UNIT I

INTRODUCTION TO MICROWAVE SYSTEMS AND ANTENNAS

Microwave frequency bands, Physical concept of radiation, Near- and far-field regions, Fields and Power Radiated by an Antenna, Antenna Pattern Characteristics, Antenna Gain and Efficiency, Aperture Efficiency and Effective Area, Antenna Noise Temperature and G/T, Impedance matching, Friis transmission equation, Link budget and link margin, Noise Characterization of a microwave receiver.

PART A

1. **An antenna has a filed pattern given by E(θ)=$cos^2(\theta)$ for $0^\circ \leq \theta \leq 90^\circ$.Find HPBW.(N/D'20) (N/D'17)**

   E(θ) at half power =0.707

   0.707=$cos^2(\theta)$

   cos θ=$\sqrt{0.707}$ = 0.8408

$$\theta = \cos^{-1}(0.84) = 32.77^0$$

$$\theta = 33^0$$

   Half power beam width =2 θ=2(33^0)= 66^0

2. **What is meant by link budget ? Mention a simple link budget equation. (N/D'20)**

   Link budget is a way of quantifying the link performance. One of the terms in a link budget is the path loss, accounting for the free-space reduction in signal strength with distance between the transmitter and receiver.

   Path loss is defined (in dB) as

$$L_0 = 20 \log\left(\frac{4\pi R}{\lambda}\right) > 0$$

3. **Define radiation intensity.(A/M'19)**

   The power radiated from an antenna per unit solid angle is called the radiation intensity U (watts per steradian or per square degree). The radiation intensity is independent of distance.

4. **An omnidirectional antenna has uniform radiation in θ=90° (horizontal)plane and fall to zero outside that plane .the pattern is constant in the $\varphi = 0$ (vertical plane)in the range 60° $\leq \theta \leq$ 120°.find directivity.(A/M'19)**

Directivity D=$\frac{41253}{\theta^{0}_{HP}\varphi^{0}_{HP}}$

$=\frac{41253}{90^{0}0^{0}}$

D=458

5. **If the noise figure of the antenna at room temperature is 2 dB ,what is the effective noise temperature.(A/M'18)**

T_O = Room temperature =290K

F(in dB)=2 dB

By formula

F=10$\log_{10} F$

2=10$\log_{10} F$

F=antilog$_{10}$($\frac{2}{10}$)=1.584

Effective noise temperature is given by

$T_e = (F-1)T_0$=(1.584-1)(290)=16.96K

6. **Write firss transmission formula and define the parameters in it.(N/D'18)**

$P_r=\frac{P_T G_T G_R \lambda^2}{(4\pi R)^2}$

- The transmit power is P_t,
- The transmit antenna gain is G_t ,
- The receive antenna gain is G_r ,
- The received power (delivered to a matched load) is P_r.
- The transmit and receive antennas are separated by the distance R.

7. Differentiate radian and streradian.(N/D'17)

Radian. A unit of measure for angles. One radian is the angle made at the center of a circle by an arc whose length is equal to the radius of the circle. Steradian is unit used for measuring solid angles, i.e 3D angles

8. Define radiation resistance.(M/J'16)

The radiation resistance is a fictitious resistance such that when it is connected in series with antenna and dissipates same power as the antenna actually radiates.

Which radiates power into free space in the form of EM waves. Hence the power dissipation from antenna is given by $P_r = I^2 R_r$

9. What is meant by retarded potential?(N/D'16)

In electrodynamics, the retarded potentials are the electromagnetic potentials for the electromagnetic field generated by time-varying electric current or charge distributions in the past.

10. The voltage induced by the application of an electric filed of strength 2 v/m is 0.7.calculate the effective length of the element. (N/D'16)

Electric field=$\frac{induced\ voltage}{effective\ length} = \frac{h}{h_e}$

E=2V/m

V=0.7

$$h_e = \frac{V}{E} = \frac{0.7}{2} = 0.35M$$

Effective length =0.35m

11. Write the frequency range for following IEEE microwave bands?

(a) L band
(b) S band
(c) C band
(d) X band

(a) L band: 1-2 GHZ
(b) S band : 2-4 GHZ
(c) C band : 4-8 GHZ
(d) X band : 8-12.4 GHZ

12. Why antenna measurements are usually done in fraunhofer zone? (M/J'16)

- The filed components are transverse to the radial direction from the antenna.
- All the power flow is directed radially outward
- The shape of files pattern is "independent of the distance"

13. The radiation resistance of antenna is 72Ω and the loss resistance is 8Ω.what is the directivity (in dB),if the power gain is 15? (N/D'18) (M/J'16)

