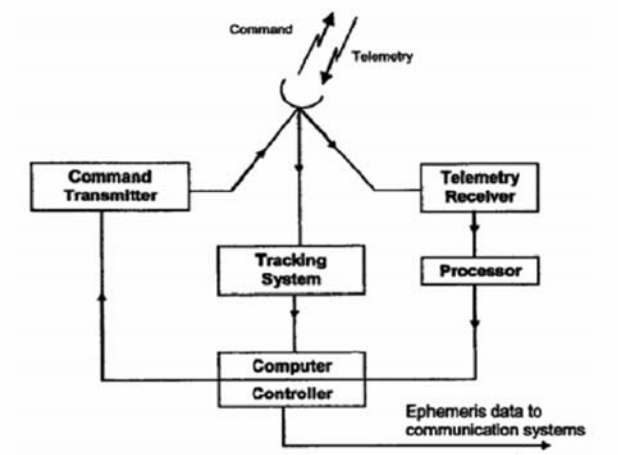
Working :

- Tunnel diode is a thin junction diode which under low forward bias conditions exhibits negative resistance useful for oscillation or amplification.
- The junction capacitance of the tunnel diode is highly dependent on the bias voltage and temperature.
- A very small tin dot about 50μm in diameter is soldered or alloyed to a heavily doped pellet of n- type Ge, GaSb or GaAs.
- The pellet is then soldered to a kovar pedestal, used for heat dissipation, which forms the anode contact.
- The cathode contact is also kovar being connected to the tin dot via a mesh screen used to reduce inductance.
- The diode has a ceramic body and hermetically sealing lid on top.
- In tunnel diode semiconductor material are very heavily doped, as much as 1000 times more than in ordinary diodes.
- This heavy doping result in a junction which has a depletion layer that is so thin (0.01μm) as to prevent tunneling to occur.
- In addition, the thinness of the junction allows microwave operation of the diode because it considerably shortens the time taken by the carriers to cross the junction.
- A current-voltage characteristics for a typical Germanium tunnel diode is shown in figure.
- Forward current rises sharply as voltage is applied.
- At point A, peak voltage occurs.
- As forward bias is increased past this point, the forward current drops and continues to drop until point B is reached, this is the valley voltage.
- At point B current starts to increase once again and does so very rapidly as bias is increases further.
- Diode exhibits dynamic negative resistance between A and B therefore, useful for oscillator applications.



Q.4(a) (iii) Illustrate how telemetry tracking and command system used in satellite communication. [4]

Ans.: [Diagram 2 marks and Explanation 2 marks]



Tlemetry, Tracking and Command (TT&C) subsystem these systems are partly on the satellite and partly at the control earth station. They support thefunctions of the spacecraft management. The main functions of a TTC system are

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

TELEMETRY:RY

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

TRACKING:

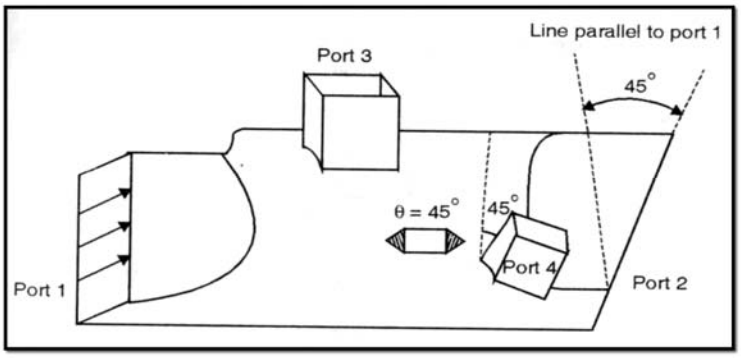
- By using velocity and acceleration sensors, on spacecraft the orbital position of satellite can be detect from earth station.
- For accurate and precise result number of earth stations can be used.

