QUESTION BANK

Name of the Department : **Electronics and Communication Engineering**

Subject Code & Name : **EC8701 & Antennas and Microwave Engineering**

Year & Semester : **IV & VII**

UNIT I -INTRODUCTION MICROWAVE SYSTEMS AND ANTENNAS

PART-A

1. Define antenna

An antenna is defined as a metallic device for radiating or receiving electromagnetic waves or radio waves. It is a transitional structure between free space wave and guided waves.

2. Give important design parameters for antennas.

Important design parameters of an antenna are

- ❖ Desired Frequency.
- ❖ Gain.
- ❖ Bandwidth.
- ❖ Impedance.
- ❖ Polarization.

3. What are properties of antenna?

The properties of antenna are,

- Antenna has identical impedance in spite of being used as transmitter or receiver.
- It exhibits directional characteristics and pattern.
- It exhibits effective height in spite of being used as either transmitter or receiver.

4. Define isotropic radiator.

Anisotropic radiator is a fictitious or hypothetical radiator which radiates electromagnetic energy in all directions uniformly. It is also called isotropic source or omnidirectional radiator or unipole.

5. How does an antenna radiate?

When an alternating voltage is applied to an antenna, it pushes and pulls the charge backward and forward in the 'wire'. This movement of charge creates a changing electric and magnetic field which can create an electromagnetic wave capable of radiating energy from the antenna.

6. What are Antenna parameters?

The antenna parameters are, Gain, Directivity, Effective aperture, Radiation Resistance, Band width, Beam width, Input Impedance. Matching – Baluns, Polarization mismatch and Antenna noise temperature.

7. What is meant by radiation pattern?

Radiation pattern of an antenna is a graphical representation of the radiation properties of the antenna as a function of space coordinates.

8. Define radian and steradian.(or)
Differentiate radian and steradian.

- The measure of a plane angle is radian. One *radian* is defined as the plane angle with its vertex at the center of a circle of radius *r*. It is subtended by an arc whose length is *r*.
- The measure of a solid angle is a steradian. One *steradian* is defined as the solid angle with its vertex at the center of a sphere of radius *r* .It is subtended by a spherical surface area equal to that of a square with each side of length *r*.

9. What is beam solid angle?

Beam solid angle (is the angle through which all the power is radiated to the free space. It is a three dimensional angle formed by the major lobe. It is measured by a unit called *steradian***.** (“S_r ”)

10. Define gain.

The ratio of maximum radiation intensity in a given direction to the maximum radiation intensity from reference antenna produced in the same direction with same input power.

$$\text{Gain (G)} = \frac{\text{Maximum radiation intensity from test antenna}}{\text{Maximum radiation intensity from the reference antenna with same input power}}$$

11. Define absolute gain.

Absolute gain of an antenna is defined as the ration of the intensity in a given direction to the radiation intensity that could be obtained if the power accepted by the antenna were radiated isotropically.

12. What is the Significance of gain of an antenna?

- ❖ Gain of an antenna is a relative measure of antenna's ability to direct radio frequency energy in a particular direction.
- ❖ Higher the gain and efficiency is more.
- ❖ By means of gain, the total power radiated by an antenna can be obtained which is otherwise difficult to find.

13. Write about power gain and directive gain.

- ❖ Directive gain and power gain of an antenna represent the ability of the antenna to focus its beam in a particular direction.
- ❖ Directive gain is a parameter dependent only on the shape of radiation pattern while power gain takes ohmic and other losses.
- ❖ The power gain of an Antenna is an actual or realized quantity which is less than directive gain due to ohmic losses in the antenna.

14. Define Directivity.

- Directivity is a measure of the concentration of radiated power in a particular direction.
- The ratio of the maximum power density to the average power radiated is called maximum directive gain (or) directivity of an antenna.

15. Define effective aperture (A_e).

Area over which the power is extracted from the incident wave and delivered to the load is called effective aperture.

16. What is the significance of aperture of an antenna?

- The Gain of an antenna is directly proportional to its aperture.
- Larger the aperture, higher the gain and narrower the Beam width

17. Define Radiation Resistance.

Radiation Resistance is defined as the fictitious resistance which when inserted in series with the antenna will consume the same amount of power as it is actually radiated. The antenna appears to the transmission line as a resistive component and this is known as the radiation resistance.

18. What is the significance of Radiation resistance of an antenna?

- Radiation resistance accounts for the power radiated by the antenna into space.
- It is equal to the radiated power in watts divided by the square of the effective current in amperes at the point of power supply ($R_r = P / I^2$).
- Thus the radiation resistance of an antenna is a **good indicator** of the strength of the electromagnetic field radiated by a transmitting antenna (received by a receiving antenna,) since its value is directly proportional to the power radiated.

19. Define Half power Beam width.

In pattern maximum, the angle between the two directions in which the radiation intensity is one half of the maximum value is called half Power Beam width.