Radiation resistance R_r=72Ω

Loss resistance R_l = 8Ω

Antenna efficiency $(\eta)=\frac{R_r}{R_r+R_l}=\frac{72}{72+8}=0.9$

The relationship between power gain and directivity is given by

$D=\frac{G_P}{\eta}=\frac{15}{0.9}=16.6$

The directivity in dB is given by

$D(dB)=10\log_{10} 16.6=15.67dB$

14. Define gain of antenna .Bring out a relationship between gain and aperture of an antenna.(A/M'17) (M/J'16) (A/M'11,N/D'11)

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.

$$G=\frac{Maximum\ radiation\ intensity\ from\ antenna\ undertest\ (AUT)}{Maximum\ radiation\ intensity\ from\ a\ reference\ antenna\ with\ same\ input\ power}$$

15. Define isotropic radiator. Write expression for average power density of it. (Dec – 14)

It is defined as a hypothetical element which radiates EM energy equally in all directions. Its is called as isotropic source or omni directional radiator or simply unipole. Example of an isotropic radiator is a point source. It is useful as a reference antenna for determining directive properties antennas

16. Define Directivity. (M/J'12,A/M'11)

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 from Pattern : $D=\frac{U(\theta,\varphi)_{max}}{U(\theta,\varphi)_{avg}}$.

Directivity from beam area : $D = \frac{4\pi}{\Omega_A}$.

17. Define effective aperture of an antenna. (M/J'12,N/D'11)

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

18. What are the 2 types of radiation pattern? [Understand]

The 2 types of radiation pattern are (**a) Field pattern and (b) power pattern**

Field pattern: If the radiation from the antenna is expressed in terms of the field strength (either E or H), then the radiation pattern is called as field pattern.

Power pattern: If the radiation pattern from the antenna is expressed in terms of power per unit area, then the resultant pattern is called power pattern.

19. Define microwave frequency band.

The term *microwave* refers to alternating current signals with frequencies between **300 MHz (3×10^8 Hz) and 30 GHz (3×10^{10} Hz),** with a corresponding electrical wavelength between 1 m and 1 cm

Three major bands:

1. Ultra High Frequency (UHF) – 0.3 GHz to 3 GHz
2. Super High Frequency (SHF) – 3 GHz to 30 GHz
3. Extra High Frequency (EHF) – 30 GHz to 300 G

20. Define link margin.

Referred to as ***fade margin***

The received power level > the threshold level required for the minimum acceptable quality of service (mini. CNR, or mini SNR).

This design allowance for received power is referred to as the ***link margin***

PART B

1. Obtain the expression for the field and power radiated by an oscillating dipole and calculate the radiation resistance. (N/D'20)
2. i) What is impedance matching ? Explain about the techniques used to solve impedance matching problems. (N/D'20)
3. ii) Using Friss transmission formula find the maximum power received at a distance of 1 Km over a free space a 100 MHz circuit consisting of a transmitting antenna of 30 dB gain and receiving antenna with a 25 dB gain is used. The power input of transmitting antenna is 150W. (N / D '20)
4. The radiation intensity of antenna is given by $\mathrm{U}(\theta) = cos^4\theta, 0^{\circ} \leq \theta \leq 90^{\circ}, 0^{\circ} \leq \varphi \leq 360^{\circ}$ Find Half power beam width (HPBW),First null beam width (FNBW) (A/M'19)
5. A transmitting antenna has an effective height $2/\pi$ times the physical length .this carries a current of 1600 Amps at the base and operating frequency of 20 KHZ. If the physical length of the antenna is 200 meters and antenna efficiency is 10%.calculate (A/M'19)
   a) Electric field intensity at 350km
   b) Radiation resistance
   c) Power radiated
   d) Power input in the antenna
   e) The voltage induced in the receiving antenna of 100 meters effective height at a distance of 350km.
6. Obtain the expressions for power radiated and the radiated resistance of a half wave dipole.(A/M'18) (OR) Derive an expression for the power radiated by the current and calculate the radiation resistance (A/M'17)
7. (i) Derive FRISS transmission formula. (A/M'18)

   (ii) Calculate the directivity of an antenna the power pattern is given by

$$\mathrm{U}(\theta,\varphi) = \begin{cases} \sin\theta\sin\varphi & 0 \leq \theta \leq \pi; 0 \leq \varphi \leq \pi \\ 0 & 0 \leq \theta \leq \pi; 0 \leq \varphi \leq 2\pi \end{cases}$$

