WINTER– 16 EXAMINATION

Model Answer

Subject Code: 17656

Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

A) Attempt any three of the following: 12

i) Define the terms w.r.t. waveguide

ANS: **02 Marks for each**

1. Cutoff frequency:

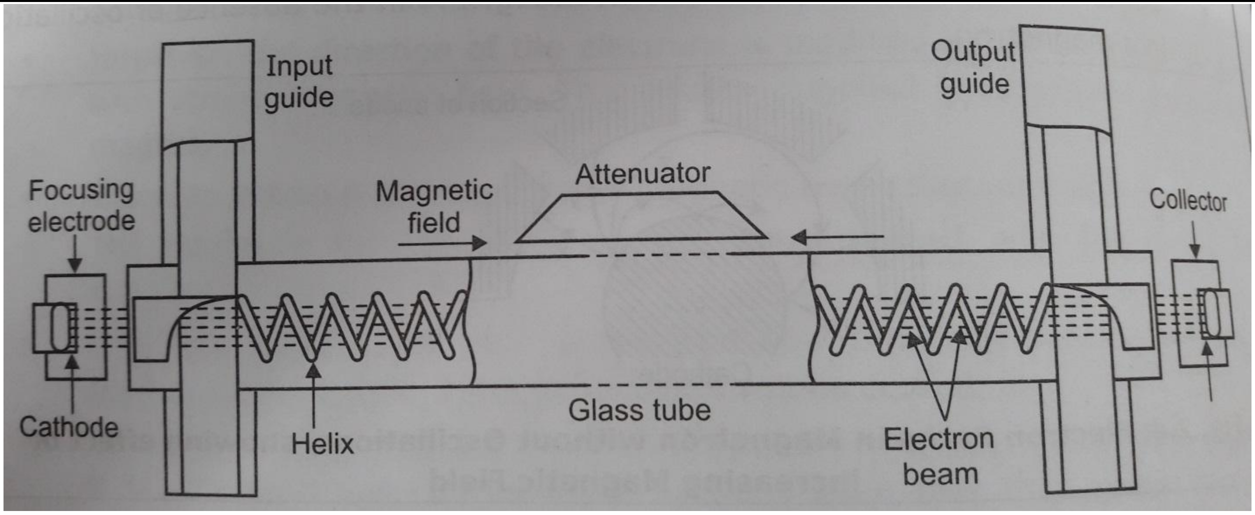
   The frequency of operation is determined by dimension 'a'. This dimension is usually made equal to one half the wavelength at the lowest frequency of operation, this frequency is known as the waveguide cut-off frequency.

2. Group velocity:

   Group velocity is the velocity at which information signal of any kind are propagated.

ii) Draw well labeled constructional diagram of TWT. State any two specifications.

ANS: **02 Marks for diagram and 02 Marks for specification**



Specifications:

1. Frequency operation: 3.1-3.5GHz

2. Output power: 150,000 watts

3. Duty cycle: greater than 15%

4. Gain: greater than 40dB

5. Pulse width: greater than 1 ms

6. Modulation: non-intercepting

iii) Write radar range equation. State factors influencing maximum range of radar.

ANS: 02 Marks for radar range equation and 02 Marks for Factors

$$rmax = \frac{PtAo^2s}{4\pi\lambda^2 Pmin}^{1/4}$$

$$rmax = \frac{PtAp\lambda^2 S}{(4\pi)^3 Pmin}^{\frac{1}{4}}$$

Factors influencing maximum range of radar are :

1. The number and most obvious is that the maximum range is proportional to fourth root of peak transmitted pulse power.

2. The peak power must be increased sixteen fold, all else being constant, if a given maximum range is doubled.

3. Decrease in minimum receivable power will have same effect as raising the transmitting power.

4. Pmin is governed by sensitivity of the receiver , minimum receivable power may be reduced by gain increase of the receiver, so reduction in noise at its input.

5. First equation shows that maximum radar range depends on target area. Also ground interference will limit this range. The presence of conducting ground, has effect of creating interference pattern such that the lowest lobe of antenna is some degrees above the horizontal.

iv) Define following terms w.r.t. satellite-

a) Azimuth angle

b) Elevation angle

ANS: 02 Marks for each

a) 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.

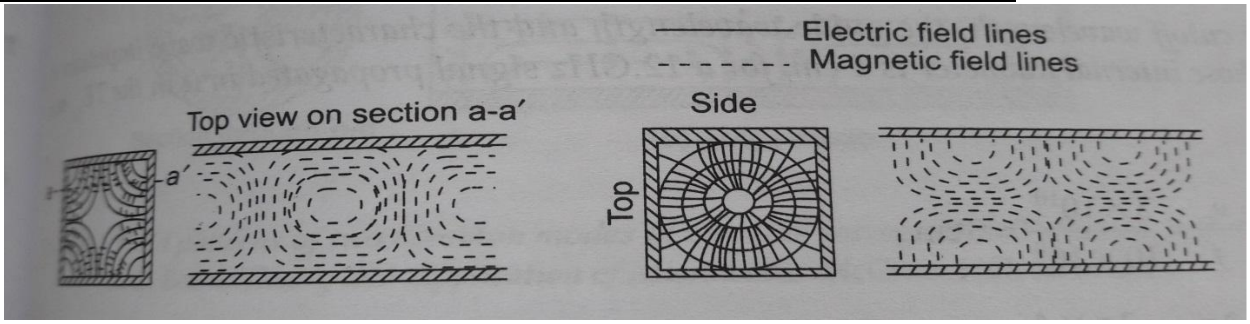
b) Elevation angle: Elevation angle is the vertical angle formed between the direction of travel of electromagnetic wave radiated from an earth station antenna pointing directly towards a satellite and horizontal plane.

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.

B) Attempt any one of the following: 6 marks

i) Justify TE_{110} mode in rectangular waveguide is the dominant mode. Draw the field pattern for TE_{110} and TE_{210} mode.

ANS: 03 Marks for justification and 03 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.

ii) With suitable sketch and waveform explain the working of IMPATT diode.

ANS: 02 Marks for diagram and 04 Marks for working

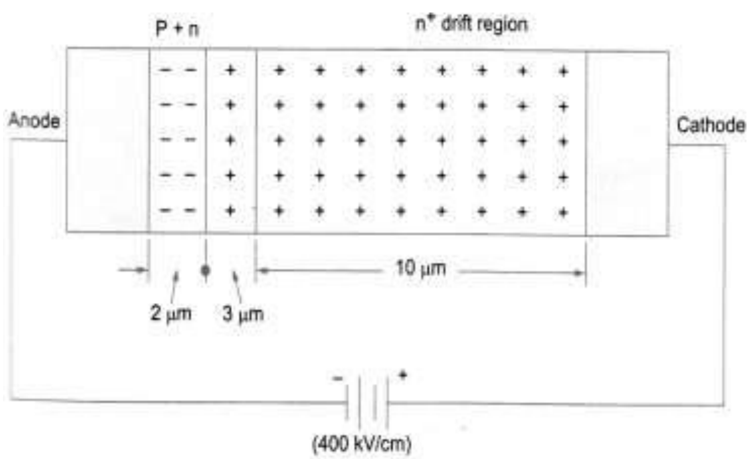


Fig. MPATT diode schematic.

Working:

- Any device which exhibits negative resistance for dc will also exhibits it for ac i.e., If an ac voltage is applied current will rise when voltage falls at an arc rate.
- Hence negative resistance can also be defined as that property of a device which causes the current through it to be 180^0 out of phase with voltage across it.

