UNIT I
FUNDAMENTALS OF RADIATION

1. What is retarded potential?

If an alternating current is flowing in a short element, the effect of current is not felt instantaneously at a distant point, but only after some time interval equal to the time required for the fields to propagate through the distance. The potential obtained considering retardation time are known as retarded potential. They are very important in radiation calculation.

2. What do you mean by an isotropic radiator?

It is a hypothetical loss less radiator having equal radiation in all directions. E.g. point source

3. What do you understand by static, induction and radiation field produced by an antenna?(May 2015)

The field terms which vary inversely as the cube of the distance [α 1/r3] are known as electrostatic fields. They are important only near the current elements and does not contribute anything for radiation.

Induction field: The field term that varies inversely as the square of the distance [α $1/r^2$] is known as induction field. It predominates at points close to current element where distance is small.

Radiation field: The field term that varies inversely as distance "r" is called as radiation fields or "far fields" that accounts for the radiation of electromagnetic waves from the antenna.

4. Define directivity of an antenna (May 2012).

Directivity D of an antenna is its maximum directive gain.

5. Define effective aperture (area) of an antenna (May 2012) (May 2015).

It is defined as the area over which the antenna collects energy from the incident wave and delivers it to the receiver load.

$$A_e = \frac{received\ power\,(watt)}{power\ flow\ per\ square meter(watts/sqm)\ for\ the\ incident\ wave}$$

6. Define the radiation resistance of an antenna. What is the importance of this quantity? (May 2015)

Radiation resistance is defined as a fictitious or hypothetical resistance that would dissipate an amount of power equal to the radiated power. Total power radiated by the antenna can be determined using the radiation resistance.

$$power\ radiated = R_r \times (I_{rms})^2$$

$$R_r = radiation\ resistance$$

$$I_{rms} = rms\ value\ of\ the\ current\ in\ antenna$$

7. What is self-impedance of an antenna?

Impedance at the point where transmission line is connected is referred to as feed point impedance or antenna input impedance. If the antenna is loss less and isolated, then the self impedance of the antenna is equal to the antenna input impedance.

8. Define the bandwidth of an antenna.

The band width of antenna is defined as "The range of frequencies within which the performance of the antenna, with respect to some characteristics [input impedance, beam, width, polarization, side lobe level, gain etc.] confirms to a specified standard.

9. Define the directive gain of an antenna.

Directive gain in a given direction, is defined as the ratio of the radiation intensity in that direction to the average radiated power. $g_d\,(\theta,\phi) = \dfrac{\Phi(\theta,\phi)}{\Phi_{av}} = \dfrac{4\pi\,\Phi(\theta,\phi)}{W_r}$

In decibels the directive gain is denoted by $G_d = 10\log_{10}(g_d)$

10. Define the antenna efficiency.

Antenna efficiency is defined as the ratio of power radiated to the total input power supplied by to the antenna and is denoted by η.

$$\eta = \frac{power\ radiated}{Total\ power\ supplied} = \frac{I^2 R_r}{I^2\left[R_r + R_l\right]}$$

$$R_r = Radiation\ resistance$$

$$R_l = loss\ resistance$$

11. What is meant by polarization?

Polarization of an antenna means the orientation of the electric field (E-vector) of the electromagnetic wave being radiated by the transmitting antenna in the far field.

12. Define beam solid angle.

The beam area or beam solid angle Ω_A for antenna is given by integral of the normalized power pattern over a sphere.

$$\Omega_A = \int_0^{2\pi} \int_0^{\pi} P_n(\theta,\phi)\ d\Omega \qquad steradian$$

$$P_n(\theta,\phi) = Normalized\ power\ pattern$$

Beam solid angle is also given approximately by

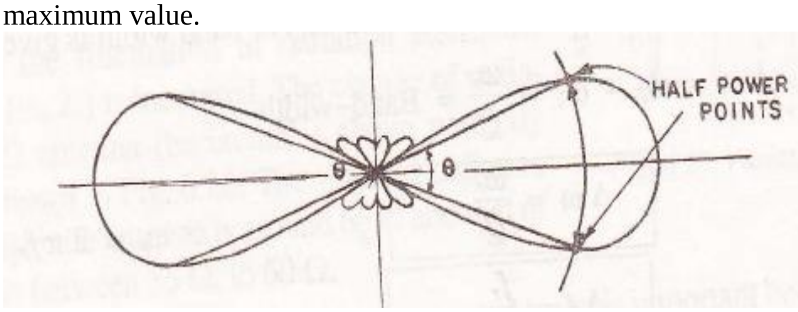
$$\Omega_A = \theta_{HP}\ \phi_{HP} \qquad steradian$$

$$\theta_{HP} = HPBW\ in\ E-plane\ or\ \theta\ plane$$

$$\phi_{HP} = HPBW\ in\ H-plane\ or\ \phi\ plane$$

13. Define Half power beam width (HPBW) of an antenna (Dec 2012).

Antenna Beam Width is a measure of directivity of an antenna. It is an angular width in degrees, measured on the radiation pattern (main lobe) between points where the radiated power has fallen to half its maximum value.

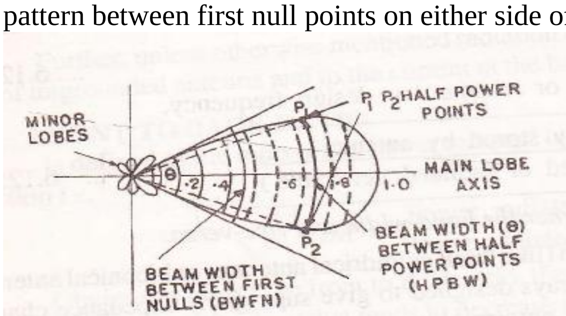


14. Define the term 'Front to back ratio'.

$$Front\ to\ back\ ratio = \frac{power\ radiated\ in\ the\ desired\ direction}{power\ radiated\ in\ the\ opposite\ direction}$$

15. Define Beam Width between First Null.

Beam width between first null (BWFN) is the angular width in degrees, measured on the radiation pattern between first null points on either side of the main lobe.