Q.4(a) (iv) Sketch the construction of circulator and isolators. State two applications of each. [4]

Ans.: [Diagram 2 marks and Explanation 2 marks]

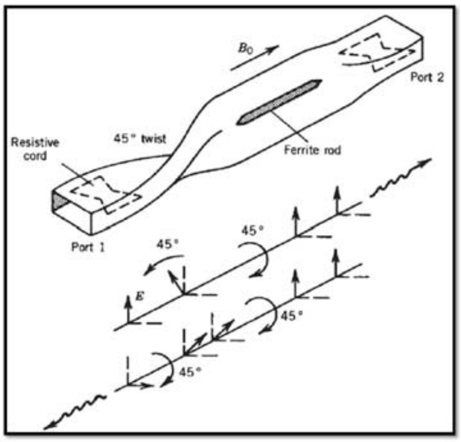
Note: Any other application can be considered.

Circulator:



Application:
(i) Circulators are used in duplexers in radars.
(ii) Another common use of circulators is as coupling elements is reflection amplifier, such as parametric amplifiers.

Isolator:



Application:
(i) Isolators are most widely used to protect high power RF sources.
(ii) Isolators are often used between the transmitter and the antenna is several communication systems and radar systems. They are also used on the output of signal generators.

Q.4(a) (v) State the two applications of each: [4]
(1) IMPATT diode (2) PIN diode

Ans.: [Four application of each diode - ½ marks for each application]

(1) IMPATT diode
   (a) Intruders alarm
   (b) Basic forms of radar
   (c) General detectors using RF technology.
(2) PIN diode
   (a) High voltage rectifiers
   (b) RF switch
   (c) Photodetector

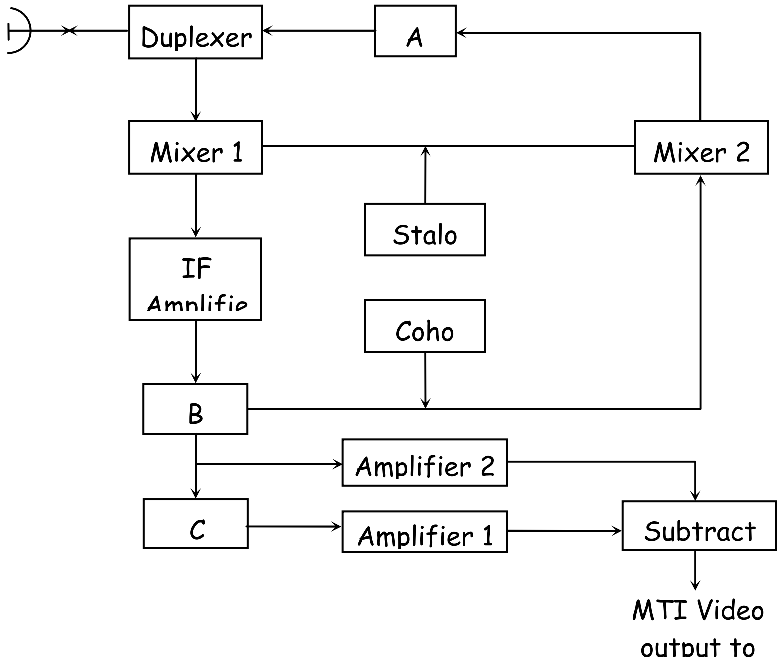
Q.4(b) Attempt any ONE questions. [6]

Q.4(b) (i) Explain the term Station keeping with reference to satellite communication. [6]

Ans.: Station keeping [1 mark each point]

- The control signals that are to be generated on ground to keep the satellite in position is known as station keeping.
- Once a satellite is in orbit, the forces acting on it tend to keep it in place.
- Variety of forces causes orbital drift of a satellite.
- So, the orbit of the satellite must be periodically adjusted.
- Most satellite contain small rockets or thruster jets for that purpose.
- Depending on how accurate the orbit must be, these rockets may be fired every several weeks or once per year.
- The process of firing the rockets underground control to maintain or adjust the orbit is referred to as station keep

Q.4(b) (ii) Identify the given diagram, label the block A, B and C and illustrate why those blocks are needed. [6]



