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Subject Name: **ANTENNAS AND WAVE PROPAGATION**

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Unit-I: Antenna Basics & Thin Linear Wire Antennas

Important points / Definitions:

1. Antenna is a transition device or a transducer between a guided wave and a free space wave or vice versa. Antenna is also said to be an impedance transforming device.

2. Radiation pattern is the relative distribution of radiated power as a function of distance in space. It is a graph which shows the variation in actual field strength of the EM wave at all points which are at equal distance from the antenna. The energy radiated in a particular direction by an antenna is measured in terms of field strength. (E Volts/m)

3. The power radiated from an antenna per unit solid angle is called the **radiation intensity** U

4. The ratio of the main beam area to the (total) beam area is called the (main) **beam efficiency**

5. The **directivity** of an antenna is equal to the ratio of the maximum power density P(θ, ϕ)max (watts/m2) to its average value over a sphere as observed in the far field of an antenna

6. Effective Aperture(Ae). It is the area over which the power is extracted from the incident wave and delivered to the load is called effective aperture.

7. Scattering Aperture(As.) It is the ratio of the reradiated power to the power density of the incident wave. Loss Aperture. (Ae). It is the area of the antenna which dissipates power as heat.

8. Collecting aperture. (Ae). It is the addition of above three apertures. Physical aperture. (Ap). This aperture is a measure of the physical size of the antenna.

9. Aperture efficiency:The ratio of the effective aperture to the physical aperture is the aperture efficiency. i.e Aperture efficiency = ηap = Ae / Ap (dimensionless).

10 .The **effective height** h of an antenna is the parameter related to the aperture. It may be defined as the ratio of the induced voltage to the incident field that is H= V / E.

11.The **field zone**: The fields around an antenna ay be divided into two principal regions. i. Near field zone (Fresnel zone) ii. Far field zone (Fraunhofer zone)

Short Questions (minimum 10 previous JNTUH Questions – Year to be mentioned)

1. What is meant by Beam Area? [2]
2. What is meant by Polarization? [3]
3. What is quarter wave monopole? [2]
4. Write the relation between effective aperture and Directivity. [3]
5. Distinguish between near field and far fields. [2]
6. Explain the concept of Retarded vector potential. [3]
7. Define the terms antenna efficiency and radiation efficiency. [2]
8. If the power density due to a point source in a free space at a distance of 25 Km is 100 micro watt/m^2 then what is the power density if the distance is (i) doubled (ii) halved. [3]

Long Questions (minimum 10 previous JNTUH Questions – Year to be mentioned)

1. Find the radiation resistance of elementary dipole with linear current distribution. [10]
2. Derive the expression for far field components of a small loop antenna. [10]
3. Derive an expression for the radiation resistance of a Half wave dipole antenna.
4.What is meant by the effective area of an antenna? How is it related to the gain? [5+5]
5. Discuss about loop antenna. What are the disadvantages of loop antenna? What are applications loop antennas? [10]
6. Derive the expression for radiation fields of a centre fed half wavelength dipole antenna. Sketch the radiation pattern.
7. Prove the reciprocity theorem as applicable to antennas and hence show the equality of directional pattern for transmission and reception by same antenna. [5+5]
8. Compare far fields of small loop antenna and short dipole antenna.
9. What is the radiation resistance of antenna? Derive the expression for radiation resistance of half wave length dipole antenna. [5+5]
10. Derive the relation between Directivity and effective aperture of an antenna.
11. Find the radiation resistance of a loop antenna of diameter 0.5 m operating at a frequency of 1 MHz. [5+5]
12. Calculate the power gain of a Half wave dipole whose ohmic losses and directive gain

are 7 ohms and 1.64 respectively.

