Department of Electronics and Communication Engineering

EC8701 – ANTENNAS & MICROWAVE ENGINEERING

PART- A – EPC

UNIT - I

1. What is radiation pattern?

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).

TYPES : Field pattern , Power pattern

2. Differentiate Far field and Near field region

When a signal from a transmitter is applied to an antenna, it sends out electromagnetic waves in to free space. The EM field characteristics vary as a function of distance from the antenna. They are broadly divided into two regions, the near-field region, and the far field region.

The Far Field Region is the region that comes after the near radiative near field. In this region, the EM fields are dominated by radiating fields. The E and H-fields are orthogonal to each other and to the direction of propagation as with plane waves. The far-field region is represented by the following equation:

$$Far\ Field\ Region > \frac{2D^2}{\lambda}$$

Where D = Maximum linear dimension of the antenna

λ = Wavelength of the EM Waves

Antennas are usually used to transfer signals at large distances which are considered to be in the far-field region. One condition that must be met when making measurements in the far field region is that the distance from the antenna must be much greater than the size of the antenna and the wavelength.

The Near Field Region is the region right next to the antenna. It is defined by the following equation:

$$Near\ Field\ Region < \frac{2D^2}{\lambda}$$

Where D = Maximum linear dimension of the antenna

λ = Wavelength of the EM Waves

In this region, the fields are sort of unpredictable and therefore no measurements are usually made in this region.

Reactive Near Field:

$$Reactive\ Near\ Field\ Region < 0.62\sqrt{\frac{D^3}{\lambda}}$$

Where D = Maximum linear dimension of the antenna
λ = Wavelength of the EM Waves

Radiative Near Field:

$$0.62\sqrt{\frac{D^3}{\lambda}} < Radiative\ Near\ Field\ Region < \frac{2D^2}{\lambda}$$

Where D = Maximum linear dimension of the antenna
λ = Wavelength of the EM Waves

3. **Define Directivity**

   The directivity (D) of an antenna is the ratio of the maximum radiation intensity **U (θ,φ)max** to its average radiation intensity **U (θ,φ)avg**

$$Directivity, D = \frac{U_{(\theta,\varphi)max}}{U_{(\theta,\varphi)avg}} = \frac{4\pi}{\Omega A}$$

4. **What is meant by Effective aperture**

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

$$\text{Effective aperture Ae} = \frac{Power\ received}{Power\ density}, \text{m}^2$$

5. **What is link budget? Mention a simple link budget equation**

   The link budget is a design aid , calculated during the design of a communication system to determine the received power , to ensure that the information is received intelligibly with an adequate signal to noise ratio.

   Received Power (dBm) = Transmitted Power (dBm) + Gains (dB) – Losses (dB)

6. **Define the term antenna gain**

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

$$\boldsymbol{Gain\ (G) = \frac{Maximum\ radiation\ intensity\ from\ test\ Antenna}{Maximum\ radiation\ intensity\ from\ the\ refrence\ Antenna}}$$

7. Develop Friis equation and explain each of it's parameters

$$R_R = P_T((G_T G_R)\frac{\lambda}{4\pi d}$$

Where

P_R – Received power (w)

P_T – Transmitted power (w)

G_T – Transmitted antenna gain

G_R – Receiver antenna gain

λ - wavelength – Distance between two antennas

- 8. **What is meant by impedance matching of an antenna.**

  Impedance matching is designing source and load impedances to minimize signal reflection or maximize power transfer.

9.Find the equation for antenna noise temperature with it's definition

The total power available $P = kT_A B \quad W$

Let the effective aperture of antenna be Ae , . then the power density per unit bandwidth is produced in the direction of the radiation .This is called as flux density, S

Hence , Power available $P = kAeB \quad W$

Equate these two equations. $T_A = \frac{SA_e}{k} \quad K$

10. Define front to back ratio

It is the ratio of power radiated in the desired direction to the power radiated in the opposite direction.

$$FBR = \frac{Power\ radiated\ in\ the\ desired\ direction}{Power\ radiated\ in\ opposite\ direction}$$

11. 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

12. What is radiation resistance?

The antenna is a radiating device in which power is radiated into space in the form of electromagnetic wave.