- Thus is the kind of negative resistance exhibited by IMPATT diode i.e., If we show voltage and current have a 180 ^{0} phase difference, then negative resistance in IMPATT diode is proved.
- A combination of delay involved in generating avalanche current multiplication together with delay due to transit time through a different space provides the necessary 180^0 phase difference between applied voltage and the resulting current in an IMPATT diode.

2. Attempt any four of the following: 16

a) A rectangular waveguide measures 3x 4.5cm internally and has a 9GHz signal propagated in it. Calculate the cut off wave length, the guide wavelength, phase velocity and characteristic wave impedance for TE$_{110}$ mode.

ANS: 02 Marks for formulae and 02 Marks for proper answer

SOLUTION

Calculating the free-space wavelength gives

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

(*a*) The cutoff wavelength will be

$$\lambda_0 = \frac{2a}{m} = \frac{2 \times 4.5}{1} = 9 \text{ cm}$$

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

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

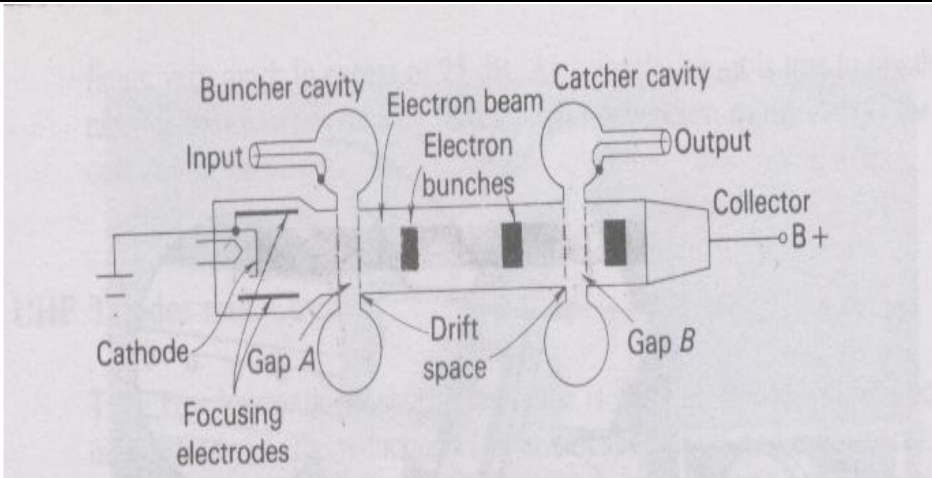
$$v_p = \frac{v_c}{\rho} = \frac{3 \times 10^8}{0.93} = 3.23 \times 10^8 \text{ m/s}$$

The characteristic wave impedance is

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

b) Why do practical Klystron amplifiers generally have more than two cavities? How can broad band operation be achieved in multicavity Klystrons?

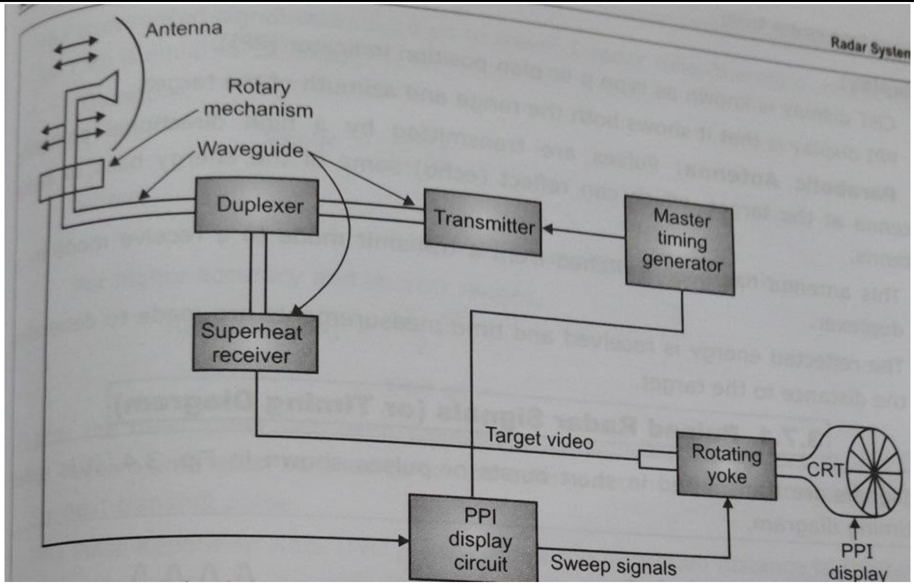
ANS: 02 Marks for each



- 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.

c) Write the operation of pulsed radar to detect the object.

ANS: 02 Marks for block diagram and 02 Marks for explanation



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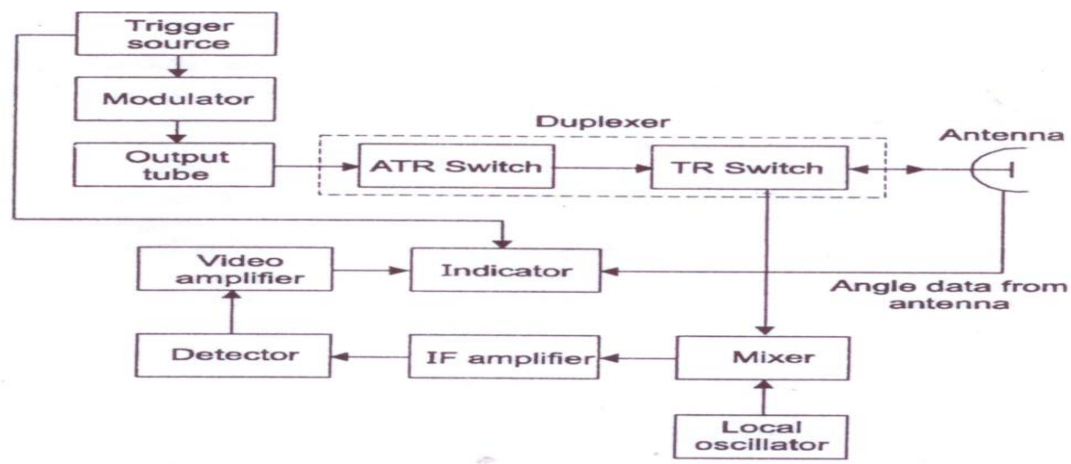


Pulsed Radar Block Diagram

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 indicator.
  - PPI display is that it shows both range and azimuth of the target.

d) What is uplink and downlink frequency? Give reason for difference in uplink and downlink frequency.

ANS: 02 Marks for definition and 02 Marks for reason

Uplink frequency:

The communication between earth station transmitter towards satellite is known as uplink frequency.

Uplink of satellite is the frequency at which the earth station is transmitting the signal and satellite receiving it.

Uplink frequency range = 5.9 GHz to 6.4GHz

Downlink frequency:

The communication between satellite towards earth station receiver is known as downlink frequency.

Downlink fdrequency of satellite is the frequency at which the satellite is transmitting the signal and earth station receiving it.