13. Derive expressions for the components of the radiated field of an alternating current element. [5+5]

Fill in the Blanks / Choose the Best: (Minimum 10 to 15 with Answers)

1. Directivity is inversely proportional to……… [ ]

a) HPBW b) FNBW c) Beam area d) Beam width

2.. Gain is always -------------than directivity [ ]

a) Greater b) lesser c) Equal to d) none

3.. Directivity and Resolution are------------ [ ]

a) Different b) same c) Both a and b d) none

4.. Effective aperture is always ----------- than Physical aperture. [ ]

a) Higher b) lower c) Both a and b d) none

5.Alternating current element is given by [ ]
a)I dl b) I dl cosωt c) I dl sinωt d) I

6. ---------potential is used to find the field components of current element [ ]
a) Scalar Potential, V b) Vector Potential, A c) Both a and b d) None

7. -------- is basic building block for any practical antenna [ ]
a) Current element b) Monopole c) Dipole d) Loop

8. The HΦ Component will consists of----------field. [ ]
a) Radiation b) Induction c) Both a and b d) All

9. The Eθ Component will consists of---------- [ ]
a) Radiation b) Induction c) Electro static d) All

10. The Er Component will consists of---------- [ ]

a) Induction b) Electro static c) Both a and b d) All

11. The induction and radiation fields of current element are equal at distance of ------ [ ]

a) λ/2 b) λ/4 c) λ/6 d) λ/10

12. The radiation resistance of current element is given by [ ]

a) Rr = 80Π 2 (dl/λ)2 b) Rr = 20Π 2 (dl/λ)2 c) Rr = 10Π 2 (dl/λ)2 d) None

13. The radiation resistance of short dipole is given by [ ]

a) Rr = 80Π 2 (dl/λ)2 b) Rr = 20Π 2 (dl/λ)2 c) Rr = 10Π 2 (dl/λ)2 d) None

14. The radiation resistance of short monopole is given by [ ]

a) Rr = 80Π 2 (dl/λ)2 b) Rr = 20Π 2 (dl/λ)2 c) Rr = 10Π 2 (dl/λ)2 d) None

Unit-II VHF, UHF and Microwave Antennas - I

Important points / Definitions:

1.Yagi-Uda antenna is the most commonly used type of antenna for TV reception over the last few decades. It has high gain and directivity .The frequency range in which the Yagi-Uda antennas operate is around 30 MHz to 3GHz which belong to the VHF and UHF bands.

2.**Helical antenna** or helix antenna is the antenna in which the conducting wire is wound in helical shape and connected to the ground plate with a feeder line. It is the simplest antenna, which provides circularly polarized wave

3. **Horn antenna** may be considered as a flared out wave guide, by which the directivity is improved and the diffraction is reduced. The operational frequency range of a horn antenna is around 300MHz to 30GHz. This antenna works in UHF and SHF frequency ranges. Sectorial horn antenna, flares out in only one direction.

4.Flaring in the direction of Electric vector produces the sectorial E-plane horn. Similarly, flaring in the direction of Magnetic vector, produces the sectorial H-plane horn.

5.Pyramidal horn antenna has flaring on both sides. If flaring is done on both the E & H walls of a rectangular waveguide, then pyramidal horn antenna is produced. This antenna has the shape of a truncated pyramid.

6.Conical horn :When the walls of a circular wave guide are flared, it is known as a conical horn. This is a logical termination of a circular wave guide.

7.The predominant modes of operation of a helical antenna are −

- Normal or perpendicular mode of radiation.
- Axial or end-fire or beam mode of radiation

8.In axial mode of radiation, the radiation is in the end-fire direction along the helical axis and the waves are circularly or nearly circularly polarized

9.In normal mode of radiation, the radiation field is normal to the helix axis

Short Questions (minimum 10 previous JNTUH Questions – Year to be mentioned)

1. Why folded dipole antenna is used in yagi antenna? [2]
2. What is axial mode of radiation? [3]
3. What is optimum horn? Explain its important features. [2]
4. Explain how unidirectional pattern is formed in Yag Uda antenna from the bi directional pattern of folded dipole. [3]
5. Write down the characteristics of folded dipole. [2]
6. Explain the construction of Yagi-Uda antenna. [3]
7. Draw the structure of helical antenna with a coaxial line feed. [2]
8. What is the spacing between elements of Yagi - Uda antenna [3]

Long Questions (minimum 10 previous JNTUH Questions – Year to be mentioned)

1.What is Yagi-uda Antenna? Explain the construction and operation of Yagi-uda Antenna. Also explain its general characteristics. [10]