W' = I2 Rr ; Rr = W'/ I2 Where Rr is a fictitious resistance called as radiation resistance.

13. What is meant by antenna beam width?

Antenna beam width is a measure of directivity of an antenna. Antenna beam width is an angular width in degrees, measured on the radiation pattern (major lobe) between points where the radiated power has fallen to half its maximum value .This is called as "beam width" between half power points or half power beam width.(HPBW).

14. What is meant by isotropic radiator?

A isotropic radiator is a fictitious radiator and is defined as a radiator which radiates fields uniformly in all directions. It is also called as isotropic source or omni directional radiator or simply unipole

15. Define gain

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

Maximum radiation intensity from test antenna

Gain (G) = ---

Maximum radiation intensity from the reference antenna with

same input power

UNIT – II

1. **What is aperture blockage? Give one example**

   The feed antenna blocks some of the radiation that would be transmitted by the reflector. The relative reduction in effective area of a reflector antenna due to the masking effect of antenna parts, such as the feed and sub reflector.

   Example - The parabolic dish has desirable properties relative to a single focal point.

2. **Describe the features of the pyramidal horn antenna**

   A pyramidal horn is formed by flaring both the E plane and H plane of a rectangular waveguide.

The features are,
(i) Pyramidal microwave horn antenna, with a bandwidth of 0.8 to 18 GHz.
(ii) A coaxial cable feed line attaches to the connector visible at top.
(iii) This type is called a ridged horn.
(iv) The curving fins visible inside the mouth of the horn increase the antenna's bandwidth

3. **Discuss the significance of aperture of antennas**

The aperture of the antenna is the area whose orientation is normal to the direction from where the electromagnetic wave is coming .This is done in order to intercept the equivalent power from the incoming wave as it can be produced by the antenna which is receiving it.

4. **Give the applications of micro strip antenna**

(i) Satellite radio receivers.
(ii) Broad Band Communications (wireless).
(ii) Air craft's.

5. **Illustrate the basic concept of reflector antenna.**

An antenna reflector is a device that reflects electromagnetic waves. Antenna reflectors can exist as a standalone device for redirecting radio frequency (RF) energy, or can be integrated as part of an antenna assembly.

6. **Mention the types of feeding structures used for a micro strip patch.**

The four most popular feed techniques used:
Micro Strip Line,
Coaxial Probe (Both Contacting Schemes),
Aperture Coupling And
Proximity Coupling (Both Non-Contacting Schemes).

7. **State Huygens principle for Aperture antennas**

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 that a secondary wave front can be constructed as the envelope of these secondary waves.

8. **What are the limitations of reflector antenna? Apply the methods to overcome them**

In spite of feed horn at focus and uniform illumination, certain amount of power from feed is bound to slop over the edges of parabolic reflector. This power is responsible to form side lobes in the radiation pattern.

This is overcome by placing feed exactly at the focus of the parabolic reflector antenna. This is difficult to achieve practically

9. **Why log periodic antenna is called so?**

The geometry of log periodic antenna is so chosen that electrical properties must repeat periodically with logarithm of the frequency

10. **What are different types of Horn antenna**

(i) Pyramidal horn
(ii) Sectorial horn
(iii) Conical horn
(iv) Scalar horn or Exponential Horn

(v) Corrugated Horn
(vi) Gain horn
(vii) Feed horn

11. Define Spill over efficiency?

This measures the amount of radiation from the feed antenna that is reflected by the reflector. Due to the finite size of the reflector, some of the radiation from the feed antenna will travel away from the main axis at an angle greater than $\boldsymbol{\theta}_0$, thus not being reflected. This efficiency can be improved by moving the feed closer to the reflector, or by increasing the size of the reflector.