Downlink frequency range = 3.7 GHz to 4.2 GHz

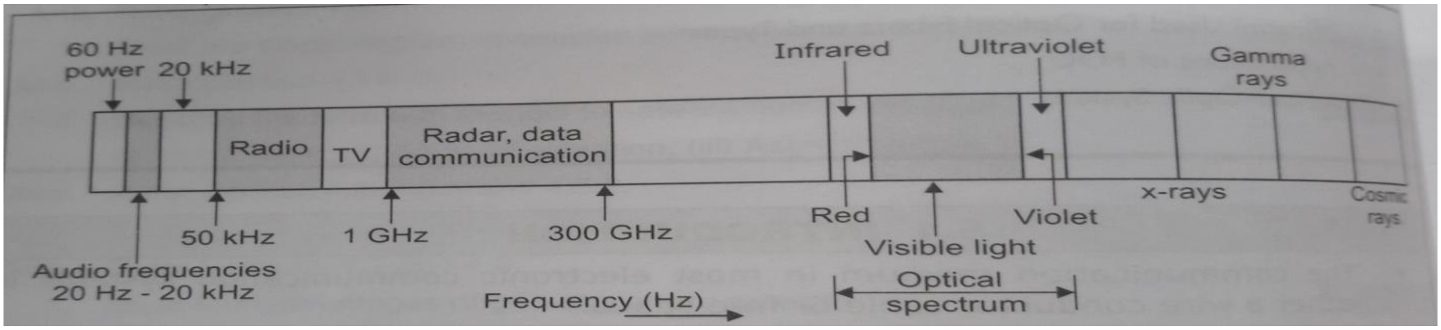
Reasons: 1. Same antenna is used for transmission & reception.

2. The uplink and downlink bands are separated in frequency to prevent oscillations within the satellite amplifier while simultaneously transmission and reception.

3. Moreover low frequency band is used on the downlink to exploit the lower atmospheric losses thereby minimizing satellite power amplifier requirements.

e) Draw the frequency for optical communication with band name and its range.

ANS: 04 Marks for diagram and labeling



f) Compare SMSI and MMGI fibers based on

i) Mode

ii) Refractive index profile

iii) Data rate

iv) Application

ANS: 01 Mark for each point

S. No	Parameter	SMSI	MMGI
1	Mode	Single	Multi
2	Refractive index profile	Uniform	Non-uniform
3	Data rate	Slow	High
4	Application	Subscriber local network communication	Local network and WAN

3. Attempt any four of the following: 16 marks

a) State any three advantages and one disadvantage of circular waveguide.

ANS: 03 Marks for advantages and 01 mark for disadvantage

Advantages:

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.

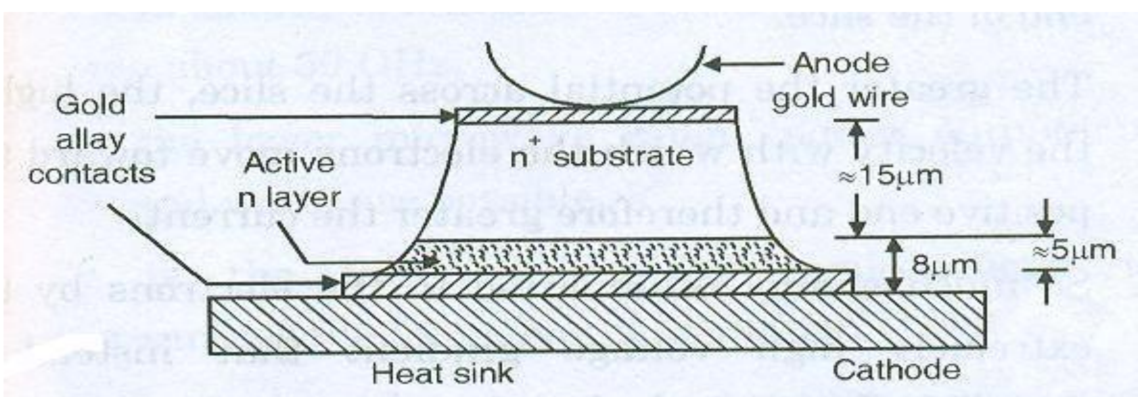
Disadvantage:

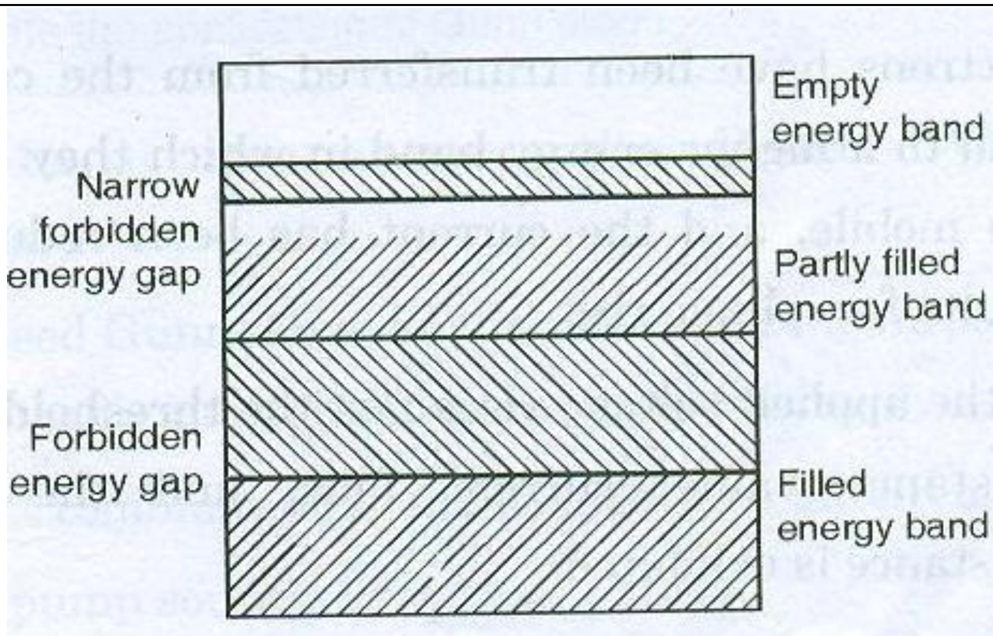
1.Physical size is the primary lower frequency limitation.

2. It is difficult to install

b) With neat diagram, illustrate the working of the Gunn diode.

ANS: 02 Marks for Diagram and 02 Marks for Working





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 the rest of the electrons in the sample. The EF inside the dip[ole 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.

c) With the aid of a sketch, explain the PPI radar indicator.

ANS: 02 Marks for Diagram and 02 Marks for Explanation

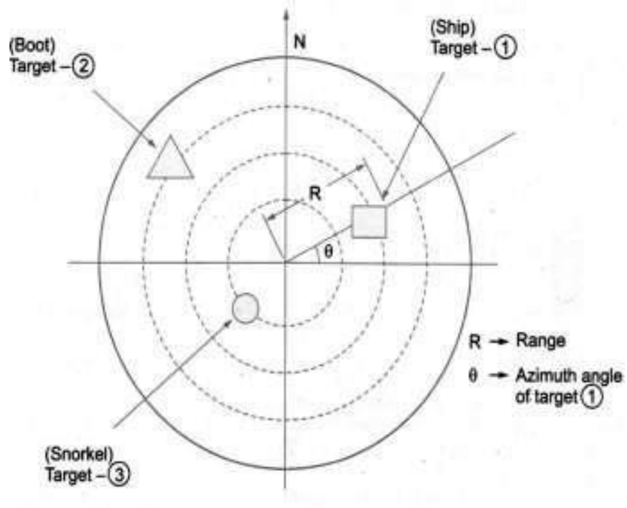


Fig. PPI display

- **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 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 dose not flicker.

d) Compare non synchronous and synchronous satellite based on

i) Orbit
ii) Visibility
iii) Altitude
iv) Footprint

Ans: 01 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

e) State any six advantages and two disadvantages of fiber optic cable.

