Advanced Communication System

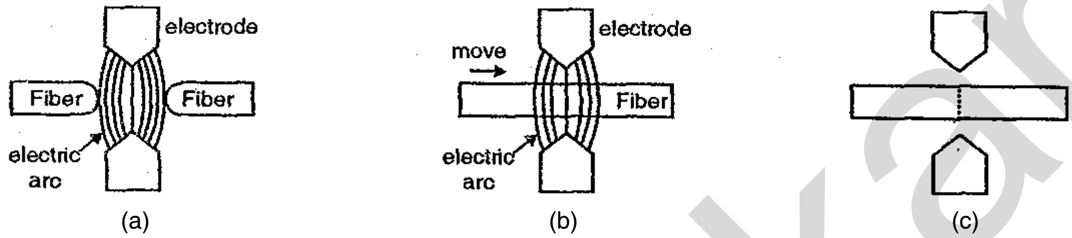
Time: 3 Hrs.] Prelim Question Paper Solution [Marks : 100

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

Q.1(a) (i) State splicing technologies used for optical fiber? Explain Fusion splicing in detail? [4]

(A) (i) Fusion Splicing (ii) Mechanical Splicing

Fusion Splicing



- The fusion splicing of single fiber involves the heating of two prepared fiber ends to their fusing points with the application of axial pressure between two optical fiber.
- It is essential that shipped fiber ends are adequately positioned and aligned in order to achieve good continuity at junction.
- Flame heating source such as microplasma torches are utilized & widely used heating source is electric are, which gives consistant, easily controlled, heat under field condition.
  This heat may weaken the fiber.

Q.1(a) (ii) Compare Between waveguide and Two wire transmission line. [4]

(A)

	Waveguide	Two wire transmission line
(i)	It is a hollow metallic pipe which carry microwave energy.	Two wire transmission line. It is conductor which carry electrical energy.
(ii)	Dielectric losses are less.	Dielectric losses are more.
(iii)	For analysis, wave theory is considered	For analysis, circuit theory is considered
(iv)	It can handle more power	It can handle less power
(v)	Rectangular circular waveguides are available	Twisted pair, co–axial cable are available
(vi)	Radiation, copper losses are less	Radiation, copper losses are more.

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

(A) **(1) Cut-off frequency :** 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 & b is narrower dimension.

(2) Cut-off wavelength : 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, λ_c = cut off wavelength

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

(A) **(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 purposes, 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 ang!e is the vertical ang!e formed bet\"Jeen the direction oft rave! of electromagnetic wave radiated from an earth station antenna pointing directly 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) Explain the working principle and construction of PIN diode? Write two applications? [6]

(A) In Pin diode intrinsic larger is sandwiched between P & N region.
GaAs is used in construction of PIN diode.

It has narrow larger of P–type semiconductor separated from an equally narrow n–type material by thicker region of intrinsic material.

Working :

- PIN diode acts as ordinary diode of frequency upto 100 MHZ. At this frequency it works
  as rectifier. At microwave frequencies the diode acts as a variable resistance.
- When a bias is varied on a PIN diode it's microwave resistance changes from 5 to 10 kΩ when bias &
- It changes from 1 to 10Ω when bias is positive
- If diode is mounted across 50–2 co–axial line, it will not significantly load the line when it is back biased, so that power flow will be unaffected
- When diode is forward biased, its resistance becomes very low. So that most of power is reflected and hardly any transmitted.
- Thus the diode is acting as a switch.

Application:

1. Used for microwave power switching limiting
2. Used as a pulse modulator.

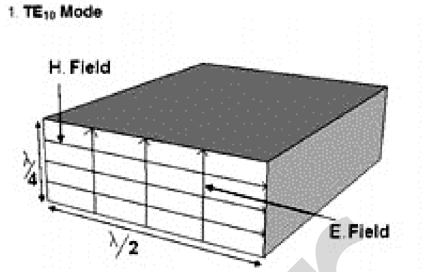
Q.1(b) (ii) Describe TE and TM modes in rectangular waveguide. [6]

(A) TE stands for transverse Electric mode. Here electric Field of the signal is perpendicular to the direction of propagation through waveguide and the magnetic field component can be in the direction of propagation. It is labeled as $TE_{m,n}$ where m an n are integers denoting the number of half wavelengths of EF intensity variations along the broader and narrower dimension.

$TE_{m,0}$ Modes : The equation of characteristic wave impedance is given by

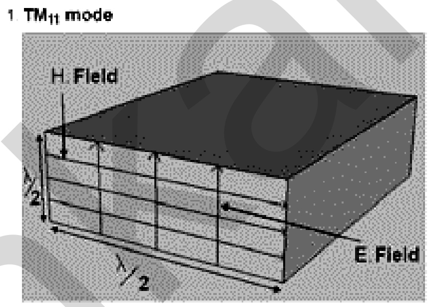
$$Z_0 = \frac{377}{\sqrt{1-\left(\frac{\lambda}{\lambda_c}\right)^2}}$$

Where,
Z_0 = characteristic wave impedance of the waveguide
It is seen that the different $TE_{m,0}$ modes all have different cutoff wavelengths and therefore encounter different characteristic wave impedances.



$TE_{m,n}$ Modes : The cut-off wavelength for $TE_{m,n}$ mode is given by –

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



$TE_{m,n}$ Modes : In TM modes, the magnetic field is transverse only, and the electric field has a component in the direction of propagation. Since lines of magnetic force are closed loops, if a magnetic field exists and is changing in the x direction, it must also exist and be changing in the y direction. Hence $TMm_{,0}$ modes cannot exist in rectangular waveguides. The formula for characteristic wave impedance for TM modes is,

$$Z_0 = 337\sqrt{1-\left(\frac{\lambda}{\lambda_c}\right)^2}$$

Q.2 Attempt any FOUR questions. [16]

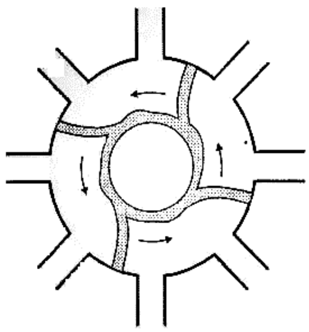
Q.2(a) List two advantages and two applications of circular waveguide? [4]

(A) (i) Propagates both vertically and horizontally polarized wave in the same waveguide.
(ii) Easy to manufacture and join together.

Application:
(i) Rotating joints in radars to connect the horn antenna feeding a paroboloid reflector.
(ii) For short and medium distance broad band communication.