UNIT – III

1. What is mean by uniform linear array?

An antenna composed of a relatively large number of usually identical elements arranged in a single line or in a plane with uniform spacing usually with a uniform feed system

2. Define phased array.

A phased array, in antenna theory, is an array of antennas in which all of the phases of each signal that feeds each antenna are set in such a way that the effective radiation pattern of the entire array is set toward the desired direction and that the signals emanating toward undesired directions are suppressed. It is a way to direct waves of radiation toward a desired direction

3. Write about pattern multiplication and its advantages.

The field pattern of an array of non isotropic but similar point sources is the product of the pattern of the individual source and the pattern of an array of isotropic point sources having the same locations, relative amplitudes, and phase as the non-isotropic point sources.

4. Point out the features of smart antennas and where it is used?

(i) Phased array
(ii) Digital beam forming
(iii) Intelligent antenna and Spatial processing

These are used in acoustic signal processing , track and scan radar , radio astronomy and radio telescopes and mostly in cellular systems like W- CDMA , UMTS and LTE

5. Interpret the meaning of array factor.

The array factor quantifies the effect of combining radiating elements in an array without the element specific radiation pattern taken into account. The overall radiation is defined by this array factor.

6. How to eliminate minor lobes?

Secondary or side lobes in the linear broadside arrays are to be eliminated then the radiating sources must have current amplitudes proportional to the coefficient of the above binomial series.

7. Summarize the advantages and disadvantages of binomial array.

Advantages:

(i) The binomial array is one in which all the elements are fed with current of non uniform amplitude such that it reduces minor lobes.

(ii) Hence, we use Pascal triangle to select the coefficient or amplitudes of elements.
(iii) Secondary lobes do not appear in the radiation pattern

Disadvantages:

(i) HPBW increases and hence the directivity decreases.
(ii) Large amplitude ratio is required for a design of a large array

8. What are the various difference between binomial and linear arrays?

Binomial Array	Linear Array
1. The binomial array is one in which all the elements are fed with currents of non-uniform amplitude.	1. In antenna array if the individual antennas are equal spaced in a straight line, then it is said to be linear array.
2. Elements are fed with unequal amplitude.	2. If elements are fed with equal amplitude, it is called as uniform linear array.
3. We use Pascal triangle to select the coefficient or amplitudes of elements.	3. We do not use Pascal triangle,
4. Principle of multiplication of pattern is used for derivation of pattern.	4. Principle of multiplication of pattern is used for derivation of pattern.
5. Secondary lobes does not appear in the radiation pattern.	5.Secondary lobes appear in the radiation pattern
6. HPBW increases and directivity decreases.	6. HPBW is less compared to binomial array.
For Example: *For 5 element array with λ/2 spacing HPBW = 31°*	**For Example:** For 5 "element array with λ/2 spacing HPBW=23^0.
7. Design is complex for large array due to large amplitude ratio.	7. Design is simple for large array due to uniform amplitude

9. What is Tapering of Arrays:

The bidirectional patterns of antennas contain minor lobes in addition to major lobes. These minor lobes not only waste the amount of power but cause interference thus they are undesirable. The interference is severe in case of radar applications where it may cause improper detection of the target object.

Tapering is a technique in which currents or amplitudes are fed non-uniformly in the sources of a linear array. If the centre source is made to radiate more strongly than the end sources, the level of minor lobes are reduced. By tapering of arrays from centre to end according to some prescription reduces the side lobe level. I f the tapering amplitudes follow coefficients of binomial series or Tchebyscheff polynomial, then accordingly the arrays are known as binomial arrays or dolph Tchebyscheff arrays respectively.

10. Compare beam steering beam forming.

Beam steering (moving): It is an analog processing which change only the phase between antenna arrays to steer only one beam in specific directions

Beam forming: it is to build array of single antenna elements to form radiation beams

UNIT – IV

1. Discuss about attenuator and resonator

Attenuator: It is a microwave two port device that reduces the power of a signal without appreciably distorting its waveform.