20. Define Beam efficiency.

The ratio of the main beam area to the total beam area is called beam efficiency.

Beam efficiency $S_M = W_M / W_A$.

The total beam area (W_A) consists of the main beam area (W_M) plus the minor lobe area (W_m) .

Thus $W_A = W_M + W_m$.

21. Define Antenna Temperature.(or)Define Brightness temperature of an antenna.

Antenna temperature is defined as the temperature of far field region (space and near surroundings) which are coupled to the antenna through radiation resistance.

22. Define induction field. (or)What do you mean by induction field?

The induction field is the field which predominates at distance close to the current element, r<<wavelength. It represents the energy stored in the magnetic field surrounding the current element or conductor. This field is also known as near field.

23. Define Radiation field. (Or) What do you mean by radiation field

The radiation field will be produced at a larger distance from the current element, r>> wavelength. It is also called as distant field or far field.

24. What is the field zone?

The field around an antenna is called field zone. It may be divided into two principal regions.

- Near field (Induction field) zone called as Fresnel zone
- Far field (Radiation field) zone called as Fraunhofer zone

25. Define antenna efficiency.

The efficiency of an antenna is defined as the ratio of power radiated to the total input power supplied to the antenna.

Antenna efficiency = Power radiated / Total input power.

PART-B

1. Explain the radiation concept of an antenna with a diagram.
2. What are antenna field zones? Explain the types with the necessary equation.
3. Discuss the fields and power radiated by an antenna.
4. Explain the different types of antenna parameters with their characteristics.
5. Explain about Antenna gain and efficiency.
6. Explain the terms (i) Aperture efficiency (ii) Effective area.
7. Explain the concept of antenna noise temperature and derive the expression for G/T.
8. Derive the expression for the Friis transmission formula.
9. Explain the concept of link budget and link margin with the necessary equation.
10. Explain noise characterization of a microwave receiver and derive the expression for S/N ratio.
11. Discuss the concept of impedance matching.

UNIT-II RADIATION MECHANISMS AND DESIGN ASPECTS

PART-A

1. Define Hertzian dipole or oscillating dipole.

A Hertzian dipole is a short linear antenna which when radiating is assumed to carry constant current along its length. It is also defined as an infinitesimal current element Idl which does not exist in real life.

2. What is a short dipole?

A short dipole is the one in which the field is oscillating because of the oscillating voltage and current. It is named so because the length of the dipole is short and the current is almost constant throughout the entire length of the dipole.

3. How radiations are created from a short dipole.

The dipole has two equal charges of opposite sign oscillating up and down in harmonic motion. The charges will move towards each other and electric field lines were created. When the charges meet the midpoint, the field lines cut each other, and new fields are created. This process is spontaneous, and hence more fields are created around the antenna.

4. Why a short dipole is also called an elemental dipole?

A short dipole that does have a uniform current will be called as an elemental dipole.
This dipole will be shorter than one-tenth of a wavelength.

5. What is infinitesimal dipole?

When the length of the short dipole is vanishingly small, then that dipole is called an infinitesimal dipole. If dl be the infinitesimal small length and I will be current, then Idl is called the current element.

6. Define half-wave dipole.

Half wavelength dipole or simply half-wave dipole or $\lambda/2$ antenna is one of the simplest antennas and is frequently employed as an element of a more complex directional system. Ex: Antenna arrays. It is used above 2 MHz.

7. What are the salient features of a folded dipole antenna?

- It is a single antenna consisting of 2 or 3 elements.
- The input impedance of a folded dipole is 4 times that of a straight dipole.

8. List the advantages and applications of a folded dipole antenna.

Advantages:

- It has a high impedance.
- It has greater bandwidth
- It has wideband in frequency
- Construction is simple and cheap.

Applications:

- Used in wideband operation such as television
- Used as a feed element in Yagi uda antennas

9. What is a loop antenna?

A loop antenna is a radiating coil of any convenient cross-section of one or more turns carrying radiofrequency current. It may assume any shape (e.g. rectangular, square, triangular, and hexagonal).

10. What are electrically small loop antennas?

Electrically small loop antennas are one in which the overall length of the loop is less than one-tenth of the wavelength. Electrically small loop antennas hare small radiation resistances that are usually smaller than the loop resistances They are very poor radiators and seldom employed for transmission in radio communication.

11. List the uses of a loop antenna.

Various uses of the loop antenna are:

- It is used as a receiving antenna in portable radio and pagers.
- It is used as probes for field measurements and as directional antennas for radio wave navigation.
- It is used to estimate the direction of radio wave propagation.

12. What is the difference between the slot antenna and its complementary dipole antenna?

- Polarization is different. i.e., The electric fields associated with the slot antenna is identical with the magnetic field of the complementary dipole antenna.
- The electric field will be vertically polarized for the slot and horizontally polarised for the dipole.
- The radiation from the backside of the conducting plane of the slot antenna has the opposite polarity from that of the complementary antenna.