ANS: (6 points of Advantages 3M, 2points of disadvantages 1M)

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:

1. Interfacing Costs:

To be practical and useful, they must be connected to standard electronic facilities, which often require expensive interfaces.

2. 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.

3. 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.

4. Optical fiber cables are more susceptible to losses introduced by bending the cable:

Bending the cable causes irregularities in the cable dimensions, resulting in a loss of signal power.

5. 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.

4. A) Attempt any three of the following: 12

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

ANS:

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

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

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

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

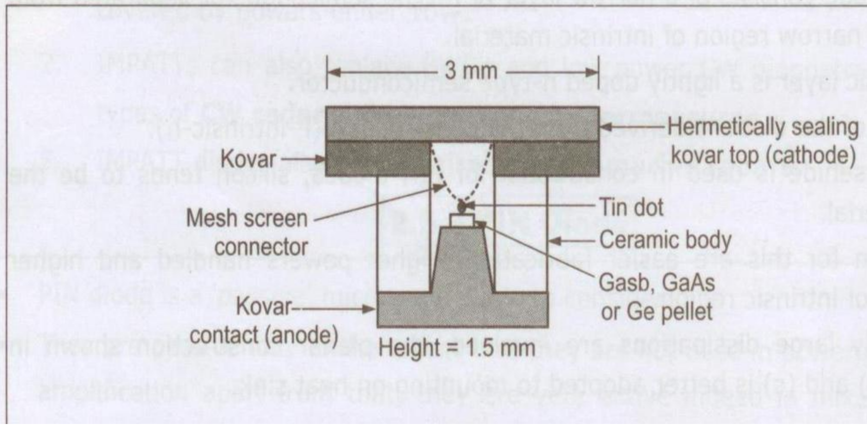
$$= \frac{3}{0.898} = 3.34\text{cm}$$

$$Z_0 = \frac{\mathfrak{Z}}{\sqrt{1-(\lambda/\lambda_0)^2}} = \frac{120\pi}{0.898} = 420\,\Omega$$

ii) Sketch the construction of tunnel diode and write its operation.

ANS: 02 Marks for Diagram and 02 Marks for Operation

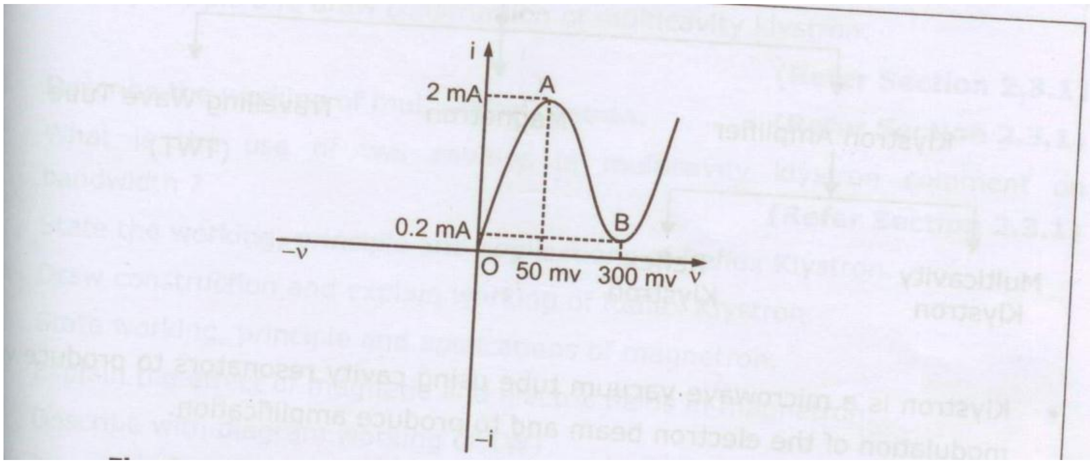
Construction:



- **Operation:**

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



iii)What is Doppler effect. How Doppler effect is used to calculate the relative velocity.

ANS: 02 Marks for Doppler effect and 02 Marks for effective use

The frequency shift that occurs when there is relative motion between transmitting station and remote object is known Doppler effect**.**

The frequency shift that occurs, when there is a relative motion between the transmitting station and a remote object is known as Doppler effect.

By measuring the amount of frequency, difference between the transmitted and the reflected signal, it is possible to determine the relative speed between the RADAR unit and the observed object

$V = 1.1\,f \times \lambda$

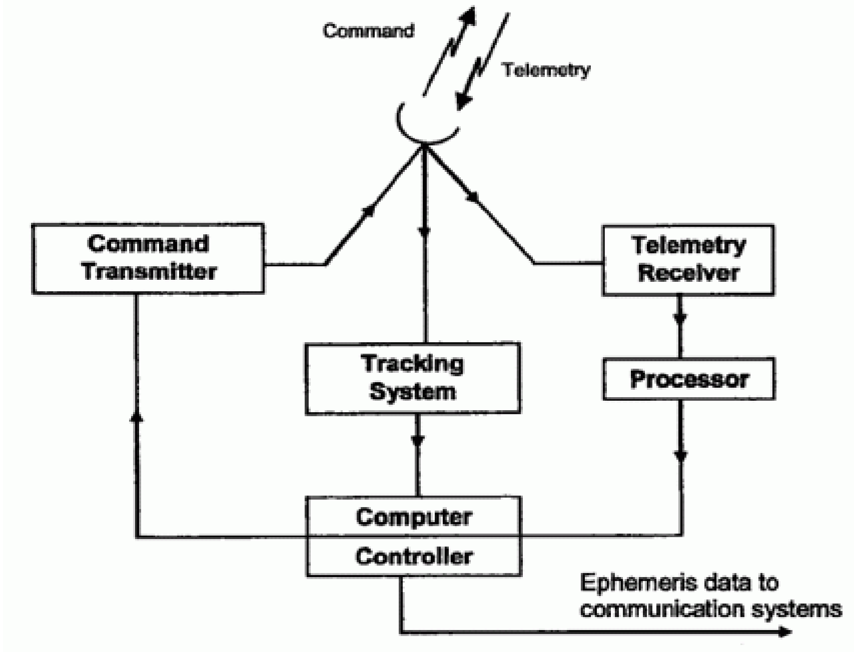
Where v = relative speed between the two objects (m/s)

F = frequency difference between the transmitted and reflected signals (Hz)

Λ = wavelength of transmitted signal (m)

iv) Illustrate how telemetry tracking and command system used in satellite communication.

ANS: 01 Mark for diagram and 1½ Marks for each uses



Telemetry, 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 transmit the monitored data to the
- satellite control center via a separate Telemetry link.
- To support the determination of orbital parameters.
- To provide a source to earth station for tracking.
- To receive commands from the control center for performing various functions of the satellite.

Typical functions include:

- To correct the position and attitude of the satellite.
- To control the antenna pointing and communication system configuration to suit current traffic
- requirements. To operate switches on the spacecraft.