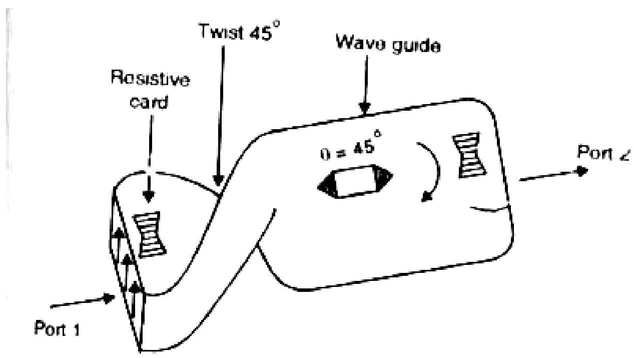
Ans.: [3 marks for identifying the blocks and 3 marks for justification]

Block A : Klystron Amplifier
Block B : Phase detector
Block C : Delay line
Klystron amplifier: It amplifies higher frequencies.
Phase detector: Detects phase difference between transmitted and received signals will be constant for fixed targets, whereas it will vary for moving targets.
Delay line: Because of the delay times required, delay lines are used to provide delay.

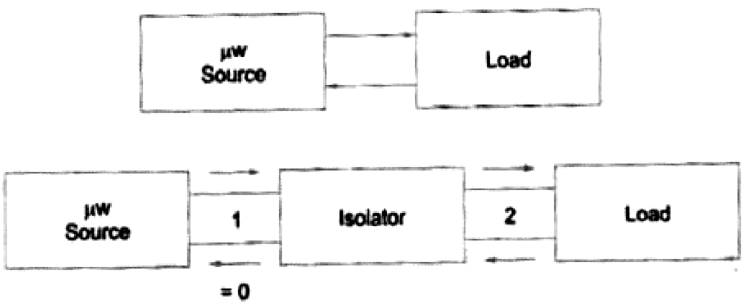
Q.5 Attempt any FOUR questions. [16]

Q.5(a) Draw the constructional diagram of Isolator and illustrate its operation. [4]

Ans.: [Diagram 2 marks and Explanation 2 marks]



Or



Working: It provides very small attenuation for transmission from port 1 to 2. But provides very high attenuation for transmission from port 2 to 1. In most microwave generator the output amplitude tens to fluctuate with change in load impedance. Fluctuations occur due to mismatch of generator output to load that results reflected wave from load. That reflected wave causes in stability of stability of amplitude and frequency of microwave generator. If isolator is inserted between generator and load then generator is connected to load with zero attenuation and reflection. If any reflection generated from load side than those are completely absorbed by isolator without affecting generator output. Therefore generator appears to be matched for all loads.

Q.5(b) Calculate critical angle of incidence between two material with different refractive indices n_1 = 1.4 and n_2 = 1.36. Also calculate numerical aperture and acceptance cone angle. **[4]**

Ans.: [Diagram 2 marks Explanation 2 marks]

(a) Critical angle ($\varnothing_C$) = $\text{Sin}^{-1} (n_2/n_1)$

$\varnothing_C = \sin^{-1} (1.36/1.4)$

$\varnothing_C = 76.27°$

(b) Numerical aperture (NA) = $(n_1^2 - n_2^2)^{1/2}$

$NA = (1.4^2 - 1.36^2)^{1/2}$

NA = 0.33

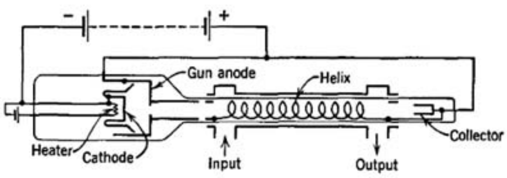
(c) Acceptance angle (θa) = $\sin^{-1}$ NA

$\theta_a = \text{Sin}^{-1}\ 0.33$

$\theta_a = 19.32°$

Q.5(c) Draw TWT and give its two applications. **[4]**

Ans.: [Diagram 2 marks, Explanation 2 marks]