13. What is a horn antenna?

It is a flared-out waveguide. It is a transition (or) matching section from the guided mode inside the waveguide to the unguided (free space) mode outside the waveguide.

14. What are the different types of horn antennas?

1. Sectoral horn antenna
2. Pyramidal horn antenna
3. Conical horn antenna
4. Biconical horn antenna

15. What are the various feeds used in reflector antennas?

1. Dipole antenna
2. Horn antenna
3. End fire feed
4. Cassegrain feed

16. What is the reflector type of antenna?

The antenna which is used to eliminate the backward radiations from an antenna and to modify the radiation pattern in the desired manner to the desired direction is called a reflector type of antenna.

17. What are the most widely used types of reflectors?

(i) Plane sheet reflector

(ii) Comer reflector

(iii) Parabolic reflector

(iv) Hyperbolic reflector

(v) Elliptical reflector

(vi) Circular reflector

18. What is a parabolic reflector?

It is a parabola shaped reflective device used to collect or distribute energy entering the reflector at an angle.

19. What is a frequency-independent antenna?

If the structure of the antenna is defined in terms of angles only, then it comes under the category of a frequency-independent antenna.

e.g., Log periodic antenna, spiral antenna.

20. Define pitch angle concerning the helical antenna. What happens when $\alpha=0^0$ and α $=90^0$

It is the angle between a line tangent to the helix wire and the plane normal to the helix axis.

Pitch angle, $\alpha = \tan^{-1}\left(\frac{S}{\pi D}\right)$

where, S- helix turn spacing D-diameter of helix

If $\alpha = 0^0$, then helix becomes a loop

If $\alpha = 90^0$, then helix becomes a linear conductor

21. What are the limitations of the normal mode operation of a helical antenna?

Bandwidth is very narrow.

The efficiency of radiation (η) is low.

22. Define the log periodic antenna.

It is a broadband, multi-element narrow beam, a frequency-independent antenna that has impedance and radiation characteristics that are regularly repetitive as a logarithmic function of frequency.

23. List out the applications of a helical antenna.

A helical antenna is used in

- VHF transmission such as satellite communication.
- Space telemetry link with ballistic missiles, satellites, etc.

24. Define Rumsey's principle for frequency-independent antennas.

Rumsey's principle: It states that the impedance and pattern properties of an antenna will be frequency independent if the antenna shape is specified only in terms of angles.

25. State Huygens's principle.

Huygens's principle states that "each point on a primary wave front can be considered to be a new source of a secondary spherical wave and that a secondary wave front can be constructed as the envelope of these secondary spherical waves".

PART-B

1. Derive the radiation resistance of an oscillating electric dipole.
2. Derive magnetic field components of dipole having dimension $l << \lambda/2$.
3. Deduce the field quantities and draw the radiation pattern of a half-wave dipole.

4. Obtain the expression for power radiated by half-wave dipole and find its radiation resistance.
5. What is a loop antenna? Explain in detail.
6. What is a reflector antenna? Explain the principle of operation and application of parabolic reflector and various types of feed used?
7. Compare flat reflector and corner reflector antennas. Explain how a paraboloidal antenna gives a highly directional pattern.
8. Explain in detail about different types of horn antenna with relevant diagrams and equations.
9. Discuss the various feed techniques for Rectangular patch antenna with neat diagrams.
10. Explain the radiation mechanism of the slot antenna with a diagram. Explain different feed methods of slot antenna?
11. Explain in detail about Microstrip patch antennas.
12. Explain the construction and characteristics features of frequency independent antennas.
13. With a neat diagram explain the helical antenna and briefly describe its operation in axial mode. How does it differ from other antennas?
14. With necessary illustrations explain the radiation characteristics of the multi- element log periodic antenna and mention its possible applications.
15. Discuss in detail about Spiral antenna.

UNIT-III ANTENNA ARRAYS AND APPLICATIONS

PART-A

1. What is an antenna array?

An antenna array is a radiating system of similar antennas spaced properly to get greater directivity in a desired direction.

2. What is the need of antenna array?

In the point to point communication, it is desired to have most of the energy radiated in one particular direction. This means it is desired to have greater directivity in a desired direction particularly which is not possible with single dipole antenna. Hence to increase field strength in the desired direction antenna array is used which consists of a group of similar antennas properly spaced and oriented in desired direction.

3. List the uses of antenna arrays?

The uses of antenna arrays are

- To achieve high gain in one particular direction.
- To provide diversity reception.
- To cancel interference from a particular set of direction.
- To steer the array so that it is most sensitive in one particular direction.
- To maximize the signal to Interference plus noise ratio (SINR).

4. What are the advantages of antenna arrays?

The advantages of antenna arrays are

- ✓ Greater directivity in a desired direction.
- ✓ Diversity reception.
- ✓ Interference is cancelled from a particular set of direction.