2. Explain the Half-Wavelength Folded Dipole. [10]

3. Discuss in detail about the pyramidal Horn antenna and write down its merits and demerits.

4. What are the design considerations of pyramidal Horns? Explain. [5+5]

5. Explain about the operating principle of Helical antenna in Normal and Axial modes.

6. Design Yagi-Uda antenna of 6 elements to provide gain of 12 dB if the operating frequency is 200 MHz. [5+5]

7. Derive the construction and basic principles of operation of a helical antenna under (i) normal mode of operation (ii) axial mode of operation

8. Explain the working of folded dipole antenna. [5+5]

9. Draw the sketch of Yagi Uda array antenna. Prove how the longer antenna behind the main antenna behaves as a reflector and the shorter antenna in front of main antenna acts as a director.

10. What is electromagnetic horn antenna? What are the various types of horn? What are their practical applications? [5+5]

11. Write short notes on Yagi-Uda array Antenna and its applications, advantages and drawbacks.

12. Discuss different types of horn antennas with neat sketches. [7+3]

13. With neat sketch, explain the operation of helical antenna. [10]

Fill in the Blanks / Choose the Best: (Minimum 10 to 15 with Answers)

1.Microwave frequency range is------- [ ]

a) above 30MHZ b) above 300MHZ C) above 200MHZ d) above 2000MHZ.

2. Yagi-Uda antenna consists of----- [ ]

a) Folded Dipole b) Reflector C) Director d) All above

3. The radiation resistance of folded dipole of equal radii is---------- [ ]

a) 657Ohms b) 292 Ohms C) 300 Ohms d) 277 Ohms

4. The radiation resistance of folded dipole of unequal radii (r2=2r1) is---------- [ ]

a) 657Ohms b) 292 Ohms C) 300 Ohms d) 277 Ohms

5. The helix is having the geometry of ------------ [ ]

a) straight wire b) cirle C) cylinder d) All above.

6. The radiation pattern of helix in Axial mode is----------- [ ]

a) Bi directional b) Uni directional C) 4 lobed d) Omni directional

7. The radiation pattern of helix in Normal mode is----------- [ ]

a) Bi directional b) Uni directional C) 4 lobed d) Omni directional

8.. Horn antennas used in the frequency range of---------- [ ]

a) VHF b) UHF C) SHF d) MW

Unit III VHF, UHF and Microwave Antennas - II

Important points / Definitions:

1.**Micro strip** antenna consists of a very thin metallic strip placed on a ground plane with a di-electric material in-between. The radiating element and feed lines are placed by the process of photo-etching on the di-electric material.

2.These are very low size antennas having low radiation.

3.The Micro strip antennas are popular for low profile applications at frequencies above 100MHz.

4.The **advantages** of Micro strip antenna −

- Lighteweight
- Low cost
- Ease of installation

5.The **disadvantages** of Micro strip antenna −

- Inefficient radiation
- Narrow frequency bandwidth

6.The **applications** of Micro strip antenna −

- Used in Space craft applications
- Used in Air craft applications
- Used in Low profile antenna applications

Short Questions (minimum 10 previous JNTUH Questions – Year to be mentioned)

1. What is Lunenburg lens? [2]
2. What are the various feeds used in reflectors? [3]
3. Why is zoning done in lens antenna? [2]
4. Discuss various methods available for analysis of microstrip antenna. [3]
5. List any five applications of patch antennas. [2]
6. Discuss the features of Micro-strip antennas. [3]

7. What are the disadvantages of lens antennas? [2]
8. Write short notes on horn antenna. [3]

Long Questions (minimum 10 previous JNTUH Questions – Year to be mentioned)

1. Describe the parabolic reflector used at micro frequencies. [10]

2. Explain the different types of lens antennas. [10]

3. Discuss the principle of operation and the consideration which have to be gone into the design and construction of parabolic reflector antenna.