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

(A)
- 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(c) List advantages and disadvantages of fibre optic cable as compare to conventional cable. (2 points each). [4]

(A) Advantages

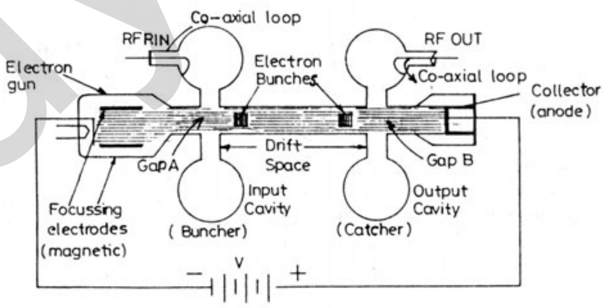
- Good information carrying capacity, which depends on bandwidth of the cable and fiber optical cable have much greater bandwidth.
- Lower loss as there is less signal attenuation over long distances.
- Fiber optical cable has lightweight and small size as compared to electrical cable.
- Optical cable does not cause interface because they do not carry the signals, which cause interference.
- Fiber optical cables cannot be tapped as easily as electrical cables.
- Fiber optical cables do not carry electricity. Therefore, there is no shock hazard.
- Fiber Optical cables are stronger than electrical cables.
- Materials required for fiber optical cables are easily available.
- They are simple in construction.

Disadvantages

- **Interfacing Costs :** To be practical and useful, they must be connected to standard electronic facilities, which often require expensive interfaces.
- **Strength :** Optical fibers by themselves have a significantly lower tensile strength than coaxial cable. This can be improved by coating the fiber with a protective jacket of PVC.
- **Remote electrical power :** Occasionally it is necessary to provide electrical power to remote interface or regenerating equipment. This cannot be accomplished with the optical cable, so additional metallic cables must be included in the cable assembly.
- **Optical fiber cables are more susceptible to losses introduced by bending the cable :** Bending the cable cause irregularities in the cable dimensions, resulting in a loss of signal power.
- **Specialized tools, equipment and training :** Optical fiber cables require special tools to splice and repair cables and special test equipment to make routine measurements. Sometimes it is difficult to locate faults in optical cables because there is no electrical continuity.

Q.2(d) Why do practical Klystron amplifiers generally have more than two cavities? How can broad band operation be achieved in multicavity Klystrons. [4]

(A)

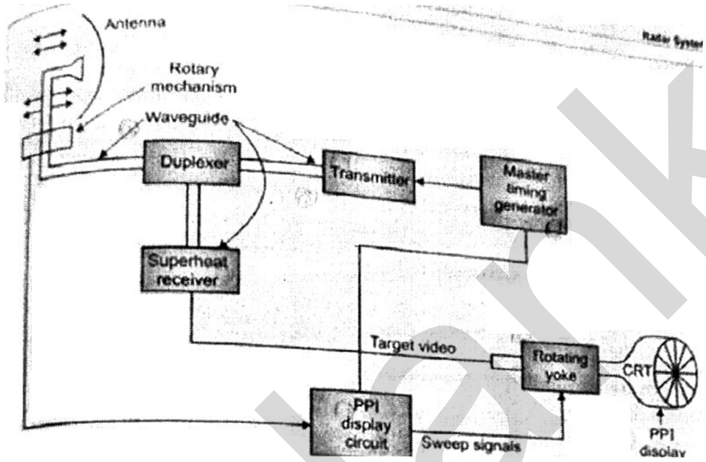


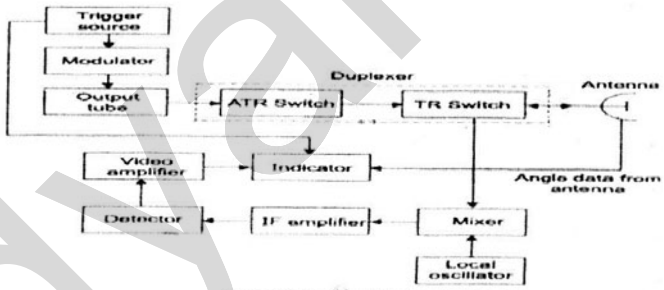
Two cavity klystron amplifier

- The bunching process in a two cavity klystron is by no means complete, since there are large number of out of phase electrons arriving at the catcher cavity between bunches. More than two cavities are always employed in practical klystron amplifier.
- Four cavities present in klystron amplifier and upto seven cavities have been used in practice.
- Partially bunched current pulses will now also excite oscillations in the intermediate cavities, and these cavities in turn set up gap voltages which help to produce more complete bunching. Having the extra cavities helps to improve the efficiency and power gain.
- The cavities may all be tuned to the same frequency such synchronous tuning being employed for narrowband operation.

- For broadband work, for example with UHF klystrons used as TV transmitter output tubes, or 6 GHz tube used as power amplifiers in some satellite station transmitters, stagger tuning is used.
- Here each of the intermediate cavities acts as a buncher with the passing electron beam inducing and enhanced RF voltage than the previous cavity.
- With the mult-icavities power gain of around 50 dB can be easily achieved. The cavities can all be tuned to self frequency for narrow band operation.
- Bandwidth can be improved by staggered tuning of cavities upto about 80 MHz with reduction in gain(to about 45dB) . This staggered tuning is employed in UHF klystron. For TV transmitter output tubes and in satellite earth station transmitter as a power amplifiers at C band.

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





Pulsed Radar Block Diagram

There are four basic subsystems : 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 superheterodyne type.
  Display
  - CRT display is known as type p or plan position indictor.
  - PPI display is that it shows both range and azimuth of the target.

Q.2(e) Compare SMSI and MMGI fibers based on **[4]**
(i) Mode **(ii) Refractive index profile**
(iii) Data rate **(iv) Application**

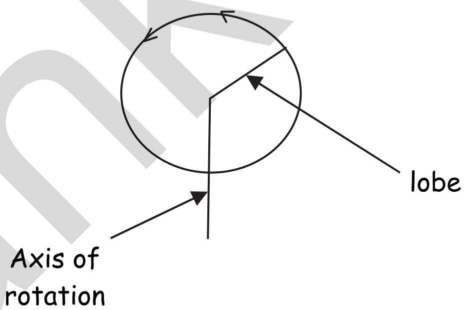
(A)

Sr. No.	Parameter	SMSI	MMGI
(i)	Mode	Single	Multi
(ii)	Refractive index profile	Uniform	Non-uniform
(iii)	Data rate	Slow	High
(iv)	Application	Subscriber local network communication	Local network and WAN

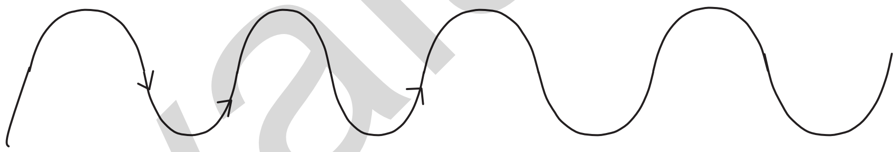
Q.3 Attempt any FOUR questions. **[16]**

Q.3(a) Explain Antenna scanning method's used in radar. **[4]**

(A) Radar antennas are often made to scan given area of the surrounding space
There are many scanning patterns depending on its application.
Horizontal Scanning
Scans only in horizontal plane wherever the scanning in horizontal directional is required example ship is ship securing then horizontal scanning is performed.