16. Calculate the radiation resistance of current element of length $\lambda/20$ (May2012).

$$R_r = 80\pi^2\left(\frac{dl}{\lambda}\right)^2$$

$$dl = \frac{\lambda}{20}$$

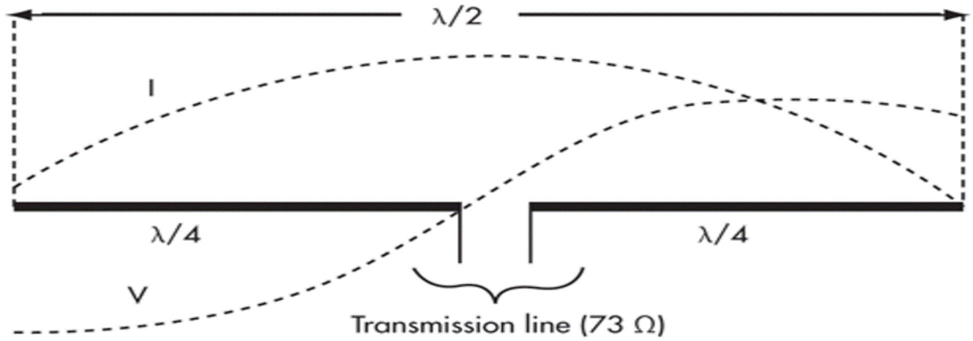
$$R_r = 1.974\,ohms$$

17. State the need for BALUN.

A Balun is used to transform the balanced input of the antenna into unbalanced impedance so that an unbalanced transmission line can be connected to it. (To connect an unbalanced line (e.g., Coaxial cable) to a balanced antenna (e.g., Dipole antenna)).

18. How a dipole antenna can be formed from a 2 wire open circuited transmission line? (Dec 2013)

A half wave length dipole antenna can be formed from a two wire transmission line as shown in figure.



19. What is the effective area of a half wave dipole operating at 1 GHz? (May 2013)

$$A_e = \frac{\lambda^2}{4\pi} g_d$$

$$f = 1GHz$$

$$\lambda = \frac{3\times10^8}{1\times10^9} = 0.3m$$

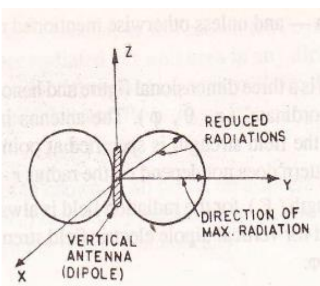
$$g_d = directive\ gain = 1.644$$

$$A_e = \frac{0.3^2}{4\pi}\times1.644 = 0.012m^2$$

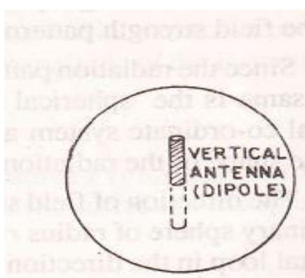
20. Draw the E plane and H plane radiation pattern of a dipole. (May 2014)

E plane pattern is referred to as vertical pattern and H plane pattern is referred to as horizontal pattern.

Vertical Pattern:



Horizontal pattern:



21. What are dB_i and dB_d ? Write their significances. (Dec 2013)

dBi is the amount of focus applied by an antenna with respect to an "Isotropic Radiator" (a dispersion pattern that radiates the energy equally in all directions onto an imaginary sphere surrounding a point source). Thus an antenna with 2.1 dBi of gain focuses the energy so that some areas on an imaginary sphere surrounding the antenna will have 2.1 dB more signal strength than the strength of the strongest spot on the sphere around an Isotropic Radiator.

dBd refers to the antenna gain with respect to a reference dipole antenna. A reference dipole antenna is defined to have 2.15 dBi of gain.

dBi = dBd + 2.15 and dBd = dBi - 2.15

22. Define folded dipole.

A folded dipole consists of two parallel $\lambda/2$ dipoles connected to each other at the ends. It is fed at the centre of one of the dipoles and the other dipole is shorted.

23. Design a 3 element Yagi-Uda antenna to operate at a frequency of 200 MHz. (May 2013)

Length of driven element $= \frac{478}{f_{MHz}} = \frac{478}{200} = 2.39\ feet$

Length of reflector $= \frac{492}{f_{MHz}} = \frac{492}{200} = 2.46\ feet$

Length of director $= \frac{461.5}{f_{MHz}} = \frac{461.5}{200} = 2.31\, feet$

Element spacing $= \frac{142}{f_{MHz}} = \frac{142}{200} = 0.71\, feet$

24. Define antenna temperature.

It is defined as the temperature of far or distant regions of space and near surroundings which are coupled to the antenna through radiation resistance.

25. What are parasitic elements and where are they used?

Reflector and director are passive elements which are not connected to the feeder line directly, but they are simply grounded and are called parasitic elements. The parasitic elements receive their excitation from the nearby driven element. They are used in Yagi-uda array for TV reception.