4. Explain the various feeding mechanisms used in parabolic reflector antennas. [5+5]

5. Show that the contour of a nonmetallic dielectric lens antenna is a hyperbola.

6. Explain the principle of working of lens antenna. [5+5]

7. Explain in detail Flar sheet and corner reflector antennas in detail.

8. Explain different feed methods used for parabolic reflector antennas. [5+5]

9. With necessary diagrams explain the principle of operation of Lens antennas and also discuss its advantages and disadvantages. [10]

10. Explain the geometry of paraboloidal reflector with neat diagram.

11. Calculate the 3dB beam width and power gain of a parabolic antenna at a frequency of 1.6GHz with 2.4 meter diameter and 48% antenna efficiency? [6+4]

12. Compare UHF and VHF antennas.

13. What are the various feeds used in reflectors? [7+3]

Fill in the Blanks / Choose the Best: (Minimum 10 to 15 with Answers)

1.Micro strip antenna was first introduced by ………… [ ]

A)Marconi B)Hertz C)Munson D) Cassegrain

2. The widely used shape for patch antennas is ………… [ ]

A)Rectangular B)Circular C)Elliptical D)Parabolic

3. The efficiency of Micro strip antenna is …………………. [ ]

A)High B)Very high C infinite D)Low

4. For square corner reflector the flaring angle is……………………. [ ]

A)30 degrees B)60 degrees C)90 degrees D)180 degrees

5. The no. of images formed for a square corner reflector, using method of images are… [ ]

A)3 B)5 C) 7 D) 6

6. The no. of images formed for a 30 degrees corner reflector, using method of Images are……….. [ ]

A)3 B)5 C)7 D)6

7. The no. of images formed for a 60 degrees corner reflector, using method of images are……….. [ ]

A)3 B)5 C)7 D)6

8. A single narrow beam of radiation results in square corner reflector for spacing of s=……….. [ ]

A)2λ B)λ C)3λ/2 D)λ/2

9. Two narrow beams of radiation results in square corner reflector for spacing of s=……… [ ]

A) 2λ B) λ C) 3λ/2 D)λ/2

10. Three narrow beams of radiation results in square corner reflector for spacing of s=……….. [ ]

A)2λ B) λ C)3λ/2 D) λ/2

Unit-IV: Antenna Arrays & Antenna Measurements

Important points / Definitions:

1.A **Collinear array** consists of two or more half-wave dipoles, which are placed end to end. These antennas are placed on a common line or axis, being parallel or collinear.

2.The maximum radiation in these arrays is broad side and perpendicular to the line of array. These arrays are also called as broad cast or **Omni-directional arrays**

3.Driven element:The antennas radiate individually and while in array, the radiation of all the elements sum up to form the radiation beam. All the elements of the array need not be connected to the feed. The dipole that is connected to the feed is known as a driven element.

4.Parasitic Elements: The elements, which are added do not possess an electrical connection between them to the driven element or the feed. They are positioned so that they lie in the induction field of the driven element. Hence, they are known as parasitic elements.

5.Reflector: If one of the parasitic element, which is 5% longer than driven element, is placed close to the driven element is longer, then it acts as a concave mirror, which reflects the energy in the direction of the radiation pattern rather than its own direction and hence is known as a reflector.

6.Director:A parasitic element, which is 5% shorter than the driven element, from which it receives energy, tends to increase radiation in its own direction and therefore, behaves like convergent convex lens. This element is called as a director. A number of directors are placed to increase the directivity

7.The antenna array in its simplest form, having a number of elements of equal size, equally spaced along a straight line or axis, forming collinear points, with all dipoles in the same phase, from the same source together form **the broad side array.**

8.End-fire array is same as that of the broad side array. The magnitude of currents in each element is same, but there is a phase difference between these currents

Short Questions (minimum 10 previous JNTUH Questions – Year to be mentioned)

1. Define isotopic source. [2]
2. What is reciprocity of an antenna? [3]
3. Explain how beam steering is achieved in uniform linear array? [2]
4. Calculate directivity of a given linear uniform BSA of 10 element with separation of $\lambda/4$ between the elements. [3]
5. What is a uniform linear array? [2]
6. A linear broad-side array consists of 4 equal isotropic sources with λ / 3 spacing(overalL length of array =λ). Calculate the beam width. [3]
7. What is the main disadvantage of binomial array? [2]
8. Draw uniform linear array. [3].