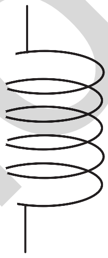


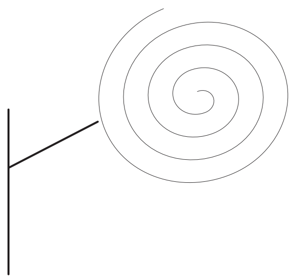
Nodding scan is an extension of this, the antenna is moved rapidly in elevation while it rotates more slowly in azimuth and scanning in both planes is obtained. This system can be used to scan limited sector.



Noddi

Helical Scanning: In this the elevation of the antenna is raised slowly while it rotates more rapidly in azimuth.





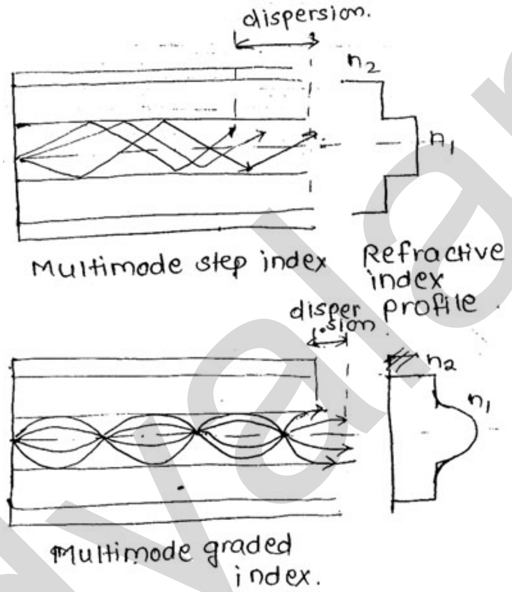
If a limited area of more or les circular shape is to be covered, then spiral scan may be used.

Q.3(b) Give characteristics and classification of fiber. **[4]**

(A) The char of light transmission thro a glass fiber depend on many factors.
(i) The composition of fiber
(ii) The amount & type of light introduced in fibers
(iii) The diameter & length of fiber.

- Composition of fiber determines the refractive index by the process called doping. Other material are introduced into material that after its index number. This process produces a single fiber core with core index n_1 & cladding index n_2

- Another chas. op fiber, which depend on its size, is it's mode of operation. Mode refers to mathematical & physical description of propagation of energy thro a medium no. of mode supported by single fiber can be 1 to 1,00,000 fibers can provide path for one light rays or may rays i.e. single mode or multimode.
- Archive Index profile It describes the relation of multiple indices which exist in the core adding of particular fiber.
  There are 2 major, indicates
  (i) Step index
  (ii) Graded index
  (i) Step index
  The step index decribes an abrupt index change from core to cladding. Core & cladding both are having uniform refractive index.
  (ii) Graded index
  With graded index, the highest index is at the center. This number gradually decreases until reaches the index no. of cladding.
  Three classifications of fiber(Types)
  (a) Multimode step index fiber
  (b) Multimode graded index fiber.
  (c) Single mode step index fiber.



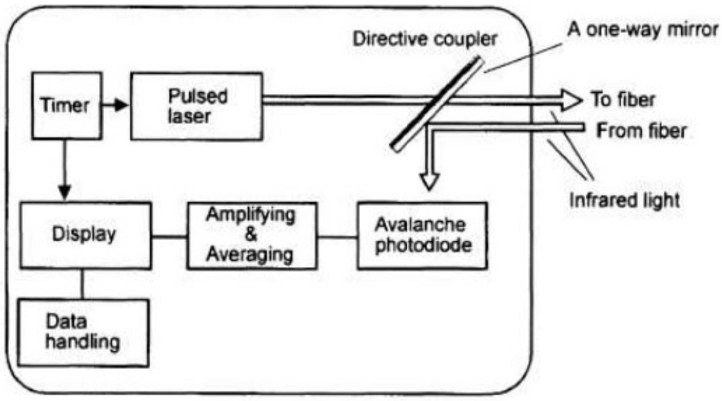
(a) Multimode step index fiber.
Has a core diameter from 100 to 970 μm. With this large core diameter, there are many paths thro' which light can travel multimode. Therefore, the light ray travelling the straight path through the center reaches the end before the other rays, which follow a zigzag path. the difference in the length of time it takes the various rays to exit the fiber is called modal dispersion. This form of a signal distortion which limits the bandwidth of fiber.

(b) Multimode graded index fiber.
Because light rays travels more slowly than the light nearer the surface. Therefore, both light rays arrive at the exit point at almost the same time, thus reducing model dispersion. Graded index fiber has core diameter ranging from 50–85 μm & cladding diameter of 125 μm.

(c) Single mode step index fiber.
It is widely used in wide–band communication with this fiber, a light ray can travel on only one path. Therefore, modal dispersion is zero. The core diameter of this fiber range from 5μm – 10μm.

Q.3(c) Describe working principle of OTDR with its Block diagram? [4]

(A) Block diagram of OTDR



The main block of reflector meter are the generator of the testing impulse and detection system of the backscattered signal.

An optical time domain reflectometer is used in fiber optics to measure the time and intensity of light reflected. It is used as a trouble shooting device to find fault, splices and bends in fiber optic cables, with an eye toward identifying light locs.

A light pulse is launched into the fiber in forward direction from laser using either a directional coupler or beam splitter.

Coupler makes possible to couple optical excitation power into the tested fiber and simultaneously to deviate the backscattered power to optical receiver.

The backscattered light is deflected using an avalanche photodiode.

O/P of photodiode drives integrator improves the received signal to noise ratio by giving an nonthematic average over a no. of measurement taken at one point within a fiber.
Then signal is fed to log. amplifier and average measurements for successive points with the fiber are plotted.

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

(A) **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.

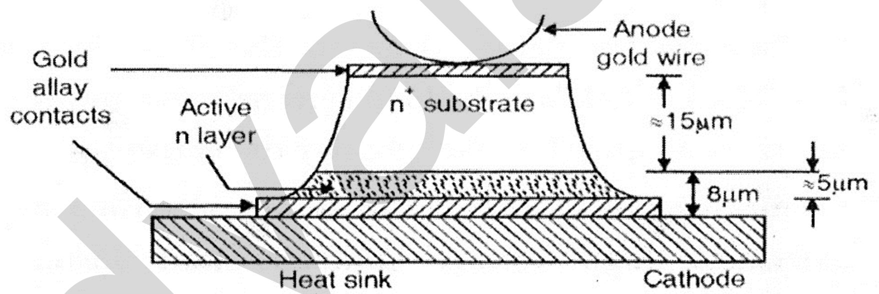
Uniform service characteristics : Satellites provide a more or less uniform service within their coverage area, better known as a 'footprint'. This overcomes some of the problems related to the fragmentation of service that result from connecting network segments from various terrestrial telecommunication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

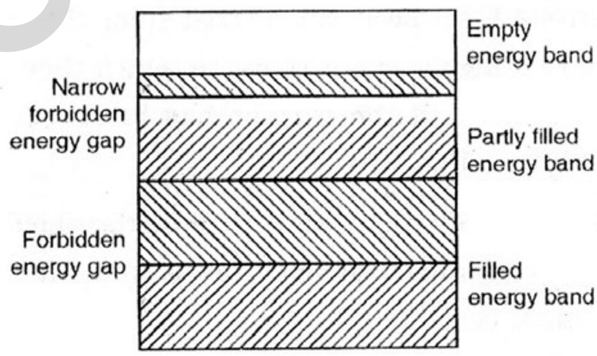
Immunity to natural disaster : Satellites are more immune to natural disaster such as floods, earthquakes, storms, etc., as compared to Earth-based terrestrial networks.