PART B

1. (i) Explain the principle of reciprocity as applied to an antenna.
(ii) Derive the wave equation for uniform plane waves in an infinitely extending conducting medium. and obtain its solution. **(May 2013) (May 2012)**

2. Define and explain in detail the terms Radiation Resistance, gain, Directivity, Effective aperture, beam width, Bandwidth and Polarization of an antenna. **(Dec 2012) (May 2015)**

3. Derive the electric and magnetic field components of Hertzian dipole. **(Dec 2012) (May 2015)**

4. Explain in detail about:
1) Radiation pattern 2) Polarization 3) Antenna Temperature 4) Beam solid angle. **(May 2012)**

5. Derive the field quantities and draw the radiation pattern for a half wavelength dipole. **(Dec 2011) (May 2015)**

6. (i) Show that the directivity of an alternating current element is 1.76dB.
(ii) Show that at distance $r = 0.159\lambda$ the induction field is equal to radiation field for a current element.

7. (i) Calculate the radiation efficiency of an antenna if the input power is 100W and the power dissipated in it is 1W. (3)
(ii) Define input impedance and their dependence on antenna performance. (5)
(iii) Define and explain the polarization and its significance in antenna analysis. (8)

8. (i) Find the effective area of a Hertzian dipole operating at 100 MHz.
(ii) Derive the directivity of half wave dipole antenna. **(Dec 2013)**
(iii) Find the current required to radiate power of 50 W at 60 MHz from a 0.1λ Hertzian dipole

9. (i) Two spacecrafts are separated by 3Km. Each has an antenna with directivity D=200 operating at 2GHz. If craft A receives 20dB power what is the transmitted power by the craft B? **(May 2015)**
(ii) Show that the input resistance of a half wave folded dipole is four times that of single half-wave dipole.

10. With a neat sketch, explain the construction and operation of multi element Yagi-Uda antenna. **(Dec 2011)**

UNIT- II

APERTURE AND SLOT ANTENNAS

1. State Babinet's principle and how it gives rise to the concept of complementary antenna? (May 2013)

Babinet's princple states that the sum of the field at a point behind a plane having a screen and the field at the same point when a complimentary screen is substituted, is equal to the field at the point when no screen is present.

This principle can be applied to slot antenna analysis.

2. State uniqueness theorem (May 2012)

Uniqueness theorem states that, for a given set of sources and boundary conditions in a lossy medium, the solution to Maxwell's equations is unique.

3. State Snell's law of refraction.

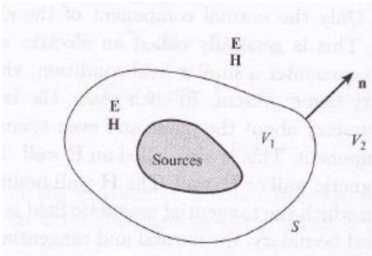
$$\frac{\sin\theta_t}{\sin\theta_i} = \sqrt{\frac{\epsilon_{r1}}{\epsilon_{r2}}}$$

$\theta_i = angle\ of\ incidence,\ \theta_t = angle\ of\ refraction$

$\epsilon_{r1} = relative\ dielectric\ constant\ of\ region\ 1$

$\epsilon_{r2} = relative\ dielectric\ constant\ of\ region\ 2$

4. What is field equivalence principle? (May 2014)



Fields and sources

According to the field equivalence principle, the fields in V_2 due to the sources in V_1 can also be generated by an equivalent set of virtual sources on surface **S**, given by $J_S = n \times H$ and $M_S = E \times n$ where **E** and **H** are the fields on the surface **S** produced by the original set of sources in volume V. The set of virtual sources produce null fields everywhere in V_1. Here, M_S represents the magnetic surface current density and J_S represents electric surface current density.

5. Give two examples for microwave antenna.

Horn antenna, Lens antenna

6. What is slot radiator? What is its operating principle?

When a slot in a large metallic plane is coupled to an R.F source, it behaves like a diploe antenna mounted over a reflecting surface. The slot is coupled to a feed line in such a manner that E-field lies along the short axis of the slot.

7. Mention any three aperture antennas.

Slot antenna, horn antenna, lens antenna.

8. What are the features of pyramidal horn antenna? (May 2015)

The pyramidal horn is obtained by flaring all the sides of a rectangular wave guide to form a pyramid-shaped horn with a rectangular aperture.

- It is one of the most often used horn antennas.
- It is used as a primary feed for reflector antennas.
- It is used as standard gain reference antennas in antenna measurements.

9. What is a sectoral horn?

Horn antenna is a wave guide one end of which is flared out.

- If flaring is along the direction of electric field, it is called sectoral E-plane horn.
- If flaring is along the direction of magnetic field, it is called sectoral H-plane horn

10. What is a corner reflector?

A corner reflector is made up of two flat-plate reflectors joined together to form a corner. The corner reflector is generally used in conjunction with a dipole or dipole array kept parallel to the corner line. Corner reflector gives a higher directivity.

11. Mention any three curved reflector shapes.

Parabolic, Parabolic cylinder, Hyperboloid

12. Give the applications of lens antenna.

They are used in the higher end of the microwave spectrum and millimetre wave frequencies.

13. What is 'zoning' in lens antenna?

Zoning is a method used to reduce the bulk (weight) of the antenna. The lens is divided in to several circular zones and the dielectric material is removed from each zone such that the electrical path length between adjacent zones differs by an integer multiple of a wave length.

14. What are the two methods of 'zoning' in dielectric lens antenna?

Zoning the non-refracting surface, zoning the refracting surface

15. What are the drawbacks of lens antenna?

- Due to the reflection at the dielectric-air interface, a matching quarter wave transformer is required which limits the band width of the lens antenna to the bandwidth of the matching device.
- A lens antenna is generally heavy and bulky.