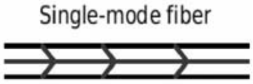


Application:

- TWT as are commonly used as amplifiers in satellite transponders, where the input signal is very weak and the output needs to be high power.
- A TWTA whose output drives an antenna is a type of transmitter. TWTA transmitters are used extensively in radar, particularly in airborne fire-control radar systems, and in electronic warfare and self-protection systems. In such applications, a control grid is typically introduced between the TWT's electron gun and slow-wave structure to allow pulsed operation. The circuit that drives the control grid is usually referred to as a grid modulator.
- Another major use of TWT as is for the electromagnetic compatibility (EMC) testing industry for immunity testing of electronic devices.

Q.5(d) Differentiate between single mode and multimode fiber. **[4]**

Ans.: [one point 1 mark. Any four point consider]

Single mode fiber	Multi mode fiber
• Core radius is small. • Supports one mode of propagation. • Optical source–LASER. • The launching of optical power into fiber is difficult as the core radius is small. • Supports larger band width. • Intermodal dispersion is absent. • Used for long distance communication. Diagram  Single-mode fiber	• Core radius is large. • Supports hundreds of modes. • Optical source–LED • The launching of optical power into fiber is easer as the core radius is large. • Supports lesser bandwidth. • These fiber suffer from Intermodal dispersion. • Used for short distance communication. Diagram  Multi-mode fiber

Q.5(e) Compare between edge emitter and surface emitter LED's. **[4]**

Ans.: [Any four - 1 mark each]

Sr. No.	Surface emitter LED	Edge emitter LED
1.	Easy to fabricate	Difficult to fabricate
2.	Easy to mount and handle	Difficult to mount and handle
3.	Require less critical tolerances	Need critical tolerance on fabrication
4.	Less Reliable	Highly reliable
5.	Low system performance	High system performance
6.	Less modulation Bandwidth	Better modulation, Bandwidth of the order of hundreds of MHz
7.	Couple less optical power into law NA fiber	Couple more optical power into low NA fiber
8.	Light is emitted from the surface of active Layer	Light is emitted from edge of active Layer
9.	Wider spectral width	Narrow spectral width
10.	Maximum quantum efficiency is up to 60%	Internal quantum efficiency is in the range of 60% to 80%

Q.5(f) List and explain the properties of splicing. **[4]**

Ans.: [List 2 marks, Explanation 2 marks]

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

Cable Preparation: Cable preparation and handling procedures for a particular cable design normally are recommended by the specific cable manufacturer, and should be followed carefully. However, some general fiber-related precautions apply for all cable designs. Sufficient individual fiber lengths should be available such that when each spliced fiber pair is completed, the slack fiber will mount properly into the organizer with sharp bends or kinks. Also, some excess fiber length may be required should an unacceptable splice need to be remade.

Fiber Preparation:

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

Surface Cleaning: Any acrylate coating residue that remains after stripping should be removed from the bare fiber surface. A clean, lint-free cotton (or alcohol-soaked) pad gently pulled over the fiber surface works well for most mechanically stripped fibers with acrylate coatings. It is important to handle bare fibers as little as possible from this point until the splice is complete. Taking this precaution will minimize the chance of contaminating the fibers with dust or body oils, which may contribute to higher splice losses and lower tensile strengths. It also is important to completed the remaining splicing process as quickly as possible, since delays will expose the fiber to additional airborne contaminants. Failure to utilize careful cleaning practices may cause the glass surface to become abraded leading to lower splice strength.