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(e) With neat diagram, illustrate the working of the Gunn diode. [4]
(A)





Operation
When a DC bias of value equal or more than threshold field (of about 3.3kV/cm) is applied to an n-type GaAs sample, the charge density and electric field within the sample become non-uniform creating domains that is electron in some region of the sample will be first to experience the intervalley transfer than rest of the electrons in the sample. The EF inside the dipole domain will begreater than the fields on either side of the dipole so the electrons

in that region or domain will move to upper valley and hence with less mobility. This creates a slight deficiency of e-1 s in the region immediately ahead. This region of excess and efficient e-1 s form a dipole layer.

As the dipole drifts along more e-1 s in the vicinity will be transferred to the U-valley until the electric field outside the dipole region is depress below the threshold EF. This dipole continues towards the anode until it is collected upon collector, the EF in the sample jumps immediately to its original value and next domain formation begins as soon as the field values exceeds the threshold values and this process is repeated cyclically.

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

Q.4(a) (i) Draw block diagram of MTI radar and explain its operation? [4]

(A)

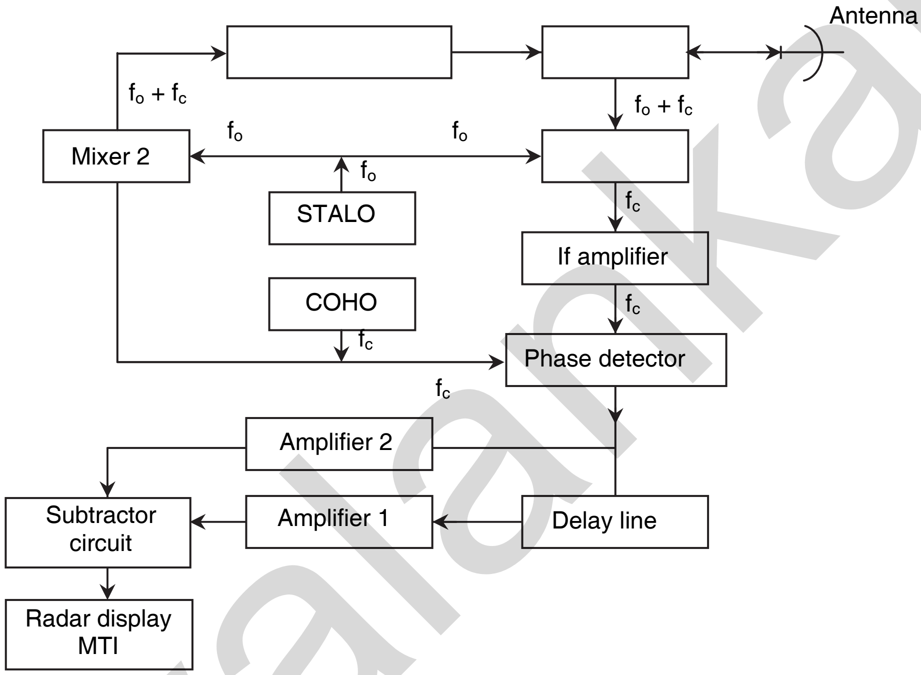


Fig. 1: Block diagram of MTI Radar

Principle:

- When it is desired to remove clutter due to stationary target & an MTI rader is employed.
- The basic principle of MTI radar is to compare a set of received echoes with those received during previous sweep & cancelling out those whose phase has remain unchanged.
- Moving targets will give change of phase & are not cancelled. The cullers due to stationery target both man made & natural are removed from displays this allows easier detection of moving targets.

Block diagram description

- It shows two mixes mixer.
- Generates transmitters frequency which is obtained by sum frequency produced by two OSC^r → The STALO (stable Local OSC^r producing f_O) & COHO (coherent OSC^r producing f_C).
- The transmitted frequency drives multi cavity klyston amplifier, which act as an o/p tube
- This amplifier provides the desired amplification for providing a high power pulse when modulator switches it ON.
- This Tx^r pulse is the o/p via the duplexes.
- Echo pulse from target is received by MT_1 radar antenna. If echo is due to moving target the echo pulse undergoes a dopples frequency shift.

- The received echo pulse then pass through mixes 1 of receiver which heterodynes the received signal of frequency ($f_O + f_C$) with o/p of STALO at f_O & produces a difference frequency f_C at it's o/p
- Two mixes 1 & 2 are identical in all respect except that mixes 2 produces different frequency where as mixes 1 produces a sum frequency.
- This different frequency signal is further amplified by an, If amplifier & given to phase sensitive detector.
- This detector compares IF signal with reference signal from COHO OSC^r.
- Frequency produced by COHO is same as IF frequency & called as coherent frequency.
- The detector provides an o/p depending up phase difference between two signal. Since all the received signal pulses will have a phase different compared with transmitted pulses. Thus phase detector gives o/p for fixed target & moving target. Doppler frequency shift causes this variation in phase difference.
- A change of half cycle in Doppler frequency shift would cause an o/p of opposite polarity in the phase detector. The o/p of phase detector therefore will have an o/p that has different magnitude.

Q.4(a) (ii) Calculate the cut off wavelength, guide wavelength, characteristic wave impedance of a wave guide whose internal diameter is 4 cm for a 12 GHz signal propagated in it in the TE_{111} mode. **[4]**

(A) $\lambda = \frac{v}{f} = \frac{3\times10^{10}}{10\times10^{9}} = 3\text{cm}$

$$\lambda_c = \frac{2\pi r}{(kr)} = \frac{2\pi\times 4/2}{1.84}$$

$$= \frac{4\pi}{1.84} = 6.83\text{cm}$$

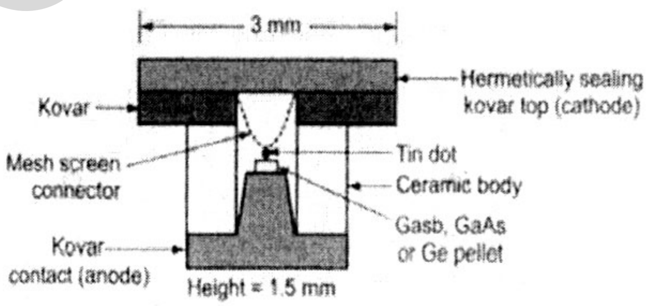
$$\lambda = \frac{\pi}{\sqrt{1-(\lambda/\lambda_0)^2}} = \frac{3}{\sqrt{1-(3/6.83)^2}} = \frac{3}{\sqrt{1-0.193}}$$

$$= \frac{3}{0.898} = 3.24\text{cm}$$

$$Z_e = \frac{3}{\sqrt{1-(\lambda/\lambda_0)^2}} = \frac{120\pi}{0.898} = 420\ \Omega$$