Maximum signal to Interference plus noise ratio(SINR)

5. List the types of Arrays by positioning.

The types of arrays are,

1. Broadside Array
2. End-fire Array:
3. Phased Array:
4. Parasitic Array:

6. What is broadside Array?

An array with equally spaced elements which are fed with a current of equal amplitude and phase is known as broadside array. In this array, maximum radiation occurs at right angles to the axis of antenna array.

7. What is end-fire Array?

An array with equally spaced elements which are fed with a current of equal amplitude and opposite phase is called as end-fire array. In this array, the maximum radiation occurs along the axis of antenna array.

8. What is phased Array?

An array of many elements with variable phase elements providing control of beam direction and pattern shape including side lobes is called phased array.

9. What is linear array?

The antenna array is said to be linear if the elements of the antenna arrays are equally spaced along a straight line.

10. What is meant by uniform linear array?

The linear antenna array is said to be uniform linear array if all the elements are fed with current of equal magnitude with progressive uniform phase-shift along the line.

11. What are the conditions to obtain end fire array pattern?

End fire array is defined as an arrangement in which the principle direction of radiation coincides with the array axis.

For end fire array, $\alpha = -\beta d$

Where, α = Phase difference of the current fed between the sources of the end fire array. d = Distance between the elements

12. Calculate the directivity of a given linear end fire array of 10 elements with a separation of λ/4 between the elements.

Given data:

No. of isotropic radiators, n = 10.

Distance between 2 elements (Antenna) = $\lambda/4$

Solution: Directivity of end fire array $4(nd/\lambda)$

$$= \frac{4(10x\,\lambda/4)}{\lambda} = 10\,degrees$$

13. Define beam width of major lobe.

Beam width of major lobe is defined as

1. The angle between first nulls (or)
2. Double the angle between first null and major lobe maxima directions.

14. What is pattern multiplication?

The total field pattern of an array of non-isotopic but similar sources is the multiplication of the individual source patterns and the pattern of array of isotopic point sources each located at the phase centre of individual source and has the relative amplitude and phase, whereas the total phase pattern is the addition of the phase pattern of the individual sources and that of the array of isotopic point sources.

15. Mention the features of radiation pattern multiplication principle.

The features of radiation pattern multiplication principle are

1. Useful tool in designing antenna.

It approximates the pattern of a complicated array without making lengthy computations

16. State the disadvantage of pattern multiplication.

Thedisadvantages of pattern multiplication are,

1. It is the technique which is usefu only for arrays containing identical elements.
2. It is nit useful for very larger arrays.

17. Write the advantages of pattern multiplication.

The advantages of pattern multiplication are,

- Pattern multiplication provides a speedy method for sketching the radiation patterns of complicated arrays just by inspection. .
- It is a useful tool in design of antenna arrays.
- This method provides the exact pattern of the resultant.
- The secondary lobes are determined from the number of nulls in the resultant pattern.

18. Distinguish between active and passive arrays.

- In active array, all the elements are driven by a physical feed. Example: phased array
- In passive array, one element (driven element) is fed and other elements are coupled to it electromagnetically. Example: parasitic array

19. State the features of Binomial array.

Features of Binomial array

- In Binomial array, radiating sources at the centre radiates more strongly than the sources at the edges.

- Minor lobes can be eliminated (But at the cost of directivity).
- HPBW is more than that of uniform array for the same array length.

20. List the Advantages and disadvantages of Binomial array.

Advantage of Binomial array:

There are no side lobes in the resultant pattern. Disadvantages of Binomial array**:**

1. Small directivity
2. Undesirable large beam width of main lobe.
3. For the design of a large array, larger amplitude ratio of sources is required.

21. What is Hansen – Wood yard array? (or)

What is the condition on phase for the end fire array with increased directivity?

Hansen – Wood yard array is an end fire array with increased directivity. It has been shown by Hansen and Wood yard that a maximum directivity is achieved by increasing the phase change of the current between the sources so that =- (d + n) where = phase difference of the current in adjacent point sources.

22. What is tapering of arrays? Why we go for non-uniform amplitude distribution of current?

In uniform linear array as the array length is increased to increase the directivity, the secondary lobes also occurs. It is tapering of arrays. To reduce the side lobe level, we go for non-uniform distribution of current.

Example: Binomial array. Tapering is done from center to end.

Example: Binomial Array: Tapering follows the coefficient of binomial series.

23. What are the disadvantages of Binomial array?

The disadvantages of binomial array are

- Increased beam width, hence the directivity decreases.
- Maintaining the large ratio of current amplitude in large arrays is difficult.

24. What is role of array element in smart antenna?

The antenna elements play an important role in shaping and scanning the radiation pattern and constraining the adaptive algorithm used by the digital signal processor. Smart antenna uses an array of printed elements. There are a number of printed element geometries, like patches or microstrips.

25.What are the parameters that determine the overall pattern of an antenna array?