Long Questions (minimum 10 previous JNTUH Questions – Year to be mentioned)

1. State reciprocity theorem for antennas. Prove that the self –impedance of an Antenna in transmitting and receiving antenna are same. [10]

2. What is linear array? Compare Broad side array and End fire array. [10

3. What is binomial array antenna. What its basic principle of working? Mention the advantages and disadvantages.

4. What is the principle of pattern multiplication explain with an example. [5+5]

5. What is near field and far field region? Why is the condition 2D2/λ chosen for far field region.

6. With a neat sketch explain the procedure of radiation pattern measurement. [5+5]

7. Derive an Expression of array factor for an n-element uniform array.

8. Explain in detail about the measurement of radiation pattern with neat diagram. [5+5]

9. Explain in detail about the Binomial array and differentiate it with a linear array.

10. Derive an expression for the radiation pattern of a Broadside uniform linear array of elements with λ / 2 spacing and obtain its radiation pattern. [5+5]

11. Discuss broadside array and end fire array with neat diagrams.
12. Derive expression for antenna array factor. [7+3]

13.An end fire array consisting of several half wave length long isotropic radiators having directive gain of 30. Find the length of array for broad side antenna?

14. A broadside array of identical antennas consists 8 isotropic radiators separated by distance λ/2. Find radiation field in a plane containing the line of array showing directions of maxima and null. [7+3]

Fill in the Blanks / Choose the Best: (Minimum 10 to 15 with Answers)

1. Linear array is a system of ------spaced elements. [ ]

a) Un equally. b) equally. c) Both a and b. d) None.

2. In a Uniform Linear array all elements are fed with a current of ----------amplitude [ ]

a) Equal. b) Unequal. c) Both a and b. d) None.

3. In a Broad side array the radiation is along----------- [ ]

a) X-direction. b) Y-direction. c) Both a and b. d) None.

4. In a end- fire array the radiation is along ----------- [ ]

a) X-direction. b) Y-direction. c) Both a and b. d) None.

5. In increased end- fire array the radiation is along----------- [ ]

a) X-direction. b) Y-direction. c) Both a and b. d) N

Unit-V: Wave Propagation – I

Important points / Definitions:

Sky wave: Waves that arrive at the receiver after reflection in the ionosphere is called sky wave

Tropospheric wave: Waves that arrive at the receiver after reflection from the troposphere region is called Tropospheric wave.(ie 10 Km from Earth surface).

Ground wave: Waves propagated over other paths near the earth surface is called ground wave propagation.

Ground wave classified into two types.
i. Space wave
ii. Surface wave.

Space Wave.: It is made up of direct wave and ground reflected wave. Also includes the portion of energy received as a result of diffraction around the earth surface and the reflection from the upper atmosphere.

Surface Wave: Wave that is guided along the earth' s surface like an EM wave is guided by a transmission is called surface wave. Attenuation of this wave is directly affected by the constant of earth along which it travels.

Fading is Variation of signal strength occur on line of sight paths as a result of the atmospheric conditions .

Multi path fading is caused by interference between the direct and ground reflected waves as well as interference between two are more paths in the atmosphere.

Diversity reception :To minimize the fading and to avoid the multi path interference the technique used are diversity reception. It is obtained by two ways.

i. Space diversity reception.
ii. Frequency diversity reception.
iii. Polarization diversity.

The factors that affect the propagation of radio waves are
i. Curvature of earth.
ii. Earth' s magnetic field.
iii. Frequency of the signal.
iv. Plane earth reflection.

The maximum Frequency that can be reflected back for a given distance of transmission is called the maximum usable frequency (MUF) for that distance.

Short Questions (minimum 10 previous JNTUH Questions – Year to be mentioned)

1) What is skip distance? [2]

2) What is wave tilt? List all the factors that affect wave tilt. [3]

3) Define Wave tilt of Ground Wave. [2]

4) Write a short note on Super Refraction.

5) Derive the expression for refractive index of ionosphere. [2]

6) Explain the concept of super refraction.