8. Define the term "directivity gain". Derive the relation between the gain of an antenna and the antenna aperture.
(N/D'18)
9. Write short notes on (i) reciprocity theorem (ii) Beam solid angle (iii) front to back ratio (iv) self impedance (v) half power beam width (vi) polarization (vii) directivity (viii) principal patterns.(N/D'18)
10. Derive the expression for the far filed component of a half wave dipole of an antenna.(A/M'17)
11. Derive the expression for the filed quantities radiated (E and H) for a small oscillation current element.
(M/J'16)
12. Explain the principle of radiation from an oscillating electric dipole. Derive the near filed and far filed expressions.
(N/D'16)

13. Explain following the term with respect to antenna

I. Radiation pattern (May-11,14, Dec-11, May-12)

II. Beam solid angle (Dex-11, May-14)

III. Radiation intensity

IV. Directivity (May-11, Dec-11, Dec-13, May-15)

V. Gain (Dec-12, 13)

VI. Bandwidth (Dec-11)

VII. Antenna impedance (May-14, Dec-13)

VIII. Effective aperture (May-11,15, Dec-12)

IX. Antenna temperature (May-11, Dec-13, May-12,14)

X. Polarization (May-11,12,14,15, Dec-11)

XI. Power gain

XII. Antenna efficiency

XIII. Beam width

XIV. Beam efficiency

XV. Effective length

UNIT II
RADIATION MECHANISMS AND DESIGN ASPECTS

Radiation Mechanisms of Linear Wire and Loop antennas, Aperture antennas, Reflector antennas, Microstrip antennas and Frequency independent antennas, Design considerations and applications.

PART A

1. Calculate the beam width between first nulls of a 2.5m paraboloid reflector used at 6GHz. (N/D' 20)

$$\lambda = \frac{300}{f(MHz)}$$

$$\frac{300}{6 \times 10^3} = 50 \times 10^3 \; meters$$

Hence BWFN $=\frac{140\lambda}{D}$ degrees $=\frac{140 \times 50 \times 10^3}{2.5}$

$= 140 \times 20 \times 10^3$

$= 2800 \times 10^3 = 2.8^0$

$$G_P = 6(\frac{D}{\lambda})^2 = 6(\frac{2.5}{50 \times 10^3})^2 = 15000$$

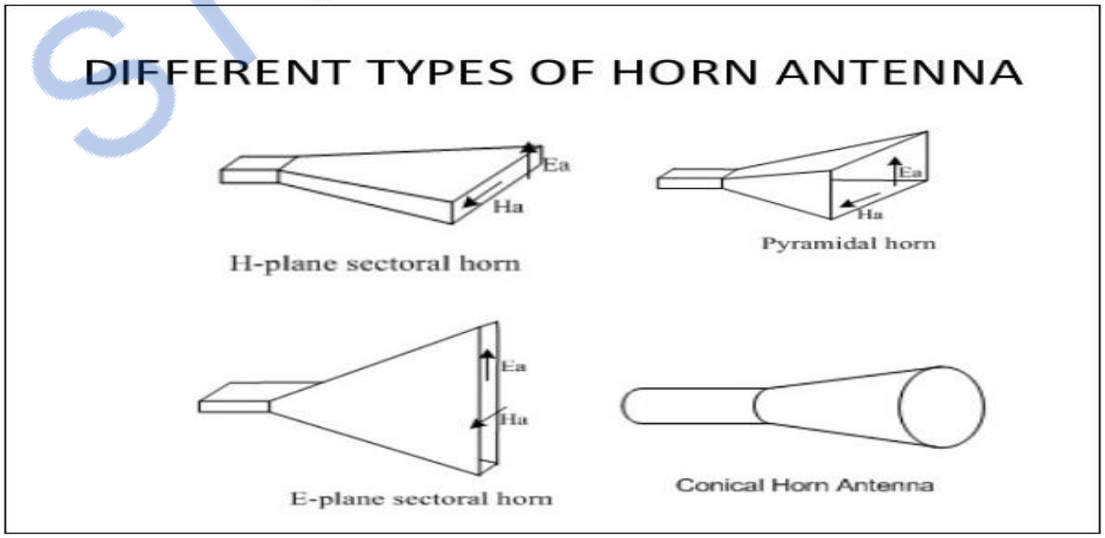
$$G_P = 10 \log_{10} 15000 = 10 \times 4.1761 = 41.761 \; db$$

2. What is aperture blockage? Give one example.(N/D ' 20)

The effect of antenna parts lying the path of rays arriving at or departing from a radiating elements or the aperture an antenna.

Example: The feeds, Sub reflectors.

3. Draw various types of horn antenna.(N/D'19)



4. **State Babinet's principle.(N/D'19)(OR) State Babinet's principle applied to the slot antenna.(N/D'18) (N/D'17) (OR) On what principle slot antenna works? Explain the principle. (M/J'16)**

   When the field behind a screen with an operating is added to the filed on a complementary structure, the sum is equal to the filed when there is no screen

5. **Write any two difference between slot antenna and its complementary dipole antenna.(A/M'19)**
   - The electric and magnetic fields are interchanged
   - The direction of the lines of electric and magnetic force abruptly reverse from one side of the metal sheet to the other. In the case of the dipole, the electric lines have the same general direction while the magnetic lines form continuous closed loops.