TELEMETRY:

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

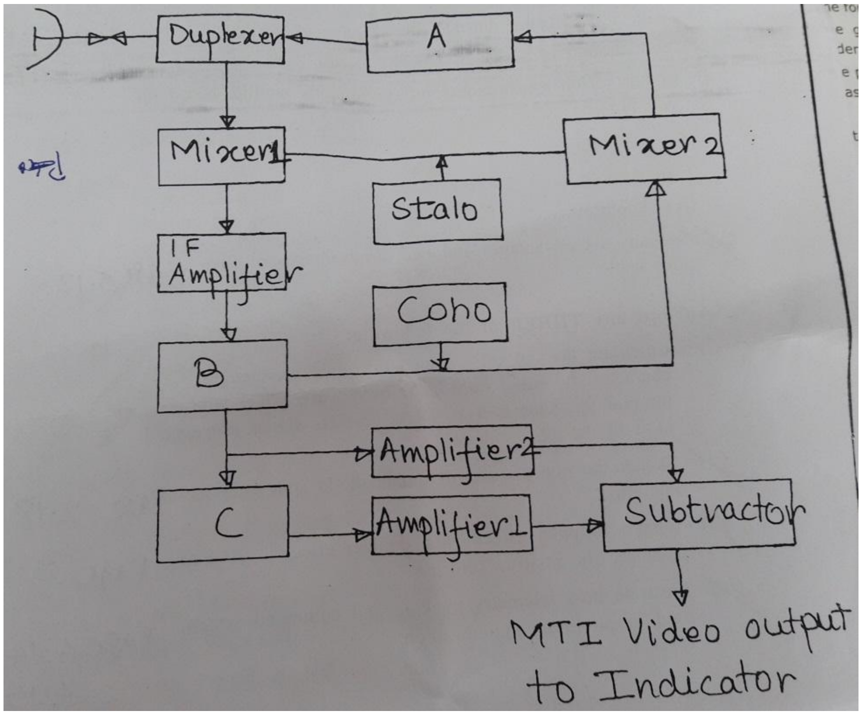
TRACKING:

- By using velocity and acceleration sensors, on spacecraft the orbital position of satellite can be

- detect from earth station.
- For accurate and precise result number of earth stations can be used.

B) Attempt any one of the following: 6

i) Identify the given diagram, label the block A,B and C and illustrate why those blocks are needed.



ANS: 02 Marks for identifying the blocks and 02 Marks for justification

Block A: Klystron Amplifier

Block B: Phase detector

Block C: Delay line

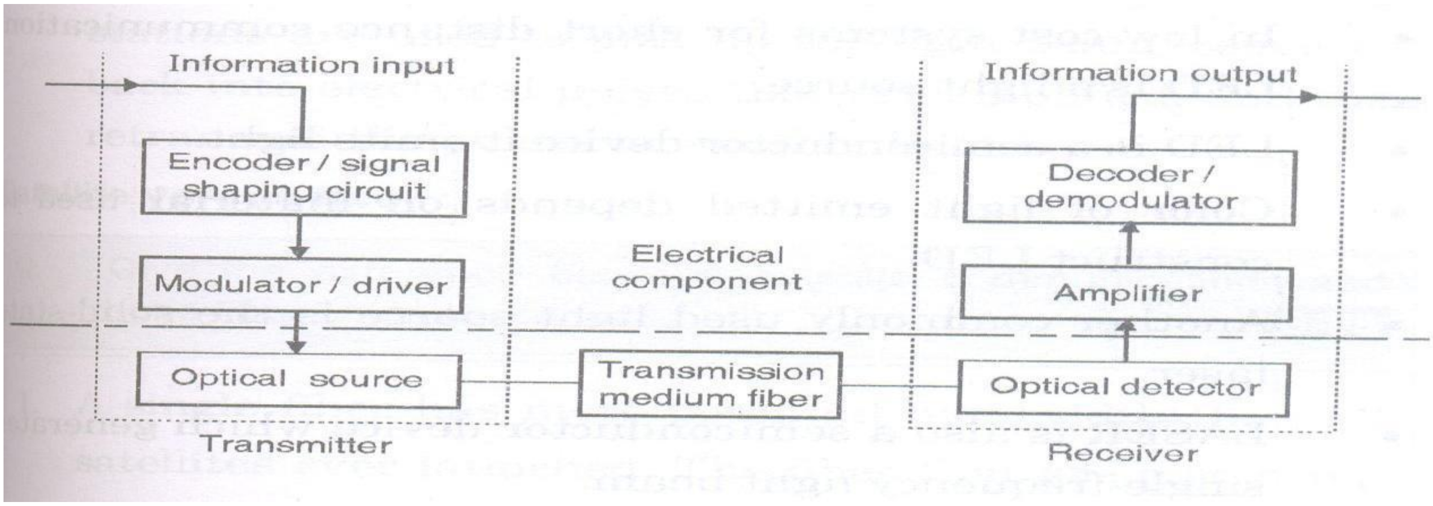
Klystron amplifier: It amplifies higher frequencies.

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.

ii) Draw the block diagram of fiber optics communication system and illustrate the function of each block.

ANS: 02 Marks for diagram and 02 Marks for explanation



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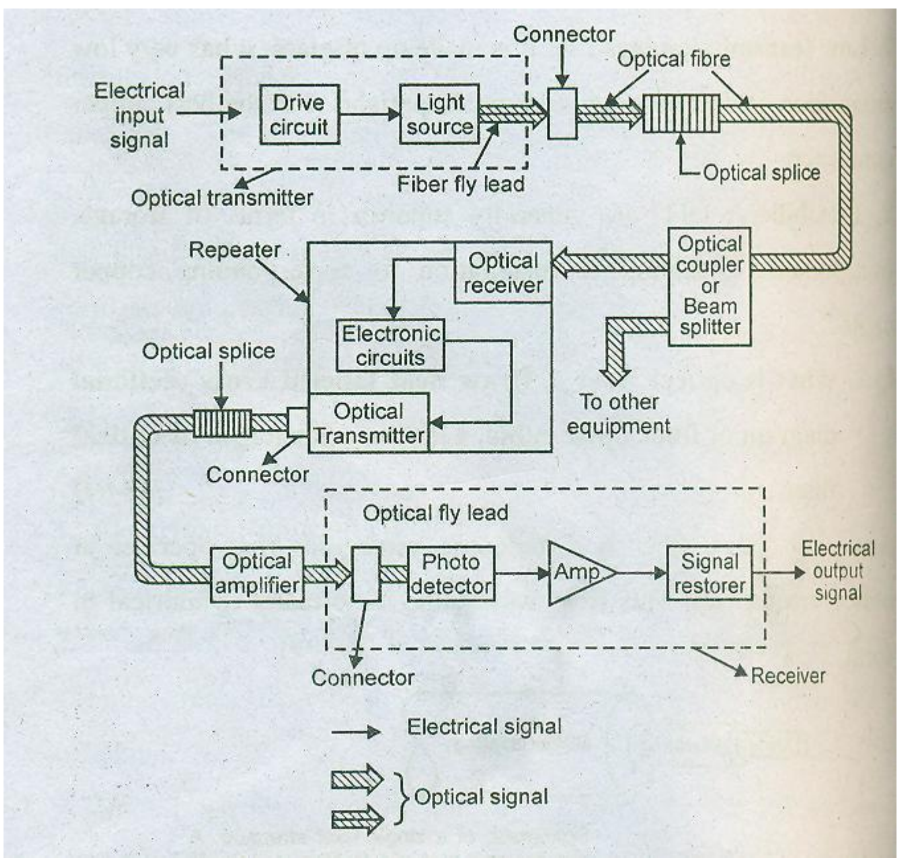


Transmitter:

1. 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.

2. 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.