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

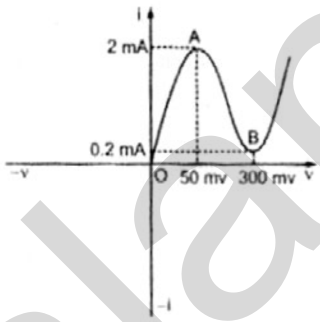
(A)



Operation

- Tunnel diode is a thin junction diode which under low forward bias conditions exhibits negative resistance useful for oscillation or amplification.
- The junction capacitance of the tunnel diode is highly dependent on the bias voltage and temperature.
- A very small tin dot about 50μm in diameter is soldered or alloyed to a heavily doped pellet of n-type Ge, GaSb or GaAs.

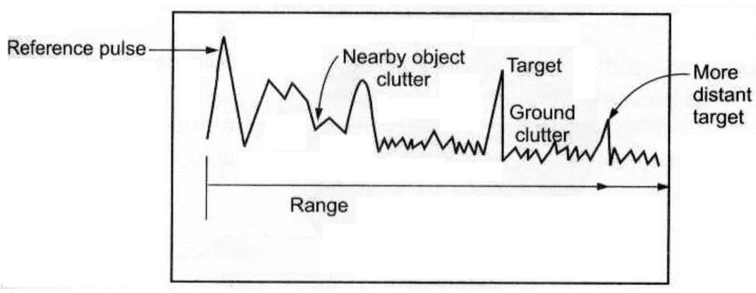
- The pellet is then soldered to a kovar pedestal, used for heat dissipation, which forms the anode contact.
- The cathode contact is also kovar being connected to the tin dot via a mesh screen used to reduce inductance.
- The diode has a ceramic body and hermetically sealing lid on top.
- In tunnel diode semiconductor material are very heavily doped, as much as 1000 times more than in ordinary diodes.
- The heavy doping results 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) (iv) Describe a scope, PPI display method with its diagram. [4]

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



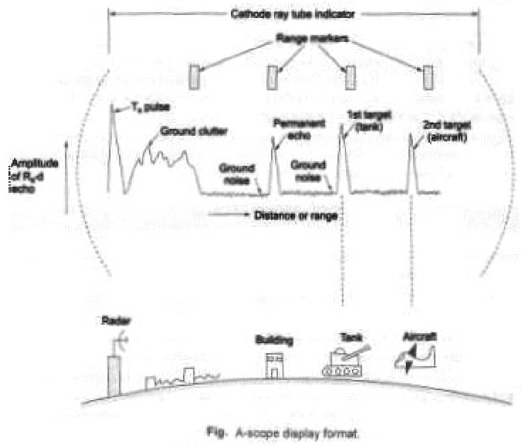
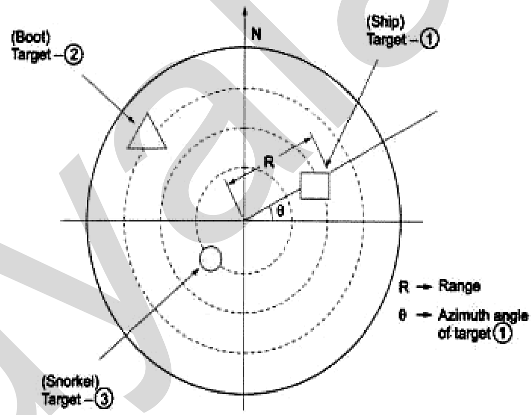


Fig. A-scope display format.

Plan-Position indicator (PPI) :

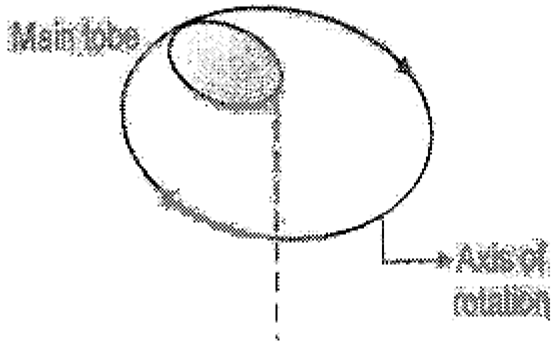
- This is an intensity- modulation type displays system which indicates both range and azimuth angle of the target simultaneously in polar co-ordinate as shown in figure.
- The Demodulated echo signals from the receivers is applied to the grid of the CRT which is biased slightly beyond cut-off.
- Only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



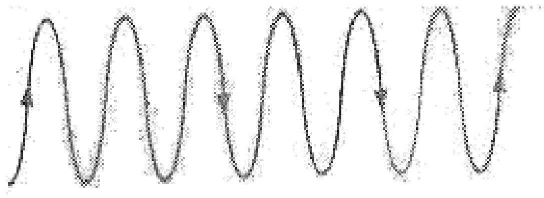
Q.4(b) Attempt any ONE questions. [6]

Q.4(b) (i) Explain horizontal, vertical, helical and spiral antenna scanning in radar system. [4]

(A) **Horizontal scanning :** If scanning is required in only plane is called horizontal scanning. e.g. Ship to ship communication, navigation.

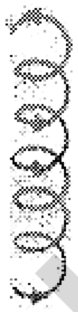


Vertical/Nodding/Elevation: In this scanning, antenna is moved rapidly assuming in slowly in elevation. It covers limited area or complete hemisphere. Thus scanning in both the planes is obtained. Its is used to scan a limited sector.

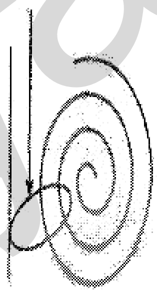


Scanning pattern

Helical : Elevation is slowly raised while it rotates more rapidly in assuming. Covers complete hemisphere and it takes place in both plane e.g. tracking of satellite. This Scanning helps searching over the complete hemisphere. The antenna is returned to the starting point at the completion of the scanning.