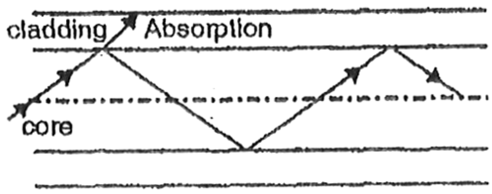
Fiber–end Angle: Since the primary attribute affecting single fusion splicing is the end angle, proper fiber–end preparation is a fundamental step in obtaining an acceptable fusion splice. Fiber–end angle requirements vary slightly from user to user, depending on the splice loss requirements and the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

Q.6 Attempt any FOUR questions. [16]

Q.6(a) Describe absorption and scattering with the help of light theory. [4]

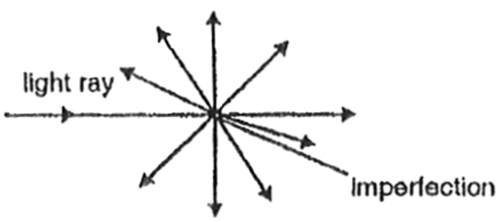
Ans.: Absorption [2 marks]

- It takes place when light strikes a surface (flat black) and is converted into heat through an exchange of energy with the atoms of the surface.
- While transferring optical signal through fiber a number of mechanisms are responsible for signal attenuation. Absorption is one of it.
- Material absorption is a loss mechanism related to material composition and the fabrication process for the fiber.
- The absorption of light may be intrinsic or extrinsic.
- Intrinsic absorption caused by the interaction with one or more of the major components of the glass.
- Extrinsic absorption caused by impurities within the glass.
- Absorption occur due to interaction of photons with molecular vibrations within the glass.
- Absorption occur due to water (OH ion) dissolved in the glass that stretches the vibrations.



Scattering

- It occurs when light strikes a substance it emits light of its own at the same wavelength as the incident light.



- Scattering of light ray is nothing but leakage of rays through fiber.
- Attenuation of the transmitted light results as the transfer may be to a leaky or radiation mode which does not continue to propagate within the fiber core, but is radiated from the fiber.
- It results from the non-perfect fiber such as irregularities in core-cladding interface, core-cladding refractive index differences along the fiber length, diameter fluctuations, strain and bubbles.

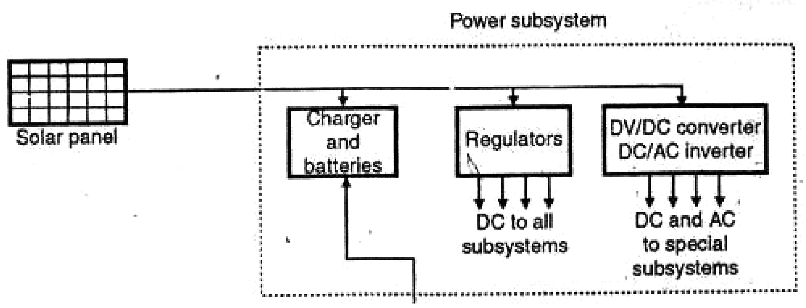
Q.6(b) How power is generated in satellite? Describe how it is distributed to other subsystem of satellite. **[4]**

Ans.: [Diagram 2 marks, Explanation 2 marks]

How power is generated in satellite

- Today every satellite uses solar panels for its basic power source. Individual solar cells can generate only small amount of DC power (by converting incident sunlight into electrical energy). So these solar panels are large arrays of photocells connected in various series and parallel circuits to create a powerful source of direct current. The key requirement of the solar panels is to always point towards the sun.

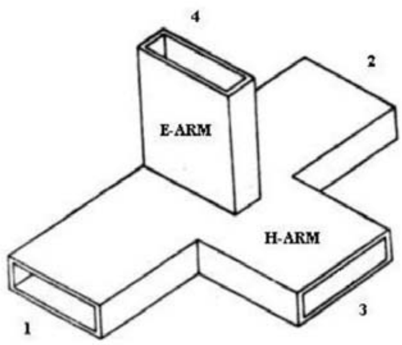
  A key component of the satellite is its power subsystem for power distribution to all subsystem. The figure shows the block diagram of power subsystem with its power distribution.