3. 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:

1. 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:

1. Optical couplers are used to couple the light output from the fiber end to the device which can be receiver or regenerator.

2. Beam splitters are used to split the light beam which can be given to other equipment.

Regenerator/ Repeater:

1. 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.

2. Therefore repeaters are placed in between to reconstruct the original signal and again retransmit it.

3. 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:

1. After an optical signal has travelled a certain distance along a fiber, it becomes greatly weakened due to power loss along the fiber.

2. 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.

3. 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:

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

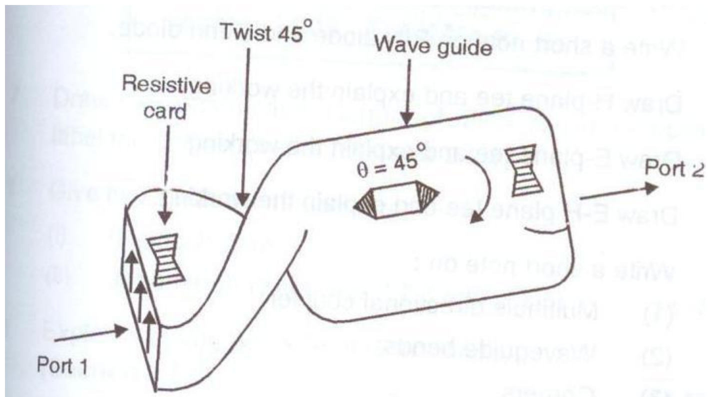
2. Inside the receiver is a photodiode that detects the weakened and distorted optical signal emerging from the end of an optical fiber and converts it to an electrical signal. (Referred to as photo current).

3. 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 of the following: 16

a) Draw the constructional diagram of Isolator and illustrate its operation.

Ans: 2M- diag, 2M- explanation



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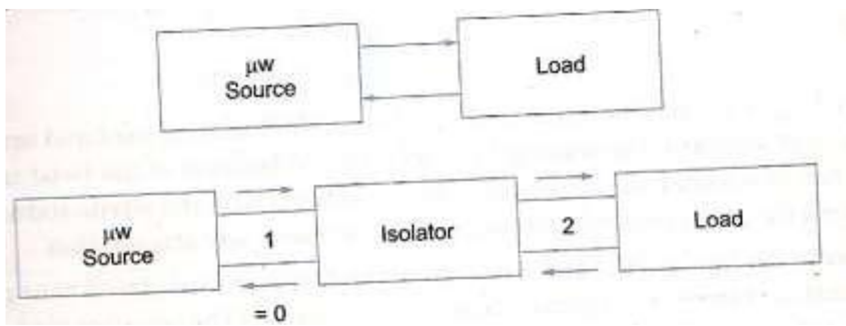
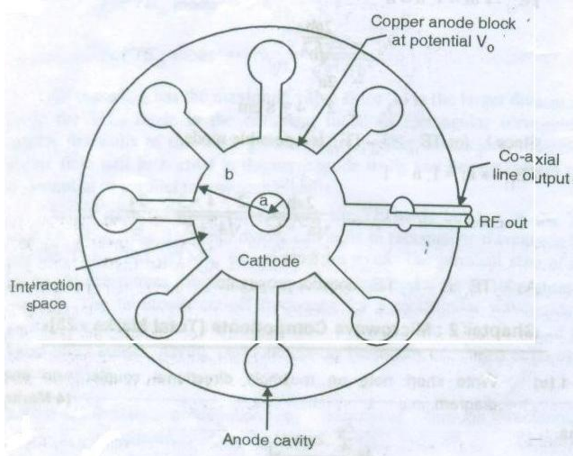


Working:

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 tends 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 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.

b) With the aid of neat diagram, illustrate phase focusing effect in the cavity magnetron.

Ans:2M-diag(any neat labelled diag),2M-explanation



Phase focussing 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 shiftaround the ring of cavity is 2πn. The correct minimum phase shift of 8-cavity should be 45^o ($45 \times 8 = 360^o$).

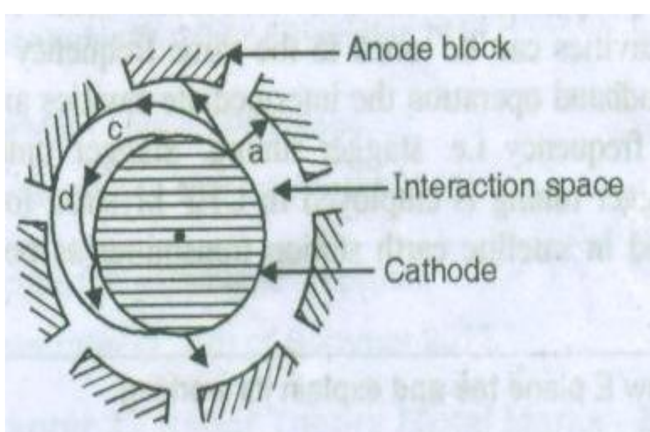
If ϕv is relative phase charge of ac electric field across adjacent cavities then,

$\phi v = 2\pi n / N$ where n = 0, + 1, + 2, + (N/2 – 1), + n/2

n – integer number

N – Number of cavities.

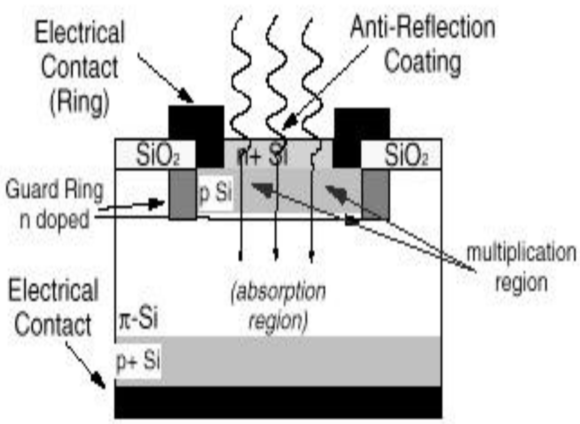
If N is an even number, N/2 mode of resonance can exist. If n = N/2, ϕv = π . This mode of resonance is called the π-mode. If n = 0, ϕv = 0, this is zero mode. Zero mode means there will be no RF electric field between anode and cathode and this mode is not used in magnetron. Now we will discuss about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

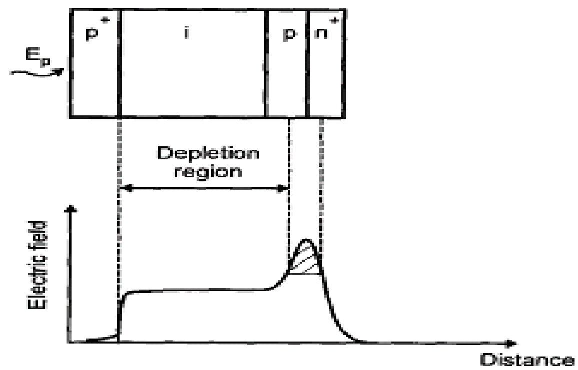


Assume RF field is absent i.e. static case. Depending on the relative strength of the electric and magnetic field the electrons emitted from the cathode and moves towards anode by traversing through the interaction space. If magnetic field is absent, the electron travels straight from cathode to the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

c) How amplification takes place in Avalanche photodiode(APD) used as optical detectors?