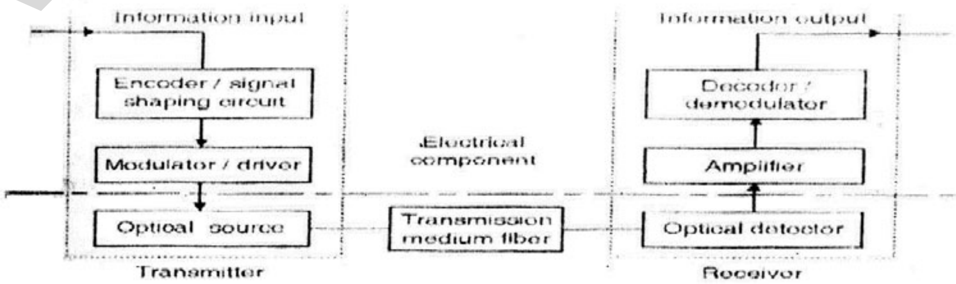


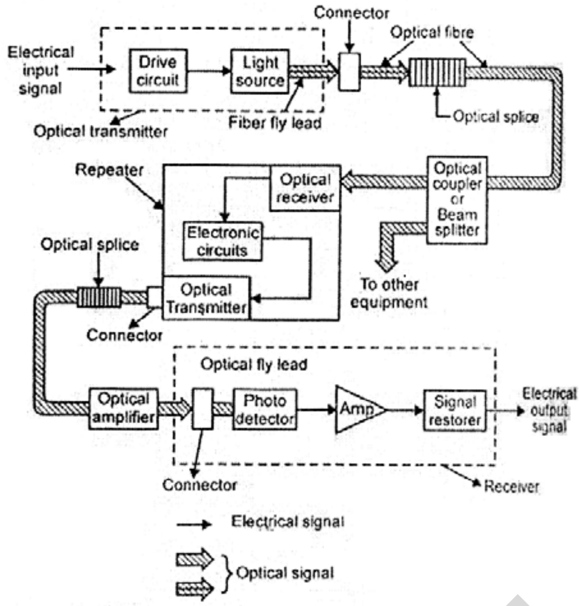
Spiral : It is required to scan limited area. When target is to be detected, scanning take place first with somewhat wide because of width. Whereas tracking is locate at exact position of target which take place with narrow phase shift beam width.



Q.4(b) (ii) Draw the block diagram of fiber optics communication system and illustrate the function of each block. [4]

(A)





Transmitter

- The transmitter first converts the input voltage to current value which is used to drive the light source. Thus it interfaces the input circuit and the light source.
- The light source is normally an infrared LED or LASER device which is driven by the current value from the V to I convertor. It emits light which is proportional to the drive current. Thus light which is proportional to the input voltage value is generated and given as input to fiber.
- A source to fiber interface is used for coupling the light source to the fiber optic cable. The light emitted from the source is inserted into the fiber such that maximum light emitted from it is coupled to the fiber.

Optical Splice

- For creating long haul communication link, it is necessary to join one fiber to other fibers permanently. For this purpose, optical splicing techniques are used to join different fibers.

Optical Coupler/Beam splitter

- Optical couplers are used to couple the light output from the fiber end to the device which can be receiver or regenerator.
- Beam splitters are used to split the light beam which can be given to other equipment.

Regenerator/Repeater

- After an optical signal is launched in to a fiber, it will become progressively attenuated and distorted with increasing distance because of scattering, absorption and dispersion mechanisms in the glass material.
- Therefore repeaters are placed in between to reconstruct the original signal and again retransmit it.
- The signal is processed in electronics domain and hence optical to electrical conversion and electrical to optical conversions are performed in the repeater.

Optical Amplifier

- After an optical signal has travelled a certain distance along a fiber, it becomes greatly weakened due to power loss along the fiber.
- Therefore, when setting up an optical link, engineers formulate a power loss budget and add amplifiers or repeaters when the path loss exceeds the available power margin.
- The periodically placed amplifiers merely give the optical signal a power boost, whereas a repeater attempts to restore the signal to its original shape.

Receiver

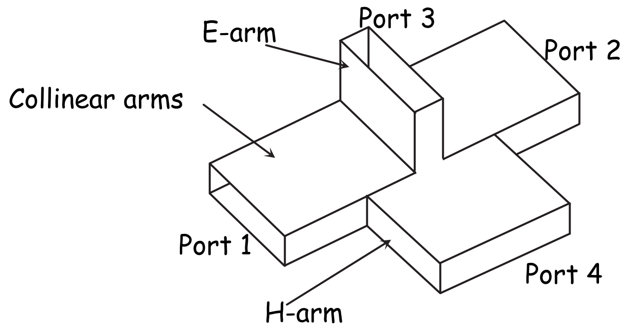
- At the destination of an optical fiber transmission line there is a coupling device (connector) which couples the light signal to the detector.

- Inside the receiver is a photodiode that detects the weakened and distorted optical signal emerging from the end of an optical fiber and converts it to an electrical signal. (Referred to as photo current).
- I to V convertor produce an output voltage proportional to the current generated by the light detector. Thus, we obtain output value which was given to the system as data input.

Q.5 Attempt any FOUR questions. **[16]**

Q.5(a) Explain the function of magic Tee in detail. **[4]**

(A)

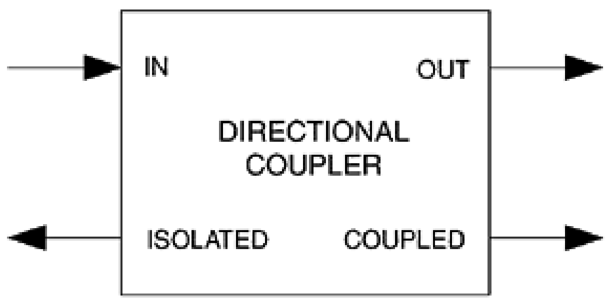


A magic tee is a combination of E plane Tee & H plane tee. Tee & H plane tee. The various properties of magic tee are as follows:

1) If 2 waves of equal amplitude & p same phase are fed into P_1 & P_2 the o/p will zero at P_3 & additive at P_4.
2) If a wave fed into P_4 i.e. H arm it will be equally divided between P_1 & P_2 with a equal amplitude & same phase & will not appear at P_3.
3) If a wave is fed into P_3 it will produce an o/p of equal magnitude & opposite phase at P_1& P_2 & o/p at P_4 is zero.
4) If a wave fed into P_2 & P_2 of equal amplitude & out of phase then o/p at the P_3 will be maximum & at P_4 will be zero.
5) If a wave is fed into one co linear arm i.e. at P_1 or P_2 it will not appear at P_2 or P_1 because E–arm causes phase delay while H–arm cause phase advance.

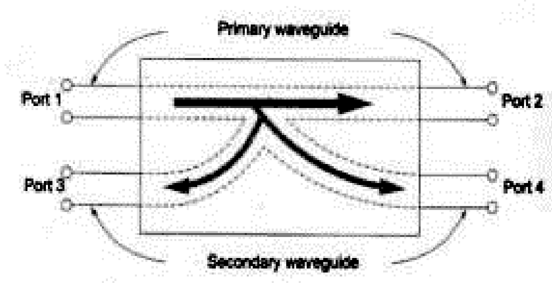
Q.5(b) Describe working of directional coupler with neat diagram. **[4]**

(A)
- Directional couplers are devices that will pass signal across one path while passing a much smaller signal along another path.
- One of the most common uses of the directional coupler is to sample a RF power signal either for controlling transmitter output power level or for measurement.
- An example of the latter use is to connect a digital frequency counter to the low-level port and the transmitter and antenna to the straight-through (high-power) ports.
- The circuit symbol for a directional coupler is shown in Fig. below. Note that there are three outputs and one input.
- The IN OUT path is low-loss and is the principal path between the signal source and the load. The coupled output is a sample of the forward path while the isolated showed very low signal. If the IN and OUT are reversed then the roles of the coupled and isolated ports also reversed.