Design parameters of Arrays are

- ✓ General array shape (linear, circular, planar)

- ✓ Element spacing.
- ✓ Element excitation amplitude.
- ✓ Element excitation phase.
- ✓ Patterns of array elements

PART-B

1) Derive the expression for an array factor of n - element linear array.

2) Explain in detail about BSA and EFA.

3) Compare BSA and EFA.

4) Derive the expression for pattern maxima, minima, and half-power beam width for broadside array.

5) Derive the expression for pattern maxima, minima, and half-power beam width for an end-fire array.

6) Explain in detail the principle of pattern multiplication.

7) Explain in detail the concept of phased arrays. Describe the working principle of an adaptive array.

9) Explain in detail about binomial array.

10) In a linear array of 4 isotropic elements spaced λ/2 apart and with equal currents fed in phase, plot the radiation pattern.

11) In a linear array of 4 isotropic elements spaced λ/2 apart and with equal currents fed out of phase, plot the radiation pattern.

12) Explain in detail the concept of smart antennas with an example.

UNIT IV – PASSIVE AND ACTIVE MICROWAVE DEVICES

PART-A

1. Define Microwave.

Microwaves are electro waves whose frequencies range from $1GH_z$ to 300GHz. Signals at these frequencies have wavelength that range from 30cm to 1mm.

2. What are the various bands available in Microwave? Give their frequency range. (or) Give IEEE microwave frequency bands.

Various bands available in microwave are

Bands	Frequency
L	1 - 2 GHz
S	2 – 4 GHz
C	4 – 8 GHz
X	8– 12 GHz
KU	12–18GHz
K	18–26GHz

3. List the applications of RF and Microwave.

The applications of RF and microwave are Communication, Radar , Radio Astronomy, Navigation, Heating and Power Applications and Spectroscopy.

4. Define S-matrix.

S matrix is a square matrix which relates all possible combinations of input ports and output ports in a microwave junction.

5. What are power dividers?

Power dividers are used to divide the input power into a number of smaller amounts of power for exciting the radiating elements in an array antenna.

6. What is E-plane tee junction?

Waveguide in which the axis of its side arm is parallel to the E-field of the main arm. Wave fed to side arm (port 3) produce waves of opposite phase and same magnitude in its collinear arms.

$$S_{13} = - S_{23}$$

7. What is H- plane tee junction?

Waveguide in which the axis of the side arm is shunting the E-field or parallel to H-field of main guide. Input at port3, produces in phase and same magnitude waves at port1 and port2.

Inputs at port1 and port2, produces output at port3 which is in phase and additive . $S_{13} = S_{23}$

8. Mention the some characteristics of reflex klystrons.

- Frequency range: 1to 25GHz

- Power output: It is a low-power generator of 10 to 500mW
- Efficiency: About 20 to 30%

9. What is Faraday's rotation law?

If a circular polarized wave is made to pass through a ferrite rod which has been influenced by an axial magnetic field B ,then the axis of polarization gets tilted in clockwise direction and amount of tilt depends upon the strength of magnetic field and geometry of the ferrite.

10. What is hybrid ring?

Hybrid ring consists of an annular line of proper electrical length to sustain standing waves, to which four arms are connected at proper intervals by means of series or parallel junctions.

11. Give some coupling parameters of directional coupler?

Some of the coupling parameters of directional coupler are Coupling coefficient, Directivity, Insertion loss, Isolation.

12. Define coupling factor.

The characteristics of a directional coupler can be expressed in terms of its coupling factor and its directivity. Assuming that the wave is propagating from

$$\text{Coupling factor (dB)} = 10 \log_{10} \frac{P_1}{P_4}$$

where P_1 = power input to port 1
P_3 = power output from port 3
P_4 = power output from port 4

port 1 to port 2 in the primary line, the coupling factor are defined as

13. Define directivity.

The directivity is a measure of how well the forward traveling wave in the primary waveguide couples only to a specific port of the secondary waveguide.

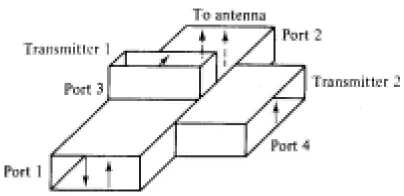
$$\text{Directivity (dB)} = 10 \log_{10} \frac{P_4}{P_3}$$

where P_1 = power input to port 1
P_3 = power output from port 3
P_4 = power output from port 4

14. Write the applications of Magic tee.

The applications of magic tee are mixing, duplexing, and impedance measurements.

A particular application requires twice more input power to an antenna than either transmitter can deliver. A magic tee may be used to couple the two

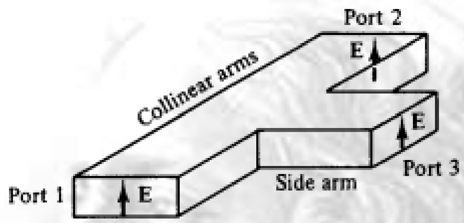


transmitters to the antenna in such a way that the transmitters do not load each other.