16. What is the main advantage of Cassegrain reflector configuration?

- The main advantage is that the primary feed horn and the associated receiver or transmitter can be located conveniently behind the main reflector.
- The necessity of running long transmission lines or waveguides is also eliminated.
- Since the horn feed is kept behind the main reflector, one can afford to have a much larger aperture for the horn.

17. What is the main disadvantage of Cassegrain reflector configuration?

The main disadvantage of Cassegrain reflector configuration is the large aperture blockage by the sub-reflector. Hence, Cassegrain reflector configuration is used only for very large aperture antennas having gain greater than 40dB.

18. What are the different types of lens antenna?

Dielectric lens antenna, Metallic lens antenna, Zoned lens antenna, Stepped lens antenna.

19. Distinguish between sectorial horn and pyramidal horn.

- Horn antenna is a wave guide one end of which is flared out. In pyramidal horn, the flaring is along E and H. It has the shape of a truncated pyramid.
- In sectoral horn, the flaring is along E or H. If flaring is along the direction of electric field, it is called sectoral E-plane horn. If flaring is along the direction of magnetic field, it is called sectoral H-plane horn.

20. What is a microstrip antenna?

A microstrip patch antenna consists of a thin metallic patch etched on the dielectric substrate using PCB technology.it is also referred as printed antenna. Its performance depends on shape (can be square, rectangular, triangular, circular) and size.

21. What is pill box antenna?

- This is a reflector antenna which has a cylindrical reflector enclosed by two parallel conducting plates perpendicular to the cylinder, spaced less than one wavelength apart.
- It is excited by a probe through a coaxial line. It produces a wide beam in E-plane and narrow beam in H-plane.
- This is used in ship-to-ship radars.

22. What is the principle of E-plane metal plate lens antenna?

In this, outgoing wave front is speeded up by the lens material. When the feed antenna is kept at the focal point of the lens antenna, the spherical wave fronts are collimated forming a plane wave front.

23. What is the principle of dielectric lens antenna?

In this, outgoing wave front is delayed by the lens material. When the feed antenna is kept at the focal point of the lens antenna, the spherical wave fronts are collimated forming a plane wave front.

24. The aperture dimensions of a pyramidal horn are 12x6 cm and operating at a frequency of 10 GHz. Find the beam width and directivity. (May 2013)

Frequency = 10 GHz

$$\lambda = \frac{3\times10^8}{10\times10^9} = 3cm$$

$$d = 12cm \quad and \quad w = 6cm$$

$$Beamwidth: \phi_E = 56\frac{\lambda}{d} = 14^0$$

$$\phi_H = 67\frac{\lambda}{w} = 33.5^0$$

$$power\,gain = \frac{4.5wd}{\lambda^2} = 36 = 15.56dB$$

$$Directivity = \frac{7.5wd}{\lambda^2} = 60$$

25. What are the features of microstrip antennas? (Dec 2011) (May 2015)

These are antennas made from patches of conducting material on a dielectric substrate above a ground plane.

Advantages: Small size, low cost, low weight, ease of installation.

Applications: They are used in space crafts, aircrafts, telemetry, satellite communications and defense radar systems.

<u>PART B</u>

1. (i) Write an essay on aperture antennas.
(ii) Compare flat reflector and corner reflector antennas.

2. Explain the radiation mechanism of horn antenna with diagram. Draw the different types of horn structures. **(May 2015) (Dec 2012) (Dec 2011)**

3. (i) Explain how a paraboloidal antenna gives a highly directional pattern?

(ii)Explain in detail about the feeding structures of parabolic reflector antenna. **(May 2013) (Dec 2011)**

4. Write in detail about:
(i) Slot antenna (ii) Lens antenna **(May 2013) (May 2012)**

5. Explain the principle of reflector antenna and discuss on different types of feed used with neat diagram. **(May 2015) (May 2014) (Dec 2012)**

6. With necessary illustrations explain the radiation characteristics of microstrip antenna with different types of feeding structures and mention its application. **(Dec 2011)**

7. (i) Explain the radiation mechanism of Cassegrain reflector antenna With necessary diagrams.
(ii)How is aperture blockage in reflector antennas avoided? **(May 2012)**

8. Explain the radiation mechanism of lens antenna and its types with necessary diagrams.

9. Explain the construction and principle of pyramidal horn antenna. A pyramidal horn antenna having aperture dimension of a=5.2cm and b=3.8cm is used at a frequency of 10GHz. Calculate its gain and half power beam widths. **(Dec 2013)**

10. (i) Discuss the various feed techniques for Rectangular patch antenna with neat diagrams.
(ii) Find the diameter of a dish antenna that will form a beam having 0.5deg, half power beam width (HPBW) at a frequency of 8.2GHz. Assuming an efficiency constant of 0.6, calculate the antenna gain and effective aperture. **(Dec 2013)**

UNIT-III
ANTENNA ARRAYS

1. What is an antenna array?

- Antenna array is system of a similar antennas oriented similarly to get greater directivity in a desired direction.
- Antenna array is a radiating system consisting of several spaced and properly phased (current phase) radiators.

2. What is end-fire array?

End-fire array is defined as an array in which the principal radiation direction is along the array axis. i.e., maximum radiation is along the axis of the array.

3. What is broad-side array?

Broadside array is defined as an array in which the principal radiation direction is perpendicular to the array axis.

4. Define uniform linear array.

Uniform linear array is one in which the elements are fed with a current of equal amplitude (magnitude) with uniform progressive phase shift along the line.