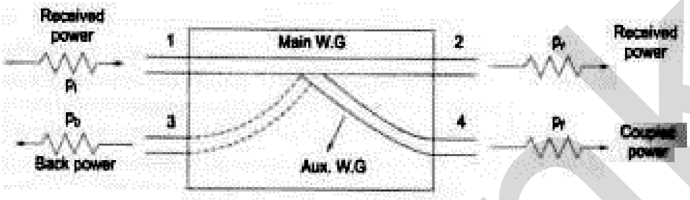


OR

Directional couplers are flanged built in waveguide assemblies which can sample a small amount of microwave power for measurement purposes. They can be designed to measure incident and/or reflected powers, SWR values, provide a signal path to a Rx or perform other desirable operations. In its most common form, the directional coupler is a four port waveguide junction consisting of a primary main waveguide and a secondary auxiliary waveguide as shown below.



(a)



(b)

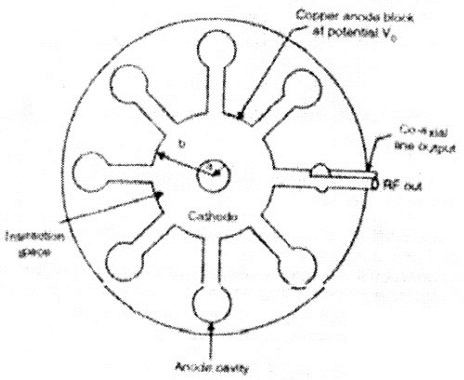
(i) The principle of operation of a two-hole directional coupler is shown in figure above. It consists of two guides; the main and the auxiliary with two tiny holes common between them as shown.
(ii) The two holes are at a distance of $\lambda g4$ where λg is the guide wavelength.
(iii) The two leakages out of holes 1 and 2 both in phase at position of 2nd hole and hence they add up contributing to Pf . But the two leakages are out of phase by 180° at the position of the 1st hole and therefore they cancel each other making $P_b = 0$ (ideally).
(iv) The magnitude of power coming out of the two holes depends on the dimension of the holes.
(v) Although a high degree of directivity can be achieved at a fixed frequency, it is quite difficult over a band of frequencies. The frequency determines the separation of the two holes as a fraction of the wavelength.

Q.5(c) Differentiate between LED and LASER. **[4]**
(A)

Parameter	LED	LASER
Principle of operation	Spontaneous emission	Stimulated emission
Output Beam	Non-coherent	Coherent
Data rate	Low (max. 400Mbps)	High (several Gbps)
Coupling efficiency	Very low	High
Spectral width	20 to 100nm	1 to 5nm
Transmission distance	Smaller	Greater
Compatible with	Multimode SI/GI fiber	Single mode fiber
Circuit complexity	Simple	Complex

Q.5(d) With the aid of neat diagram, illustrate phase focusing effect in the cavity magnetron. **[4]**

(A)

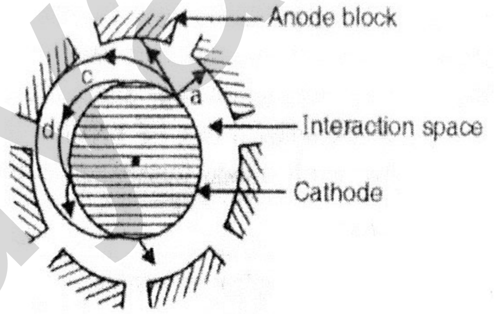


Phase focusing effect

Cavity magnetron having 8 cavities tightly coupled to each other. Generally a N-cavity tightly coupled system will have N-modes f operation. Each operation is characterized by a combination of frequency and phase of oscillation relative to the adjacent cavity. These modes must be self consistent so that the total phase shift around the ring of cavity is $2\pi n$. The correct minimum phase shift of 8-cavity should be 45° ($45 \times 8 = 360°$).

If ϕv is relative phase charge of ac electric field across adjacent cavities then,
$\phi v = 2\pi n/N$ where n = 0, + 2, + (N/2 – 1), + n/2

n – integer number
N – Number of cavities.
If N is an even number, N/2 mode of resonance can exist. If n = N/2, $\phi v = \pi$. This mode of resonance is called the π-mode. If n = 0, ϕv = 0, this is zero mode. Zero mode means there will be no RF electric field between anode and cathode and this mode is not used in magnetron. Now we will discuss about how the electrons behave in the presence of closed electric and magnetic fields.



Assume RF field is absent i.e. static case. Depending on the relative strength of the electric and magnetic field the electrons emitted from the cathode and moves towards anode by traversing through the interaction space. If magnetic field is absent, the electron travels straight from cathode to the anode due to radial electric field force acting on it as shown by trajectory 'a' shown in above figure. If magnetic field strength is increased slightly, it will exert a force bending the path of electron as shown by path 'b' in figure. If the strength of magnetic field is made sufficiently high it prevents the electrons from reaching the anode shown by path 'c' and anode current becomes zero.

Q.5(e) 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]**

(A) (i) Critical angle ($\varnothing c$) = $\sin^{-1}(n_2/n_1)$
$\varnothing c = \sin^{-1}(1.36/1.4)$
$\varnothing c$ = 76.27°

(ii) Numerical aperture (NA) = $\left(n_1^2 - n_2^2\right)^{1/2}$

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

(iii) Acceptance angle (θa) = Sin^{-1} NA

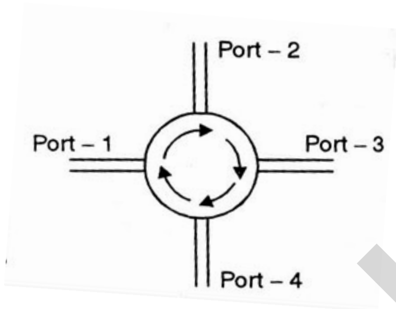
θa = sin^{-1} 0.33

θa = 19.32°

Q.6 Attempt any FOUR questions. **[16]**

Q.6(a) Explain function of : (i) Circulator (ii) Isolator **[4]**

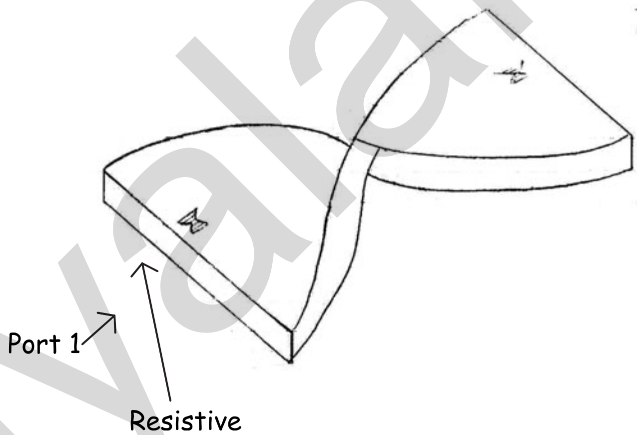
(A) (i) Circulator



Symbol of circulator

Circulator is a four port device. It has a particular property that each terminal is connected to next clockwise terminal, i.e. port 1 is connected port 2 & not to the port 3 & port 4. Circulators are used in parametric amplifiers, tunnel diode amplifier & duplexer in radar.