Ans: 2M- diag, 2M- explanation





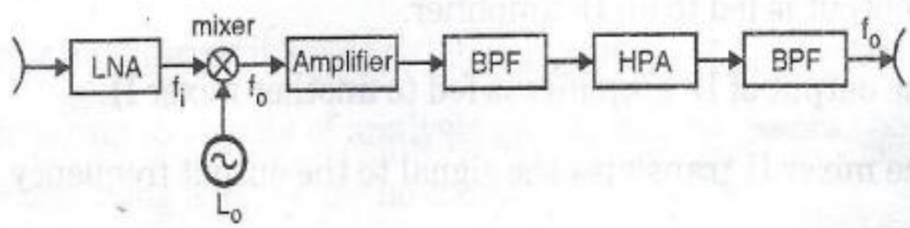
Working Principle:

The RAPD is operated in the fully depleted mode. Photons enter the device through the p+ region and are mostly absorbed by the high resistivity intrinsic p type layer where electron hole pairs are created. The relatively weak electric field in this region forces or separates the carriers causing the electrons and holes to drift into the high electric field region. The electrons are drifted towards the p-n+ layer. Because of the high field intensity, electrons are imparted with high kinetic energy. The kinetic energy of electrons is greater than bandgap energy of the valence electrons, so the collision can free a bound electron. The free electron and hole so created acquire enough kinetic energy to cause further ionization. It results in avalanche with the number of carriers growing exponentially as the process continues.

d) Draw and explain the block diagram of transponder/communication channel subsystem.

Ans: 2M- diag, 2M- explanation

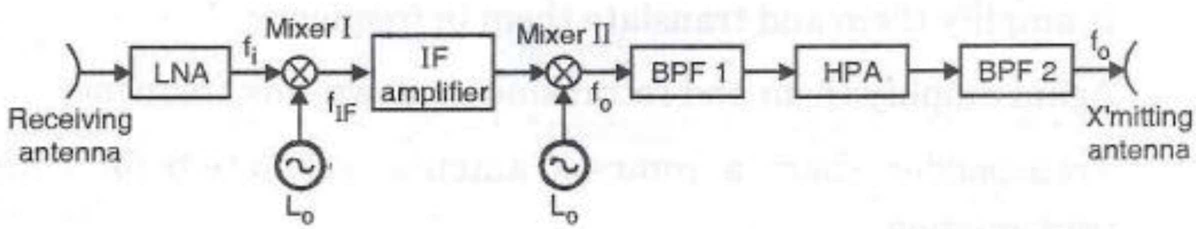
(a) Single - conversion transponder :



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

OR

Double - Conversion transponder :



First uplink signal is received by the receiving antenna. LNA amplified the received signal. Amplified signal first fed to first mixer (1).The mixer 1 translates the received signal frequency into intermediate frequency (typically 70 and 150 MHz). IF output is fed to an IF amplifier. The output of IF amplifier is fed to another mixer 2.The mixer 2 translates the signal to the output frequency.BPF1 filters the output signal and eliminates the unwanted output. HPA increases the output signal level. Again output signal is passed through BPF2 to filter out the harmonics etc. At last, transmitting antenna sends the signal over the down link. This transponder provides greater flexibility in filtering and amplification.

e) Calculate critical angle of incidence between two material with different refractive indices n1= 1.4 and n2= 1.36.Also calculate numerical aperture and acceptance cone angle.

Ans: 2M- each (marks should be given for correct formula and steps)

a) Critical angle (Øc) = $\sin^{-1}(n_2/n_1)$

Øc = $\sin^{-1}$ (1.36/1.4)

Øc =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

θa = $\sin^{-1}$0.33

θa = 19.32°

f) When the optical power launched into an 8Km length of fiber is 120µW, the mean optical power at the fiber output is 3 µW. Determine –

i. The overall signal attenuation or loss, in decibels through the fiber assuming there is no connector or splicer.

ii. The signal attenuation per kilometre for the fibers.

Ans: 2M- each (marks should be given for correct formula and steps)

1. Overall signal attenuation or loss in decibels through the fiber assuming there are no connectors or splices is given by,

Signal attenuation (α_{db} L) = $10\log_{10}$Pi/Po

= $10\log_{10} (120\times10^{-6}/3\times10^{-6})$

= $10\log_{10} 40$

= 16.0dB

2. The signal attenuation per Km for the fibers is given by,

α_{db} L = 16.0 dB

As L = 8 Km

Therefore,

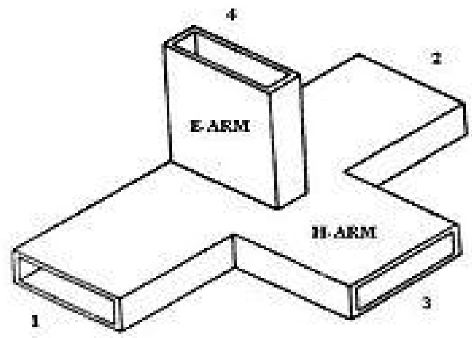
α_{db} = 16.0/8

α_{db}= 2.0dB/Km.

Q.6 attempt any FOUR of the following: 16

a) Draw the neat sketch of hybrid junction, illustrate its properties.

Ans: 2M-diag,2M-explanation

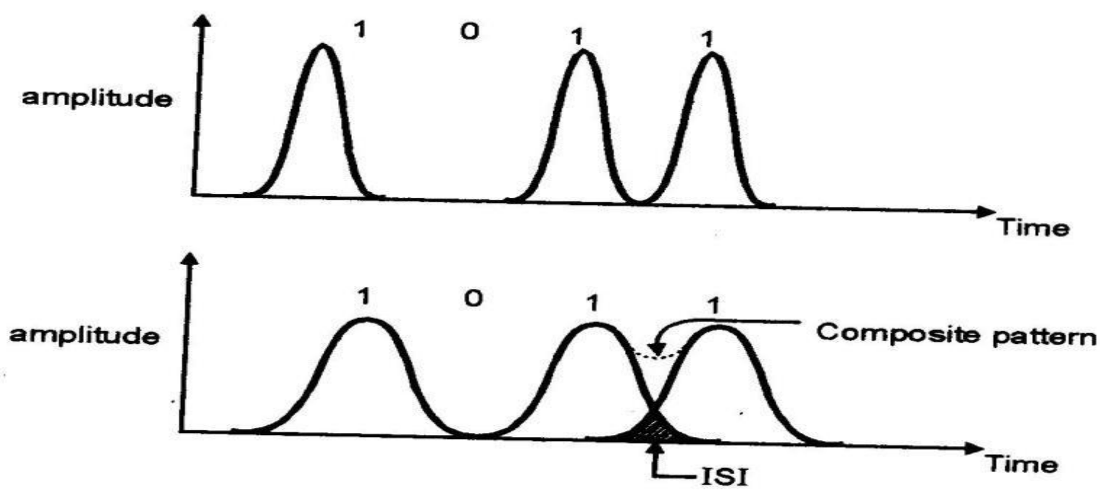


The magic tee is a combination of E and H plane tees. Arm 3 forms an H-plane tee with arms 1 and 2. Arm 4 forms an E-plane tee with arms 1 and 2. Arms 1 and 2 are sometimes called the side or collinear arms. Port 3 is called the H-plane port, and is also called the Σ port, sum port or the P-port (for "parallel"). Port 4 is the E-plane port, and is also called the Δ port, difference port, or S-port (for "series"). A signal injected into the H-plane port will be divided equally between ports 1 and 2, and will be in phase. A signal injected into the E-plane port will also be divided equally between ports 1 and 2, but will be 180 degrees out of phase. If signals are fed in through ports 1 and 2, they are added at the H-plane port and subtracted at the E-plane port.

b) Illustrate modal dispersion loss. Where it occurs and how it can be controlled.