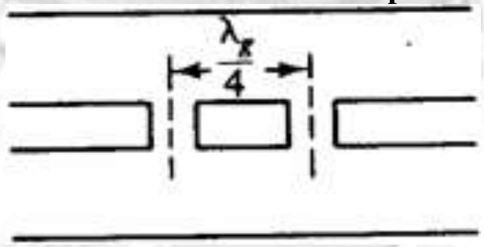
15. What is meant by hybrid rings (or) rat-race circuits? Give the significance of rat race junctions.

A hybrid ring consists of an annular line of proper electrical length to sustain standing waves, to which four arms are connected at proper intervals by means of series or parallel junctions. When a wave is fed into port 1, it will not appear at port 3 because the difference of phase shifts for the waves traveling in the clockwise and counterclockwise directions is 180°.

16. Draw the diagram of H-plane Tee junctions.



17. Draw the structure of two-hole directional coupler.



18. Find the resonant frequency of TE101 mode of an air filled rectangular cavity resonator with dimensions 5cmx4cmx2.5cm.

Sol: Given: a=5cm = 5×10^{-2}m, b=4cm=4×10^{-2}m,
d=2.5cm=2.5×10^{-2}m TE101 mode, m=1, n=0, p=1

$$f_0 = \frac{v}{2}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2 + (d)^2} \qquad = (3\times10^{8})\times44.72 = 1.34\times10^{10} \text{ m/sec}$$

19. Obtain the coupling coefficient of directional coupler if the magnitude of its scattering parameter is 0.707.

Sol: Given: S_{41}= 0.707, To find Coupling factor = - 10 log S_{41}

= 1.50

20. Give some examples of reciprocal devices.

Circulator and directional coupler are examples of reciprocal devices.

21. What is transferred electron effect?

Some materials like GaAs exhibit a negative differential mobility when biased above a threshold value of the electric field. The electrons in the lower – energy band will be transferred

into the higher energy band. The behavior is called transferred electron effect and the device is called transferred electron device or Gunn diode.

22. What is negative resistance in Gunn diode?

The carrier drift velocity is linearly increased from zero to a maximum when the electric field is varied from zero to a threshold value. When the electric field is beyond the threshold value of 3000V/cm, the drift velocity is decreased and the diode exhibits negative resistance.

23. What are the various modes of operation of Gunn diode?

i. Gunn oscillation mode.
ii. Stable amplification mode.
iii. LSA oscillation mode.

24. What are the elements that exhibit Gunn Effect?

The elements are

1. Gallium arsenide
2. Indium phosephide
3. Cadmium telluride
4. Indium arsenide

25.Define GUNN EFFECT.

Gunn effect was first observed by GUNN in n-type GaAs bulk diode. According to GUNN, above some critical voltage corresponding to an electric field of 2000-4000v/cm, the current in every specimen became a fluctuating function of time. The frequency of oscillation was determined mainly by the specimen and not by the external circuit.

26.Mention the disadvantage of IMPATT diodes.

The major disadvantages of the IMPATT diodes are

(1) Dc power is drawn due to induced electron current in the external circuit, IMPATT diodes have low efficiency.

(2)Tend to be noisy due to the avalanche process and to the high level of operating current. (3)A typical noise figure is 30dB which is worse than that of Gunn diodes.

27.What are the factors reducing efficiency of IMPATT diode?

The factors reducing efficiency of IMPATT diode are
1) Space charge effect
2) Reverse saturation current effect

3) High frequency skin effect
4) Ionization saturation effect.

28.List the types of microwave tubes.

- O–type microwave tube or linear beam
- M –type microwave tube

29.What are the applications of reflex klystron?

Reflex klystron is widely used in the laboratory for microwave measurements and in microwave receivers as local oscillators in commercial, military, and airborne Doppler radars as well as missiles.

30..What are hybrid couplers?

Hybrid couplers are inter-digitated microstrip couplers consisting of four parallel Strip lines with alternate lines tied together, It has four ports. This type of coupler is called Lange hybrid coupler.

31.Write the types of directional couplers.

Several types of directional couplers exist, such as a two—hole directional coupler, four-hole directional coupler, reverse-coupling directional coupler (Schwinger coupler), and Bethe-hole directional.

32. A directional coupler is having coupling factor of 20dB and directivity of 40dB. If the incident power is 100mW, what is the coupled power?

Sol: Given:
coupling factor = 20 dB Directivity = 40 dB

Incident power = 100mW
To find:

Coupling factor = 10 log P1/P4

Therefore coupled power P4 = $100 \times 10^{-3} / 10^{2}$ = 1mW.

PART-B

1. What do you understand by microwave components? List various components using microwave frequency.
2. Explain the operation of Directional coupler with neat diagram. Discuss the

various types of directional coupler.