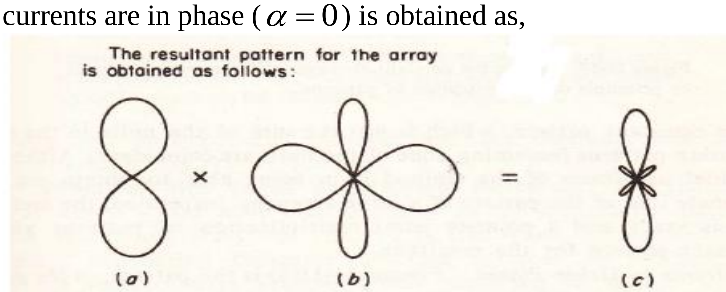
5. What do you mean by tapering of array?

- The techniques used in reduction of side lobe level are called as tapering.
- It is found that minor lobes are reduced if the center source radiates more strongly than the end sources (non-uniform current distribution). Hence tapering is done from center to end according to some prescription.

6. State the principle of pattern multiplication (Dec 2012)

Array pattern = Element pattern * Array Factor

For example, radiation pattern of a four element array in which the spacing between units is $\frac{\lambda}{2}$ and the currents are in phase ($\alpha = 0$) is obtained as,



(a) Unit pattern (b) Array Factor (c) Array pattern

7. What is the main advantage of Binomial array?

- No side lobes in the radiation pattern of Binomial array.
- Half Power Beam width is more.

8. What is the advantage of pattern multiplication?

- Simple method for obtaining radiation pattern of arrays.
- Makes it possible to sketch rapidly, almost by inspection, the radiation pattern of complicated arrays without making lengthy calculations.

9. What is uniform Array?

Array elements are fed with a current of equal amplitude (magnitude) with uniform progressive phase shift along the line.

10. Why we go for non-uniform amplitude distribution?

We go for non- uniform amplitude distribution to reduce side lobe levels.

11. Distinguish between uniform and non-uniform arrays.

Uniform linear array is one in which the elements are fed with a current of equal amplitude (magnitude).

Non-uniform linear array is one in which the elements are fed with currents of un equal amplitude(magnitude).

12. A uniform linear array contains 50 isotropic radiator with an inter element spacing of $\lambda/2$. Find the directivity of broadside forms of arrays. (May 2013)

N=50 d= $\lambda/2$

Array length=N d= $l = 25\lambda$

Directivity of Broadside array = $2\left(\frac{l}{\lambda}\right)$ =50

13. What are the advantages of antenna arrays? (May 2014)

A radiating system composed of several spaced and properly phased radiators is called as an Antenna array. Antenna array is used to have higher directivity. So this system is used in long distance communication.

14. State Huygen's principle. (Dec 2013) (May 2015)

Huygen'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 waves.

15. Define Phased arrays.

An array of many elements with the phase (also amplitude) of each element being a variable, providing control of the beam direction and pattern shape including side lobes.

16. What is relationship between directivity and HPBW?

If HPBW is greater; directivity is less. And vice-versa.

17. Define adaptive array.

Adaptive arrays have an awareness of their environment and adjust to it in a desired fashion. Thus an adaptive array can automatically steer its beam toward a desired signal while steering a null toward an undesired or interfering signal. In a more versatile adaptive array the output of each element is sampled, digitized and processed by a computer. Such an array may be called as smart antenna.

18. How number of array elements effect directivity?

As number of array element increases; the beam width will be lesser and this will result better directivity.

19. What are null directions in radiation pattern?

Direction in which radiation is not present is defined as null direction.

20. A uniform linear array of 4 isotropic elements with an inter element spacing of $\lambda/2$. Find the BWFN and directivity of end fire arrays.

n=4 d= $\lambda/2$

Array length= nd = $l = 2\lambda$

BWFN = $2\sqrt{\frac{2\lambda}{nd}}$ = 2

Directivity of end fire array = $4\left(\frac{l}{\lambda}\right)$ =8

21. What is binomial array?

Binomial array is an array whose elements are excited according to the current distribution determined by the binomial coefficient, nc_r, where n is number array elements.

22. Write the disadvantages of binomial arrays.

- The beam width of the main lobe is large which is undesirable.

- The directivity is small.
- High excitation levels are required for the centre elements of large arrays.

23. Write the techniques followed for array synthesis.

1) Schelkunoff polynomial method 2) Fourier transform method 3) Dolph-Tchebyscheff or Chebyshev method 4) Taylor's method 5) Laplace transform method 6) Woodward-Lawson method.

24. Define antenna synthesis.

Synthesis of an antenna array is the determination of antenna system details for a given input and for a required output.

25. What are the advantages of Dolph-Tschebyscheff method?

- It provides a minimum beam width for a specified side lobe level.
- It provides pattern which contains side lobes of equal level.
- The amplitude distribution is not highly tapered and hence it is more practical.

PART B

1. (i) Write a note on binomial array?

(ii) Draw the pattern of 10 element binomial array with spacing between the elements of $3\lambda/4$ and $\lambda/2$. **(May 2013)**

2. Derive the expressions for field pattern of broad side array of *n* point sources. **(May 2013)**

3. Two identical radiators are spaced $d = 3\lambda/4$ meters apart and fed with currents of equal magnitude but with 180^0 phase difference. Evaluate the resultant radiation and identify the direction of maximum & minimum radiation. **(May 2015)**

4. For a 2 element linear antenna array separated by a distance $d = 3\lambda/4$, derive the field quantities and draw its radiation pattern for the phase difference of 45^0. **(Dec 2012)**

5. Derive the expressions for field pattern of end-fire array of *n* sources of equal amplitude and spacing. **(May 2012)**

6. An antenna array consists of two identical isotropic radiators spaced by a distance of d= $\lambda/4$ meters and fed with currents of equal magnitude but with a phase difference β. Evaluate the resultant radiation for $\beta = 0^0$ and thereby identify the direction of maximum radiation. **(Dec 2011)**

7. Describe a broadside array. Deduce an expression for the radiation pattern of a broadside array with two point sources.