7) What are the types of Ground wave? [2]

8) What are the factors that affect the propagation of radio waves? [3

Long Questions (minimum 10 previous JNTUH Questions – Year to be mentioned)

1. Deduce an expression for the critical frequency of an ionized region in terms of its Maximum ionization density. [10]

2. Describe the troposphere and explain how ducts can be used for Microwave propagation. [10]

3. Derive the relation for dielectric constant of ionosphere layer in terms of plasma frequency.

4. Explain the phenomenon of ducting? What are the conditions required for manifestation of this phenomenon. [5+5]

5. Briefly explain the tropospheric propagation and multi-hop propagation.

6. Explain the following terms with diagram (i) Duct propagation (ii) Skip zone [5+5]

7. Find the maximum range of Tropospheric transmission for which the height of transmitting antenna is 100ft and that of receiving antenna is 50 ft.

8. Derive the relation between Maximum usable frequency (MUF) and skip distance.[5+5]

9. Write short notes on:

a) Virtual height

b) Line of sight propagation

c) Effect of earth's curvature

10. Briefly describe the following terms connected with sky-wave propagation:

a) Virtual height

b) Critical frequency

c) Maximum usable frequency

d) Skip distance. [10]

11.a) Describe the troposphere and explain how ducts can be used for microwave Propagation.

b) Write a short note on Multi-hop propagation. [6+4]

Fill in the Blanks / Choose the Best: (Minimum 10 to 15 with Answers)

1) The troposphere is extends up to a height of ----------------- [ ]

A) 5km B) 10km C) 15km D) 20km

2) For small distances the earth can be considered as ------------------region [ ]

A) flat B) curved C) conductor D) dielectric

3) For large distances the earth can be considered as ------------------region [ ]

A) flat B) curved C) conductor D) dielectric

4) In general the earth will acts as a ------------------- [ ]

A) leaky resistor B) leaky inductor C) leaky capacitor D) leaky transistor

5) According to Rayleigh if R>10, the reflecting surface will be considered as…………. [ ]

A) smooth region B) rough region C) both a &b D) none

6) According to Rayleigh if R<0.1, the reflecting surface will be considered as…………. [ ]

A) smooth region B) rough C) both a &b D) none

7) The line of sight (LOS) distance is the distance travelled by the …………….wave. [ ]

A) diffracted B) scattered C) reflected D) direct

8) The phenomenon of reduction of signal strength due to variation in refractive index is called…………. [ ]

A) wave tilting B) fading C) diffraction D) scattering

9) The E-Layer of Ionosphere exists between [ ]

A) 40 to 90 km B) 90 to 140 km

C) 140 to 250 km D) 250 to 400 km

10) The F2-Layer of Ionosphere exists between [ ]

A) 40 to 90 km B) 90 to 140 km C) 140 to 250 km D) 250 to 400 km

11.As one moves away from the transmitter, the ground waves eventuallydisappears because of

(A) Maximum single hop distance limitation (B) Loss of line-of-sight condition

(C) Tilting (D) Interference from the sky waves

ANSWER: Tilting

12.--------is not between F2 layer and D layer

(A) G region (B) E layer (C) F1 layer (D) All of the above

ANSWER: G region

13.The abnormal variation in ionosphere is

(A) Ionospheric storm (B) Seasonal variation

(C) Diurnal variation (D) All of the above

ANSWER: Ionospheric storm

14.The effect of skip distance in frequency is

(A) It decreases with increase in frequency

(B) It increases with increase in frequency

(C) It increases with decrease in frequency

(D) It decreases with decrease in frequency

ANSWER: It increases with increase in frequency

15. The electromagnetic waves get absorbed in the atmosphere. The absorption of electromagnetic waves mainly depends on

(A) Distance from the transmitter (B) The polarization of waves

(C) The frequency in use (D) All of the above

ANSWER: The frequency in use

16. The critical frequency of a wave is 30 MHz and departing angle is 60°. The MUF is given to be

(A) 60 MHz(B) 15 MHz(C) 120 MHz(D) 30 MHz

ANSWER: 60 MHz

17. The frequency for satellite communication should be

(A) More than the critical frequency

(B) Less than the critical frequency

(C) Equal to the critical frequency

(D) None of the above

ANSWER: More than the critical frequency

18.The fluctuation in the received signal strength at the receiver or a random variation in the received signal is known as

(A) Absorption(B) Cycling(C) Fluctuation(D) Fading

ANSWER: Fading