3. Explain the working of flap and vane type attenuator.
4. What is a power divider? Explain its uses in microwave engineering.
5. What is a Magic Tee? Derive the scattering matrix of it and list the advantages of Magic Tee.
6. Write a note on Microwave resonators.
7. What are Avalanche transit time device? Explain the operation, construction and applications of IMPATT diode.
8. Briefly explain the working principle of PIN diode.
9. Explain in detail about Schottky barrier diode.
10. What are the limitations of conventional tubes at microwave frequencies? Explain how these limitations can be overcome.
11. What are the performance characteristics of a klystron amplifier?
12. By means of an Applegate diagram explain the operation of a reflex klystron.
13. What are cross field devices? How does a magnetron sustain its oscillations using this cross field?
14. How is bunching achieved in a cavity magnetron? Explain the phase focusing effect.
15. Derive an expression for the cut off magnetic flux density with reference to a cylindrical cavity magnetron.
16. What are slow wave structures? Explain how a helical TWT achieves amplification.
17. Differentiate Klystrons and TWT.
18. Explain the terms frequency pulling and frequency pushing with reference to a magnetron.

UNIT-V MICROWAVE DESIGN PRINCIPLES

PART-A

1. What is the impedance transformation?

The ability to change impedance by adding a length of a transmission line is known as impedance transformation. When operated at a frequency corresponding to a standing wave of 1/4-wavelength along the transmission line, the line's characteristic impedance necessary for impedance transformation must be equal to the square root of the product of the source impedance and the load's impedance.

2. What is the lossless and lossy line?

If the attenuation coefficient =0$\alpha$the line is called a lossless line. A lossless line is defined as a transmission line that has no line resistance and no dielectric loss. This would imply that the conductors act like perfect conductors and the dielectric acts as a

α

perfect dielectric. (Here the attenuation coefficient =0). A lossy transmission line includes a termˆto represent the resistance of the signal flowing. down the line and a conductanceˆ to represent the possibility of a leakage current between the conductors through the insulator. (Here the attenuation coefficient $\neq 0$)

3. What is impedance matching?

Impedance matching is the practice of designing the input impedance of an electrical load or the output impedance of its corresponding signal source to maximize the power transfer or minimize signal reflection from the load. Here ($Z_L = Z_O$)

4. Why impedance matching or tuning is important?

Impedance matching or tuning is important for the following reasons:

1. Maximum power is delivered when the load is matched to the line (assuming the generator is matched), and power loss in the feed line is minimized.
2. Impedance matching sensitive receiver components (antenna, low-noise amplifier, etc.) may improve the signal-to-noise ratio of the system.
3. Impedance matching in a power distribution network (such as an antenna array feed network) may reduce amplitude and phase errors.

5. What are the different methods of impedance matching?

The various methods are using:

1. L section matching network
2. Single stub matching
3. Double stub matching
4. Quarter wave transformer

6. What is double stub matching?

A double-stub matching network matches a complex load impedance (Z_{load}) to a desired complex input impedance (Z_{in}) using two shunt stubs and a connecting line.

7. What are the applications of the Smith chart?

1. It is used to calculate impedance and admittance on any load.
2. It is used to find V_{max}, V_{min}, SWR, and reflection coefficient K.
3. It is used to find the length and position of the stub.

8. What is a microwave filter?

Microwave filters are two-port, reciprocal, passive, linear devices that heavily attenuate the unwanted signal frequencies while permitting transmission of wanted frequencies.

9. List the important filter parameters.

In designing a filter, the following important parameters are generally considered.

1. Pass-band width
2. Stop-band attenuation and frequencies
3. Input and output impedances
4. Return loss
5. Insertion loss
6. Group delay.

10. What is insertion loss?

The insertion loss is defined as the ratio of incident power to the load power.

It is given by $IL(dB) = 10 \log \dfrac{\text{incident power}(P_i)}{\text{Load power }(P_L)}$

11. Define return loss.

It is defined as the ratio of incident power to the reflected power, which tells about the amount of impedance matching at the input port.

12. Define the group delay.

The group delay is important for the multi-frequency or pulsed signals to determine the frequency dispersion or deviation from constant group delay over a given frequency band.

13. What are the commonly used filters?

The commonly used filters are

1. Low pass filter
2. High pass filter
3. Bandpass filter
4. Bandstop filter

14. What are the types of filter design?

Two methods are normally used. They are

1. Image parameter method
2. Insertion loss method

15. What are the steps involved in the insertion loss method?

Insertion loss method consists of the following steps:

1. Design of a prototype low-pass filter with the desired passband characteristics.
2. Transformation of this prototype network to the required type (low-pass, high- pass, band-pass, or band-stop) filter with the specified center and band-edge frequencies.
3. Realization of the network in microwave form by using sections of microwave transmission lines whose reactance are corresponded to those of distributed circuit elements.