8. Plot the radiation pattern of a linear array of 4 isotropic elements spaced $\lambda/2$ apart and fed out of phase with equal currents.

9. (i) Derive Array factor of an Uniform linear array. Explain the significance of array factor. **(Dec 2013)**

(ii) Compare End fire and Broadside array. **(May 2014)**

10. Explain in detail about: 1) adaptive arrays 2) Phased arrays.

UNIT IV
SPECIAL ANTENNAS

1. What is a resonant antenna?

- Resonant antennas are those which correspond to a resonant transmission line that is an exact number of half wave length long and is open at both ends.
- These are unterminated antennas and are used for fixed frequency operation.
- In resonant antennas standing wave exists. i.e, forward wave (incident wave) and backward wave (reflected wave) exists.
- The radiation patterns of resonant antenna are bidirectional due to incident and reflected waves.

2. What is a non-resonant antenna?

- Non- resonant antennas are also called as travelling wave antenna.
- Non-resonant antenna corresponds to a transmission line that is excited at one end, terminated correctly at the other end.
- No reflected waves are produced and all the incident waves are absorbed.
- Waves travel only in one direction and hence only unidirectional radiation patterns are produced.
- It is a wideband antenna and it is not sharply tuned to one frequency

3. Compare the radiation pattern of resonant and non-resonant antenna.

Resonant antenna - bidirectional radiation pattern

Non-resonant antenna – unidirectional radiation pattern

4. Which antenna is suitable for extraterrestrial communication?

Helical antenna

5. What are the two modes of radiation of helical antenna?

(i) normal mode (ii) axial mode

6. What is LPDA?

LPDA is log periodic dipole array. It is unidirectional broadband, multi element, narrow beam, frequency independent antenna that has impedance and radiation characteristics that are regularly repetitive as a logarithmic function of frequency.

7. Sketch the radiation pattern of normal mode helical antenna.

Radiation is maximum in the direction normal to the helix axis.

8. Which antenna is used for VHF communication? (Dec2012)

Helical antenna

9. What is the antenna used for mobile and wireless hand set applications? Give reason.

Helical antenna operating in the normal mode is used for mobile and wireless hand set applications. A normal mode helical antenna is compact and has an Omni directional radiation pattern in the plane normal to the axis of the helix.

10. Write the difference between active and passive antenna.

Active antenna: Includes an antenna element and amplifiers. It is possible to use long cables and still maintain performance.

Passive antenna: Includes only an antenna element, no amplifiers. It is useful only for short runs of coaxial cable. Cable loss will deteriorate system performance.

11. Mention the applications of electronic band gap structure in antennas.

- The band gap feature of EBG structure has found useful application in suppressing the surface waves in microstrip antenna designs. Hence the antenna gain and efficiency are increased while the back lobes are reduced.
- EBG is used in microstrip antenna designs for size reduction and radiation pattern control.
- EBG structures are used to reduce the mutual coupling and eliminate scan angle in the microstrip antenna arrays.
- It is used to improve the performance of wire antennas, high gain antennas and slot antennas.

12. What is wide band antenna? Give an example.

Antennas which maintain certain required characteristics like gain, front to back ratio, SWR, Polarization input impedance and radiation pattern over wide range of frequencies are called wide band or broad band antennas. Log periodic antenna is a broadband antenna.

13. What are the drawbacks of outdoor antenna measurements?

- Susceptible to EMI
- Ground and other reflections Cannot be controlled fully
- They have uncontrolled environment

14. What are the main advantages of indoor antenna measurements?

- Absence of electromagnetic interference (EMI)
- Protection of expensive equipments from environmental severities

15. What are the special features of anechoic chamber? (Dec 2012)

- Used for indoor measurements.
- A closed chamber made reflection free or echo free by lining all the surfaces of the chamber with absorbing material.
- Main component of an anechoic chamber is the absorber.
- Absorbers are made in the form of pyramids or wedges. Absorbers have very low reflection coefficient over a wide range of frequency for normal incidence.

16. List out the applications helical antenna. (May 2010)

- Used for satellite and space communication.
- Used in radio astronomy.
- In the ballistic missiles and satellites used as telemetry links.

17. Mention the types of feed method for micro strip antenna? (May 2012) (May 2013)

Using (i) micro strip transmission line (ii) Coaxial transmission line

18. Why is log periodic antennas called so? (Dec 2011)

It is an array antenna which has structural geometry such that its impedance is periodic with the logarithm of the frequency.

19. Why frequency independent antennas are called so? (May 2014)

An antenna in which the impedance, radiation pattern and directivity remain constant as a function of frequency is called as frequency independent antenna. Eg; Spiral antenna.

20. Mention the requirements of an Anechoic Chamber. (Dec 2013)

An Anechoic Chamber can be made reflection-free or echo-free by lining all the surfaces of the chamber with absorbing material. It can be made dust free and error free environment.

21. What is reconfigurable antenna?

Reconfigurable antenna has the ability to radiate more than one pattern at different frequencies and polarizations. It is the only solution for increased functionality of the antenna (direction finding, beam steering and Radiation pattern control)

22. Mention the advantages of reconfigurable antenna.

- Ability to support more than one wireless standard: good isolation between different wireless standards.
- Lower front end processing: no need for front end filtering and good out-of-band rejection.
- Act as a single element or as an array.
- Provide narrow band or wideband operation.

23. What are the advantages of helical antenna?

a) Very simple b) higher directivity c) wideband operation is possible d) circular polarization is obtained.