Resonator: It is a filter and select frequencies in oscillators, amplifiers and tuners. Fields inside a resonator store energy at the resonant frequency where equal storage of electric and magnetic energies occurs.

2. What are the applications of reflex klystron ?

(i)Signal source in MW generator

(ii) Local oscillators in receivers

(iii) It is used in FM oscillator in low power MW links.

(iv)In parametric amplifier as pump source.

3. What are the high frequency effects in conventional tubes?

The high frequency effects in conventional tubes are

i) Circuit reactance
ii) Inter electrode capacitance
iii) Lead inductance
iv) Transit time effect
v) Cathode emission
vi) Plate heat dissipation area
vii) Power loss due to skin effect, radiation and dielectric loss.

4. Write the effect of transit time.

There are two effects.

1) At low frequencies, the grid and anode signals are no longer 180^{O} out of phase, thus causing design problems with feedback in oscillators.

2) The grid begins to take power from the driving source and the power is absorbed even when the grid is negatively biased.

5. What are the differences between TWTA and klystron amplifier?

TWT	Klystron
Interaction between EM field and beam of electrons in TWT is continuous over the entire length.	Interaction in klystron occurs only at the gaps of resonant cavities.
In coupled cavity TWT, coupling effect takes place between cavities.	In klystron each cavity operates independently and there is no mutual coupling.
TWT does not have resonant cavity. It uses helix structure.	Klystron has resonant cavities.
TWT has wider bandwidth of operation.	Klystron has smaller bandwidth of operation.
TWT operates on lower efficiency.	Klystron has comparatively high efficiency.
There are two types viz. helix and coupled cavity.	There are two types viz. Two or Multi-cavity , reflex klystrons
Frequency of operation is from 300 MHz to 50 GHz	Frequency of operation is from 4 to 200 GHz
Handles CW power upto 200Watt	Handles power of 1 mW to 2.5 W

6. List the basic parameters to measure the performance of a directional coupler? Give the applications of directional coupler

Parameters : Coupling coefficient, Directivity, Insertion loss, Isolation

Applications of directional coupler

(i) Unidirectional power measurement

(ii).SWR measurement

(iii).Unidirectional wave launching

(iv). Reflectometer

(iv) Balanced duplexer

7. **Summarize the condition for oscillation in reflex klystron**

The necessary condition for oscillation is that the magnitude of the negative real part of the electronic admittance should not be less than the total conductance of the cavity circuit i.e. $|-G_e| \geq G$.

Where G=Gc + Gb +G1 = ------ Rsh

Rsh - Effective shunt resistance

Gc - Copper losses of cavity

Gb - Beam loading conductance

Gl – Load conductance

8. **What is meant by negative resistance of Gunn diode**

The Negative resistance is defined as that property of a device which causes the current through it to be 180 degree out of phase with the voltage across it.

The carrier drift velocity increases linearly from 0 to maximum when the electric field is increased from 0 to threshold value in gunn diodes. When the electric field is beyond the threshold value of 3000v/cm the drift velocity is decreased and the diode exhibit negative resistance.

9. **Examine the factors reducing the efficiency of IMPATT diode.**

(i) Space charge effect

(ii) Reverse saturation current effect

(iii) High frequency skin effect

(iv) Ionization saturation effect.

10. Determine the purpose of slow wave structures in TWT.

Slow wave structures are special circuits that are used in microwave tubes to reduce wave velocity in a certain direction so that the electron beam and the signal wave can interact. In TWT, since the beam can be accelerated only to velocities that are about a fraction of the velocity of light, slow wave structures are used.

11. Why magnetron is called as cross field device?

In cavity magnetron, there exists a radial electric field and an axial magnetic field perpendicular to each other and hence magnetron is called as a cross filed device.

12. Formulate the frequency pulling and frequency pushing in magnetrons.

Frequency pulling is caused by changes in the load impedance reflected into the cavity resonators. Frequency pushing is due to the change in anode voltage which alters the orbital velocity of electron clouds

13. Define Gunn Effect and list the modes.

Guneffect 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 fuction of time.The frequency of oscillation was determined mainly by the specimen and not by the external circuit.