16. What is a microwave power amplifier?

Power amplifiers are used in the final stages of radar and radio transmitters to increase the radiated power level. Typical output powers may be on the order of 100–500 mW for mobile voice or data communications systems, or in the range of 1– 100 W for radar or fixed-point radio systems. Important considerations for RF and microwave power amplifiers are efficiency, gain, inter modulation distortion, and thermal effects.

17. What are the two mixer characteristics?

1. Frequency up conversion
2. Frequency down-conversion.

18. List the applications of microwave mixers.

Mixer circuits can be used to shift the frequency of an input signal like as in a receiver. They can also be used as a product detector, modulator, frequency multiplier, or phase detector.

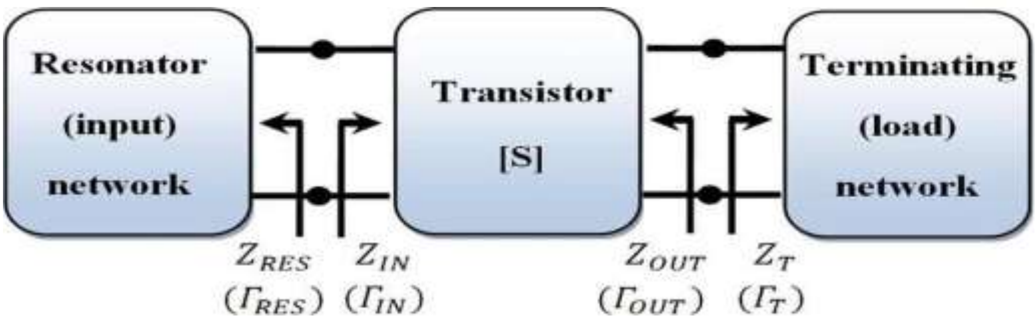
19. List the applications of an oscillator.

They provide a critical clocking function for high-speed digital systems, generate electromagnetic energy for radiation, enable frequency up and down conversion when used as local oscillators, and are used as a reference source for system synchronization.

20. What is a microwave mixer?

A mixer is a three-port device that uses a nonlinear or time-varying element to achieve frequency conversion an ideal mixer produces an output consisting of the sum and difference frequencies of its two input signals. The operation of practical RF and microwave mixers is usually based on the nonlinearity provided by either a diode or a transistor.

21. Draw the model of a transistor oscillator.



22. What is a microwave oscillator?

RF and microwave oscillators are found in all modern wireless communications, radar, and remote sensing systems to provide signal sources for frequency conversion and carrier generation. A solid-state oscillator uses an active nonlinear device, such as a diode or transistor, in conjunction with a passive circuit to convert DC to a sinusoidal steady-state RF signal. Basic transistor oscillator circuits can generally be used at low frequencies, often with crystal resonators to provide improved frequency stability and low noise performance.

23. List the important consideration of oscillators in the microwave system.

Important considerations for oscillators used in RF and microwave systems include the following:

1. Tuning range (specified in MHz/V for voltage-tuned oscillators)
2. Frequency stability (specified in PPM/◦C)

AM and FM noise (specified in dBc/Hz below the carrier, offset from the carrier) Harmonics (specified in dBc below carrier)

24. What are the drawbacks of single stub matching?

The single-stub tuner can match any load impedance (having a positive real part) to a transmission line but suffers from the disadvantage of requiring a variable length of line between the load and the stub. This may not be a problem for a fixed matching circuit but would probably pose some difficulty if an adjustable tuner was desired. In this case, the double-stub tuner, which uses two tuning stubs in fixed positions, can be used. Such tuners are often fabricated in coaxial lines with adjustable stubs connected in shunt to the main coaxial line.

25. List the various types of mixers.

1. Single-ended diode mixer
2. Single-ended FET mixer
3. Balanced mixer
4. Image reject mixer
5. Differential FET Mixer and Gilbert cell mixer.

PART-B

1. Explain the impedance of impedance transformation in transmission lines.
2. With one example, explain how the L section is used in impedance matching.
3. Explain the concept of single stub impedance matching with one example.

1. List the drawbacks of single stub matching. How double stub matching overcomes? Explain.
2. Explain how QWT is used in impedance matching?
3. Explain the design of the microwave filter using the insertion loss method.
4. Derive the design equation of microwave low pass filter.
5. Derive the equation for unilateral transducer power gain.
6. Explain the concept of stability circles with neat diagrams.
7. Explain the design of a single-stage transistor amplifier design.
8. Explain the various types of a broadband transistor amplifiers.
9. With a neat diagram, explain the operation of low noise amplifier.
10. Discuss the design of microwave oscillators using i) Transistors ii) Dielectric resonator.
11. Explain the operation of the microwave power amplifier with neat sketches.
12. Explain the design of class A power amplifier with diagrams.
13. Explain the operation of the single-ended diode mixer.
14. Discuss the working principle of i) Single-ended FET mixer ii) Balanced mixer.
15. Explain Differential FET Mixer and Gilbert cell mixer.