(ii) Isolator

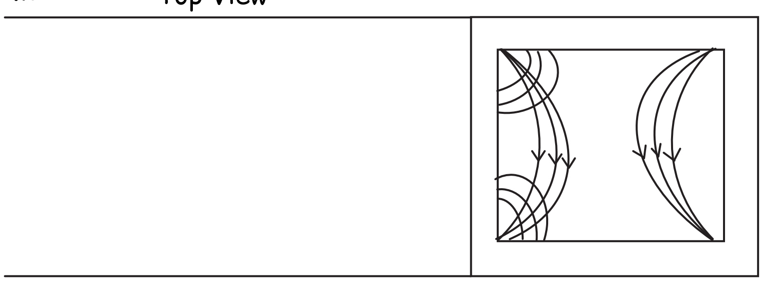


It provides very small attenuation for transmission. Isolator make use of 45° twisted rectangular waveguide. It is a two port device. In microwave generators the output amplitude & frequency tends to fluctuate with changes in load.

Fluctuation occurs due o mismatch of generator output to load. That result reflected wave from load. These reflected waves causes the instability of amplitude & frequency of microwave generator.

If the isolator is inserted between generator & load then the generator is coupled to load with zero attenuation and reflection.

$TE_{1,}$ mode Top View



Circular Waveguide
The basic behavior of wave in circular waveguide is the same as in rectangular guides.

Since circular waveguide have a different geometry and same different cup plication minor modifications are required in all the parameters and definition evolved evolved for rectangular waveguide.

1) The formula for cut off wavelength is different because of different geometry, and it is given by

$$\lambda_0 = \frac{2\pi r}{(kr)}$$

Where r = radius (internal) of waveguide
kr = constant

Q.6(b) State advantage of fiber optic commination. **[4]**

(A) **(1) Large Band Width:** 10^{13} to 10^{16} H_2
(2) Small Size and Weitht: Diameter is in μm
(3) Electrical Isolation: Fiber made from glass & fiber create no arcing, short ircuit electrically hazardous area.
(4) Immunity to interference & cross talk : Fibers are dielectric waveguide. Hence it is free from EMI and RFI. Hence immune to interference and cross talk
(5) Signal Security: Light doesn't radiate significant. Hence proved high degree of signal security.
(6) Low transmission loss: Losses are low upto 0.4 dB & low attenuation losses.
(7) Aexibility: We can provide bent to fiber upto small radii or twisted without damage.
(8) System Reliability : Less repeater are required hence in creasing the reliability and reduction the cost.

Q.6(c) Describe scattering and dispersion losses in optical fibre. **[4]**

(A) **Scattering loss :** Basically, scattering losses are caused by the interaction of light with density fluctuations within a fiber. Density changes are produced when optical fibers are manufactured.

- **Linear Scattering Losses**
  - Linear scattering occurs when optical energy is transferred from the dominant mode of operation to adjacent modes. It is proportional to the input optical power injected into the dominant mode.
  - Linear scattering is divided into two categories: Mie scattering and Rayleigh scattering.

- **Non-Linear Scattering Losses**
  - Scattering loss in a fiber also occurs due to fiber non-linearity's i.e. if the optical power at the output of the fiber does not change proportionately with the power change at the input of the fiber, the optical fiber is said to be operating in the non-linear mode. Non-Linear scattering is divided into two categories: Stimulated Raman Scattering and Stimulated Brillouin Scattering.

Dispersion loss

- Dispersion is a measure of the temporal spreading that occurs when a light pulse propagates through an optical fiber. Dispersion is sometimes referred to as delay distortion in the sense that the propagation time delay causes the pulse to broaden.
- The broadened pulse overlaps with its neighbors eventually becoming indistinguishable at the receiver input. This effect is known as inter-symbol interference (ISI).

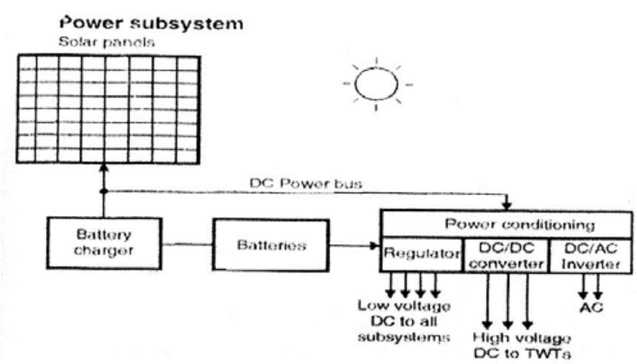
- The signal dispersion alone limits the maximum possible bandwidth or the data rate attainable with a particular optical fiber.
- Three mechanisms are responsible for the pulse broadening in fibers:
- modal (or mode) dispersion, material dispersion and waveguide dispersion. Modal dispersion is referred to as intermodal dispersion. The combination of material and waveguide dispersion is often called as intra-modal or chromatic dispersion because both are dependent on wavelength.

Q.6(d) Distinguish between splicing and connectors of fibre optic cable. **[4]**
(A)

Sr. No.	Parameter	Splicing	Connector
(i)	Connection	Splicing provide permanent connections.	Connector provide temporary connections.
(ii)	Losses	Lower loss and these losses depend on parameters such as input power distribution at the joint, the geometrical and waveguide characteristics of the two fiber ends at the joint and the fiber end face qualities.	Higher loss depends on type of connector.
(iii)	Size	Smaller size	Larger size
(iv)	Immune	Immune to environmental effects.	Conditions such as temperature, dust and moisture should have a small effect on connector loss variations.
(v)	Interfacing	Between fibre and fibre.	Between Light source and fibre and fibre and Photodiodes.
(vi)	Ease of connection	Skilled person is required	Easily handled.
(vii)	Types	Few Types e.g. Fusion splicing, mechanical splicing	Many Types e.g. ST, SC FDDI, MTP, SFF, LC, RJ-45 etc.

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

(A) Solar panels supply the electrical power for the satellite. They drive regulators and distribute d.c. power to all other subsystems. The main component of the satellite is power subsystem.



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

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

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

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