(i) Gunn mode or Transit time mode

(ii) LSA mode

(iii)Quenched and

(iv) Delayed domain modes

14. Categorize the applications of magic-Tee.

(i) Magic Tee junction is used to measure the impedance.

A null detector is connected to E-Arm port while the Microwave source is connected to H-Arm port. The collinear ports together with these ports make a bridge and the impedance measurement is done by balancing the bridge.

(ii) Magic Tee is used as a duplexer

The duplexer is a circuit which works as both the transmitter and the receiver, using a single antenna for both the purposes.

Port 1 and 2 are used as receiver and transmitter where they are isolated and hence will not interfere. An antenna is connected to E-Arm port. A matched load is connected to H-Arm port, which provides no reflections. Now there exists transmission or reception without any problem.

(iii)Magic Tee is used as a Mixer

E-Arm port is connected to the antenna and the H-Arm port is connected to the local oscillator. Port 2 has matched load which has no reflections and port 1 has the mixer circuit, which gets half of the signal power and half of the oscillator power to produce IF frequency.

(iv) Magic Tee junction is also used as Microwave Bridge, Microwave discriminator etc.

UNIT – V

1. Define Impedance matching

- Matching a load impedance to the source or internal impedance of a driving source.
- It is used to optimise the overall desired characteristics of the device and its associated input and output transmission lines.

2. List out the need for impedance matching

(i) To achieve maximum power transfer from source to load

(ii) A perfectly matched network ensures optimal power flow

3. Define un conditional stability with regard to microwave transistor amplifier

A network unconditionally stable, if the real part of the input impedance Zin and the output impedance Zoutis greater than zeo for all positive real source and load impedance at a specific frequency

4. Define transducer power gain

The gain of the amplifier when placed between source and load is called transducer power gain.

$$G_T = \frac{Power\ delivered\ to\ the\ load}{Available\ power\ from\ source}$$

5. Define Stability

The magnitude of reflection coefficient is less than unity.

$$|\gamma_l| < 1 \ \ and \ |\gamma_s| < 1$$

6. Define unilateral power gain

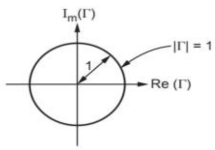
When the feedback effect of amplifier is neglected i.e ..S12=0

7. State the significance of micro strip matching

- At RF, the parasitic of the discrete elements noticeable. It complicates the calculations and components values.
- The availability of discrete components in standard value makes it difficult
- Instead of lumped elements, distributed elements are preferable at high frequencies.

8. Draw VSWR circle for reflection coefficient 1

$$\gamma = \frac{Z_L - Z_0}{Z_L + Z_0}$$



9. Define noise figure

Noise factor F is a measure of how the signal to noise ratio is degraded by a device

$$F = \frac{(S_{IN}/N_{IN})}{(S_{OUT}/N_{OUT})}$$

Noise figure NF

$$NF_{dB} = 10 * \log(F)$$

10. List the different impedance matching techniques

(i) L – type

(ii) T – type

(iii) π - type

(iv) $Single\ stub\ matc\square ing$

(v) Double stub matching

Electronics & Communication Engineering

EC8701 –ANTENNAS & MICROWAVE ENGINEERING
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UNIT 1- INTRODUCTION TO MICROWAVE SYSTEMS AND ANTENNAS

1. (i) Describe the antenna parameters. (a) Gain (b) Radiation Intensity (c) Input Impedance (d) Effective aperture (e)Radiation pattern (f) Directivity
   (ii) Show the condition under which the fields are classified as near field and far field and explain
2. What is impedance matching? Explain about the techniques used to solve the impedance matching problems.
3. (i) Illustrate the concept of (a) Bandwidth (b) Beam efficiency (c) Antenna Temperature (d) beam width
   (ii) Explain matching baluns with suitable diagram
4. Summarize the Friis equation of an antenna with diagram. Also explain the individual parameters in the equation indetail.
5. (i) Develop the concept of Link budget and Link Margin with equation and suitable examples.
   (ii) Explain about the noise characteristics of Microwave receiver