24. What do you meant by spiral antenna?

Spiral is a geometrical shape found in nature. A spiral can be geometrically described using polar coordinates. Let (r,θ) be a point in the polar coordinate system. The equation $r = r_o e^{a\theta}$, where, r_o and 'a' are positive constants, describes a curve known as a logarithmic spiral or an equiangular spiral.

25. List the different ranges of antenna measurements.

The following ranges are used for antenna parameter measurements: Outdoor range, Indoor range, Reflection range, Slant range, Elevated range, Compact range, Near field range, Ground range and Radar cross section range.

PART B

1. What is the importance of Helical antenna? Explain the construction and operation of Helical antenna with neat sketch. Highlight some of its applications. **(May 2015) (May 2014) (May 2013) (Dec 2012)**

2. With neat block diagram explain how Radiation pattern and Gain of an antenna can be measured. **(May 2013, Dec 2013)**

3. Explain the principle of operation of Log periodic antenna with neat schematic diagram. **(May 2015)**

4. Discuss in detail how a spiral antenna behaves as a frequency independent antenna. (**May 2014)**

5. (i) How is VSWR measured? Explain. **(May 2014)**

(ii) With suitable geometry describe the Radiation pattern.

6. Explain in detail about (i) Polarization measurement (ii) Gain Measurement **(May 2012, May 2014)**

7. Explain the construction of an anechoic chamber and state its merits and demerits

8. (i) Elaborate on the principle of frequency independent antennas.

(ii) Discuss in detail about dielectric antennas.

(iii) Distinguish between a reconfigurable antenna and active antenna. **(May 2014)**

9. Write notes on: (i) Reconfigurable antenna (ii) Electronic band gap (iii) Active antenna

10. Describe the procedure for the measurement of i) Antenna gain ii) VSWR. **(May 2011)**

UNIT-V
PROPAGATION OF RADIO WAVES

1. Write down the Sommer field equation for ground wave field strength.

$$E_g = \frac{AE_0}{r}$$

$$E_g = ground\ wave\ field\ strength$$

$$E_0 = Field\ strength\ at\ unit\ distance\ from\ Tx\ antenna\ neglecting\ earth's\ losses$$

$$r = Distance\ of\ the\ point\ from\ Tx\ antenna\ and\ A = Attenuation\ factor$$

2. What is meant by wave tilt in ground wave propagation?

The ground or surface wave will be attenuated due to ground attenuation i.e. due to diffraction and tilt in the wave front. As the wave progress over the curvature of the earth, the wave front starts gradually tilting more and more. This increase in the tilt of wave causes more short circuit of the electric field component and hence the field strength goes on reducing, ultimately at some appreciable distance from the transmitting antenna, the surface wave dies because of the losses.

3. Give the salient features of ground wave propagation.

The ground wave propagation is due to ground wave, which is guided along the surface of the earth. The waves must be vertically polarized to prevent short-circuiting of electric component. Since the earth's attenuation increases with increase of frequency, ground wave propagation is limited up to 2MHz only.

4. Give any four factors that influence radio wave propagation.

1) Earth's characteristics 2) Frequency of operation 3) Height of transmitting antenna 4) Polarization of transmitting antenna

5. What is tropo scatter propagation?

Forward scatter propagation or simply scatter propagation is of practical importance at VHF, UHF and microwaves. UHF and microwave signals were found to be propagated much beyond the line of sight propagation through the forward scattering due to tropospheric irregularities. It uses certain properties of troposphere and is also known as Troposcatter.

6. What is duct propagation?

The ground surface and atmospheric layer form a duct or sort of "leaky wave guide" which guides the electromagnetic wave between its walls. When frequency is high, the region where the refractive index is usually high, traps the energy and causes it to travel along the earth surface as happens in a wave-guide. This type of propagation is called duct propagation. It also referred to as super refraction.

7. What is radio horizon and optical horizon?

- Radio horizon is the range by which a direct ray from transmitting antenna reaches receiving antenna.
- Optical horizon is the distance over which Tx antenna optically 'see' the Rx antenna.

Radio horizon is about 4/3 times the optical horizon

8. What are the effects of ground on low frequency wave transmission? (May 2014)

The ground wave (or surface wave) is a wave that is guided along the surface of the earth. Earth attenuation is low for low frequency wave transmission.

9. Mention the important characteristics of D layer.

(i) Height of D layer is 50 to 90 km above the earth surface
(ii) Ionized by photo ionization of O_2 molecules
(iii) Present in day time only
(iv) Has a ionic density of 400/cc and electron density is maximum at noon
(v) Reflects very low frequency (VLF) and low frequency (LF) wave
(vi) High frequency communication is not possible via D layer and
(vii) Critical frequency is about 100kHz at vertical incidence

10. What is magneto-ionic splitting?

The earth magnetic field splits up the incident radio waves into two components of the ordinary and the extraordinary waves. The waves have elliptical polarization and rotate in opposite direction. They have different energy absorption and velocities. The phenomenon of splitting of wave into two different components by the earth's magnetic field is called as magneto-ionic splitting.

11. What is gyro frequency? What is its significance in sky wave propagation? (Dec 2013)

In ionospheric layer the vibration of electron will make a path of very narrow ellipse due to the smaller amplitude of vibration. The tendency continues until the frequency is lowered to a point at which cyclotron resonance occurs. The electrons then will follow a spiral path of steadily increasing radius along which the velocity also increases. This occurs at 1400 KHz and is termed as Gyro frequency.