Ans: 2M-diag,2M-explanation

Dispersion: Dispersion causes broadening of transmitted light pulse as they travel alongthe channel. Dispersion of transmitted light signal causes distortion for both digital andanalog transmission along fiber.



INTRAMODAL:

Intramodal dispersion is also called chromatic dispersion. It occurs in all types of optical fibers.It results from the finite spectral line width of the optical source.We know that optical sources do not just emit just a single frequency but band of frequencies. There may be propagation delay differences between the different spectral components of the transmitted signals. Delay in propagation causes broadening of each transmitted mode and so called intramodal dispersion.This delay may be caused by the dispersive properties of waveguide and the fiber structure.

Delay due to waveguide material is called material dispersion. Delay due to fiber structure is called waveguide dispersion.

The types are 1. Material dispersion 2. Waveguide dispersion

INTERMODAL:

It results from the propagation delay difference between modes within a multimode fiber travel along the channel with different group velocities.

The pulse width at output is dependent upon the transmission times of slowest and fastest modes.Multimode step index fibers exhibit a large amount of intermodal dispersion.In multimode graded index fibers is far less than that obtained in multimode step index fibres.In multimode step index, the fastest and slowest modes propagating in it may be represented by axial ray and the extreme meridional ray respectively.

The delay difference between these two rays when travelling in the fiber core allows estimation of the pulse broadening i.e intermodal dispersion.

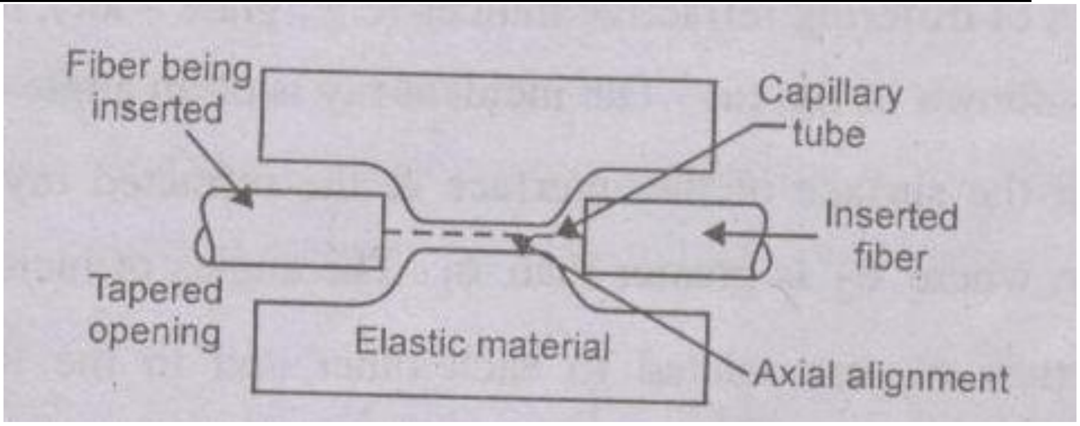
It may be reduced by propagation mechanisms within practical fibers.The differential attenuation of modes reduces intermodal dispersion.

Mode coupling or mixing reduces the intermodal dispersion.The coupling between guided modes transfers optical power from the slower to fastest modes and vice versa.Strongly coupled, optical power transmits at an average speed i.e mean of various propagating modes.Intermodal dispersion in multimode fiber is minimized by using graded index fiber.In above figure meridoinal rays follow sinusoidal trajectories of different path lengths which results from the index grading.The group velocity is inversely proportional to the refractive index.The longer sinusoidal paths are compensated for by higher speed in the lower index medium away from axis.Rays travel in the high index region at core axis at the slowest speed.Various ray paths represent the different modes propagating in the fiber.The graded profile reduces in the mode transmit time

c) Illustrate elastic tube splicing with neat diagram.

Ans: 2M-diag, 2M-explaination

Fibre splice is a permanent joint formed between two individual optical fibers in the field or factory. Used to establish long haul optical fiber links.



Schematic of an Elastic Tube Splice

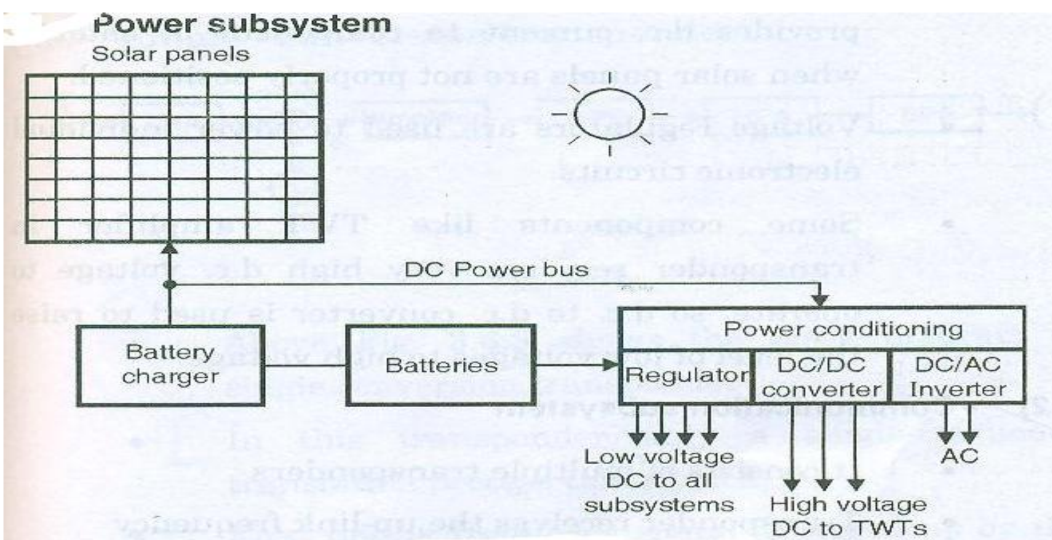
ELASTIC TUBE SPLICE:

The elastic tube splice shown cross sectionally in the figure below is a unique device that automatically performs lateral, longitudinal and angular alignment. It splices multimode fibers with losses in the same range as commercial fusion splices, but much less equipment and skill are needed. The splice mechanism is basically a tube made of elastic material. The central hole diameter is slightly smaller than that of the fiber to be spliced and is tapered on each end for easy fiber insertion. When the fiber is inserted, it expands the hole diameter so that the elastic material exerts a symmetrical force on the fiber. This symmetry feature allows an accurate and automatic alignment of the axes of the two joined fibers. A wide range of diameters can be inserted into the elastic tube. Thus the fibers to be spliced do not have to be equal in diameter, since each fiber moves into position independently relative to the tube axis.

d) How power is generated in satellite. Describe how it is distributed to other subsystem of satellite.

Ans: 2M-diag, 2M - explanation

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 providesd.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 raise the level of low voltages to high voltage.

e) Distinguish between LED and LASER diode on the basis of –

i. Operating principle

ii. Switching time

iii. Spectral width

iv. Life

Ans: 1M-each point

Sr No	PARAMETERS	LED	LASER
1	Operating principle	Spontaneous Emission	Stimulated Emission
2	Switching time	Switching time is slow	Switching time is fast.
3	Spectral width	Broad output spectrum.	Narrow output spectrum.
4	Life	Life time is more.	Life time is less.