UNIT II - RADIATION MECHANISM AND DESIGN ASPECTS

1. Obtain expression for the field and power radiated by an oscillating dipole / Half wave dipole and calculate the radiation resistance.
2. Describe the radiation mechanism with neat diagram and fields on the axis of an E- plane and H-plane sectoral horns
3. Explain in detail about Loop antenna. Derive the expression for fields at Far region. Also explain how a Loop antenna is utilized for determining the direction of an incoming radio signal.
4. With necessary sketches, explain in detail the radiation mechanism of a micro strip patch antenna. Summarize various feeding techniques for the rectangular patch antenna with neat diagrams.
5. Point out the principle of parabolic reflector antenna with the neat diagram and explain the various types of feed used. Relate the flat reflector and corner reflector.
6. Briefly explain about frequency independent planar Log spiral antenna .With necessary illustrations, explain the radiation characteristics of multi element log periodic antenna and mention its possible applications.

UNIT – III - ANTENNA ARRAYS AND APPLICATIONS

1. Explain the following cases of array of two point sources (i) Equal amplitude and in phase (ii) Equal amplitude and opposite in phase
2. Enumerate the expression for steering vector of phased array antenna & Explain beam forming networks for phased array antenna.
3. Explain the working principle of Broad side array and deduce the expression for the Radiation pattern of a broadside array with n- vertical dipoles.
4. Explain the working principle of End fire array and deduce the expression for the Radiation pattern.
5. Discuss & Derive (i) Array factor for n element dipole array (ii) Binomial Array (iii) Smart antennas- Adaptive arrays

UNIT IV - PASSIVE AND ACTIVE MICROWAVE DEVICES

1. (i) With the help of a neat diagram describe the magic Tee working principle.
   (ii) Find scattering matrix and applications of magic Tee.
2. (i) From the first principles derive the scattering matrix of a multi hole directional coupler.
   (ii) Infer the characteristics of directional coupler in terms of S parameters and explain in detail about two hole directional coupler.
3. (i) Discuss the working principle of Reflex klystron oscillator with necessary diagrams.
   (ii) Derive velocity modulation, transit time, power output mode curve/frequency characteristics of reflex klystron.
4. Discuss the working principle of Gunn diode as a transferred electron device with two valley model, Also draw the structure, equivalent circuit and V-I characteristics of Gunn diode.
5. (i) What are avalanche transit time devices? Explain the operation and construction of IMPATT diode
   (ii) Explain mechanism of oscillation of IMPATT and aspower amplifier.
6. Develop the cross sectional view of magnetron tube and explain how bunching occurs with equations of electron trajectory andderive the expression for Hull cut-off voltage.

UNIT V - MICROWAVE DESIGN PRINCIPLES

1. Describe the characteristics of amplifier and Examine the transducer power gain, unilateral power gain, available power gain and operating power gain of a microwave amplifier using S parameters
2. Write the mathematical analysis of amplifier stability.
3. Use Smith chart to find the line impedance at a point one quarter wave length from a load of $(40 - j\,20)\ \Omega$.

4. (i) Interpret the steps involved to design a low noise amplifier
   (ii) Distinguish power match and noise match in a Low NoiseAmplifier.
5. (i) Demonstrate the various types of mixers with its principle of operation
   (ii)Examine the following parameters of Conversion gain, Linearity and isolation of a mixer.

For a broadband amplifier, it is required to develop a PI-type matching network that transforms a load impedance of ZL= (50 – j 100) Ω into an input impedance of Zin = (10 + j 20) Ω. The design should involve the lowest possible nodal quality factor. Find the component values, assuming that matching should be achieved at a frequency of 2 GHz.