12. Give the salient features of E layer.

(i) Height of E layer is 90 to 140km above the earth's surface
(ii) Ionization is by X rays radiation
(iii) During night E layer is weakly ionized
(iv) Maximum electron density is at 110km and have the value 4×10^5 /cc
(v) Critical frequency is about 3MHz to 5MHz
(vi) E layer is most useful for long distance radio propagation during day hours and
(vii) The main function of E layer is to reflect some HF waves in day hours

13. Define critical frequency.

The highest frequency of wave that will be reflected from a given layer is known as critical frequency of the given layer.

$$f_c = 9\sqrt{N_m} \qquad where\ N_m\ is\ maximum\ electron\ density$$

14. What is optimum working frequency? (Dec2012) (May 2015)

The frequency normally used for ionospheric transmission is known as the optimum working frequency. It is chosen to be about 85% of MUF. It is also known as optimum Traffic frequency.

15. How are critical frequency and maximum usable frequency related?

The maximum usable frequency and critical frequency can be related by the equation of

$$f_{MUF} = f_c\left(1+\frac{D^2}{4h^2}\right)^{\frac{1}{2}}$$

Where f_{MUF} = Maximum usable frequency

f_c = Critical frequency

D = Propagation distance, h = Height of the ionosphere layer

16. What is skip distance and maximum usable frequency? (Dec 2012)

- Skip distance is the minimum distance from the transmitter at which a sky wave of given frequency is returned to earth by the ionosphere.
- The frequency which makes a given distance corresponds to the skip distance is the MUF for those two points.

17. State secant law.

$$f_{muf} = f_c \sec i \Rightarrow SecantLaw$$

$$f_{muf} = \max imum\ usable\ frequency$$

$$f_c = critical\ \ frequency$$

$$i = angle\, of\ \ vertical\, incidence$$

18. What are the causes for abnormalities in the ionosphere.

Sudden ionospheric disturbances, Ionospheric storms, Sun spot cycle, Tides and winds in the Ionosphere, Fading, Whistles, Ionospheric Cross-modulation, Atmospheric Noise

19. How the virtual height of ionosphere can be measured?

- Virtual height can be measured using ionosonde.
- Ionosonde is the instrument used to measure the virtual height of the ionosphere. This instrument transmits an RF pulse vertically in to the ionosphere from the ground. This pulse is reflected from the ionosphere and is received by the ionosonde.
- The time delay between the transmitted and the received pulse is measured which is a measure of the virtual height of the ionosphere.

20. Why is diversity reception necessary?

Due to the general fading, there is a considerable variation in the strength of short wave signals received by common receivers through ionosphere. The diversity receiving systems provide a high and intelligible level of received signals at all times.

21. Find the maximum distance that can be covered by a space wave, when the antenna heights are 60m and 120m. (May 2013)

$$d_{\max} = \sqrt{17h_t} + \sqrt{17h_r}$$

$$d_{\max} = \sqrt{17\times 120} + \sqrt{17\times 60} \quad km$$

=77.1 km

22. What is Fading? And how it is compensated? (May 2013)

Fading is the change in signal strength at the receiver due to variation in ionospheric conditions and Multipath reception.

Fading due to rapid fluctuations can be reduced by diversity reception techniques. The commonly employed diversity reception techniques are: Frequency diversity, Space diversity, polarization diversity and Time diversity.

23. What is meant by Faraday rotation? (Dec 2011) (May 2015)

Rotation of the plane of polarization is defined as Faraday rotation. It is also defined as the process of rotation of polarization ellipse of EM wave in a magneto-ionic medium. This process occurs in the ionospheric regions when a plane wave enters the ionosphere.

It is a variable effect and leads to loss of signal power at the receiving antenna due to polarization mismatch.

24. What is free space loss factor? (Dec 2013)

The factor $[\lambda/(4\pi R)]^2$ is called free space loss factor where λ is the wavelength and R is the distance between transmitting and receiving antenna. This factor is due to the propagation. It represents the attenuation of the signal due to the spreading of the power as a function of distance.

25. Differentiate Virtual height from actual height. (May 2014)

Virtual height is defined as the height to which a short pulse of energy sent vertically upward and travelling with the speed of light would reach taking the same two ways travel time as does the actual pulse reflected from the layer.

<u>PART B</u>

1. (i) Describe the Troposcatter propagation.
(ii) Explain the effect of Earth's magnetic field on EM wave propagation. **(May 2015) (May 2013)**

2. Describe the theory of propagation of Electromagnetic wave through the ionosphere in the presence of external magnetic field and show that the medium acts as doubly refracting crystal. **(May 2013)**

3. (i) Explain the mechanism of tropospheric propagation. **(May 2015)**
(ii) Why do we use high frequency waves in sky wave propagation? Explain the mechanism of propagation. **(Dec 2012)**

4. i) Describe the troposphere and explain how ducts can be used for microwave propagation.
(ii)Explain the terms: MUF, Skip distance, Virtual height, Duct propagation, fading. **(May 2015) (Dec 2012) (Dec 2011)**

5. Explain in detail about ground wave propagation and its different mechanisms with their characteristics. **(May 2012)**

6. Draw the structure of ionosphere and explain the mechanism of ionosphere propagation and its electrical properties. **(May 2015)**

7. (i) Establish the relationship between critical frequency and maximum electron density in ionosphere.
(ii) Describe the structure of the atmosphere and specify the factors affecting the radio wave propagation. **(May 2012)**

8. Derive the expression for refractive index of the ionosphere neglecting earth's magnetic field effects.

9. (i) Describe the space wave propagation and explain the importance of line of sight propagation.
(ii) Explain the following terms with diagram: (1) Super Refraction (2) Critical frequency (3) Skip Zone **(May 2014)**

10. (i) Discuss the factors that are involved in the propagation of radio waves.
(ii) Draw a 2 ray model of Sky wave propagation and explain it in detail. **(Dec 2013)**