- Everything on board operates electrically. Most satellites therefore depend entirely upon their power supplies for success. The function of the power subsystem is to provide DC power to all subsystems throughout the life of the spacecraft.
- The basic DC voltage from the solar panels is then conditioned in various ways –
  It is typically passed through voltage regulators before being used to power individual electronic circuits. Most electronic equipment works best with fixed stable voltages and therefore regulators are incorporated in most satellite systems.
- Some parts of the satellite require higher voltage than those produced by the solar panels. The TWT amplifiers in most communication transponders require thousands of volts for proper operation. Special DC to DC converters are used to translate the lower DC voltage of the solar panels to the higher DC voltage required by the TWTs.
- Some circuits of the satellite require Ac voltage so inverters (DC to AC) are used to generate AC voltage.

Q.6(c) Describe function of hybrid Tee with neat diagram. (E-H plane or Magic Tee). **[4]**

Ans.: [Diagram 2 marks Explanation 2 marks]



Explanation:

Magic tee (or magic T or hybrid tee):

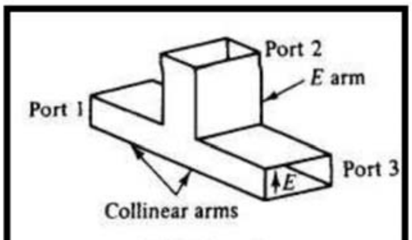
- Is a hybrid or 3 dB coupler used in microwave system. It is an alternative to the rat race coupler.
- In contrast to the rat–race, the three-dimensional structure of the magic tee makes it less readily constructed in planar technologies such as microstrip or stripline.

- The magic tee is a combination of E and H plane tees. Arm 3 form an H–plane tee with arms 1 and 2. Arm 4 forms an E–plane tee with arms 1 and 2. Arms 1 and 2 are sometimes called the side or collinear arms. Port 3 is called the H–plane port, and is also called the Σ port, sum port or the P–port (for "parallel"). Port 4 is the E-plane port, and is also called the Δ port, difference port, or S-port (for "series").
- There is no one single established convention regarding the numbering of the ports.
- To function correctly, the magic tee must incorporate an internal matching structure this structure typically consists of a post inside the H–plane tee and an inductive iris inside the E–plane limb, though many alternative structures have been proposed. Dependence on the matching structure means that the magic tee will only work over a limited frequency band.

Q.6(d) Describe the function of following junctions : **[4]**
(i) E- plane junction **(ii) H- plane junction in microwave transmission**

Ans.: [Diagram and Explanation - 1 mark for each]

E Plane junction



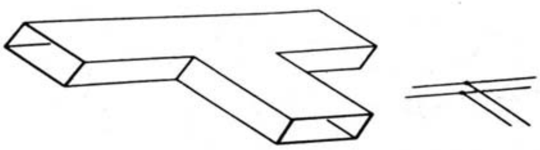
(a) *E*-plane tee

Explanation

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

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

H-Plane Junction



Hplane Tee is so called because the axis of side arm is parallel to planes of H-field of main transmission line.

As all three arms of H plane tee lay in the plane of magnetic field, the magnetic field divide itself in arms this is thus the current junction.

Since the electricity is not bent as the wave passes through a Hplane junction but merely divide between two arms, fields of same polarity approaching the junction from two main arms produce component of electric field that add in side arm

The effective valve of field leaving through the side arm is proportional to phasor sum of entering fields.

Q.6(e) Differentiate between fusion splice and V-groove splice. [4]

Ans.: [Any four point - 1 mark each]

Sr. No.	Fusion Splicing	V-groove Splicing
1.	Fusion splicing is the method of joining two optical fiber end to end using heat	V groove align two fiber in a small glass tube with a hole just slightly larger than the outer diameter of the fiber.
2.	The source of the necessary heat is usually an electric arc	It is formed by sandwiching the butteend between a v grove glass substrate and the flat glass retainer plain
3.	Fusion splicing does not have higher insertion loss	It has a very high insertion loss
4.	It has a high reliability	It has a low reliability
5.	It has a very less return losses	It has a very high returned losses
6.	It is used for single mode fiber product	It is used for single fiber and fiber ribbons
7.	It is expensive	It is inexpensive
8.	It is not a simplest method of splicing	It is simplest method of splicing.

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