6. **List the different methods of feeding microstrip antenna.(A/M'19)**
   1. **Contacting feeding**: In this method the R.f power is fed directly to the radiating patch which uses a connecting element such as micro strip or co-axial line.
   2. **Non contacting feeding:** In this method ,electro magnetic coupling is done to transfer the power from feed line to the radiating patch. The most commonly used non-contacting feed method are aperture coupling and proximity coupling.

7. **What are the secondary antenna ?Give two examples. (N/D'17)**

   Antenna that are not radiators by themselves are called secondary antenna .

   Example: Cassegrain ,Hyperbolic antenna

8. **Define pitch angle of a helical antenna.(A/M'19)**

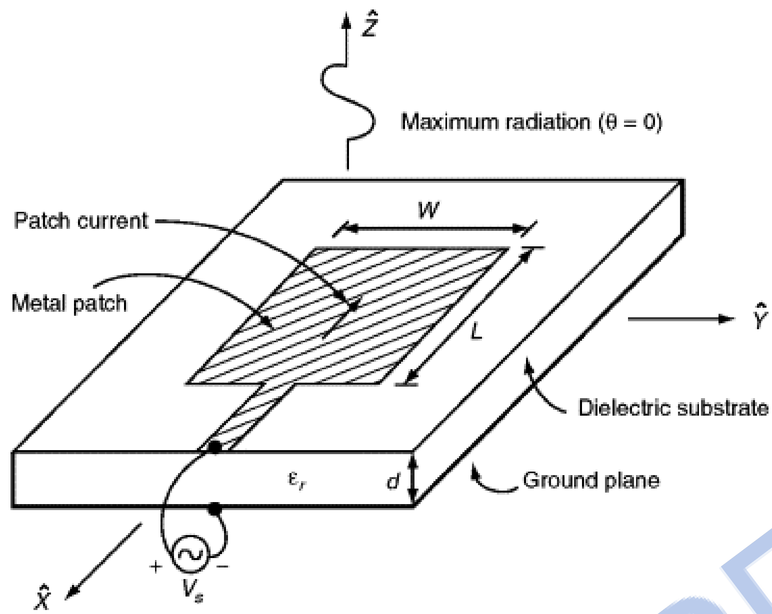
   Pitch angle (α) is the angle between a line tangent to the helix wire and the plane normal to the helix axis.

$$\tan\alpha = \frac{S}{C} = \frac{S}{\pi D} = \tan^{-1}\frac{S}{\pi D}$$

9. **State Huygen's principle.(A/M'18)**

   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.

10. **Draw the diagram representing rectangular microstrip antenna. List the substrates used for microstrips antenna.(N/D'18)**
    - Dielectric substrate used



11. Write any two differences between slot antenna and its complementary dipole antenna.(A/M'18)

- Polarization are different ie. The electric fields associated with the slot antenna are identical with the magnetic field of the complementary dipole antenna.
- The electric field be vertically polarized for the slot and horizontally polarized for the dipole
- Radiation from the back side of the conducting plane of the slot antenna has opposite polarity from that of complementary antenna

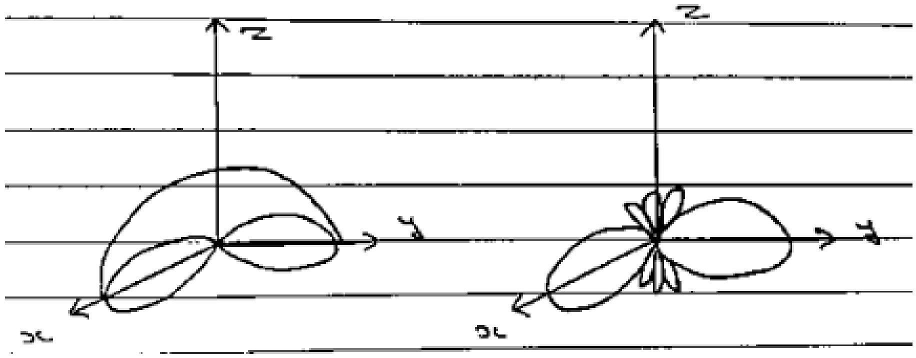
12. What are the different types of horn antenna?(A/M'17)

- Sectoral horn
- Pyramidal horn
- Conical horn
- Biconical horn antenna

13. Mention the four advantages of microstrip antenna.(A/M'17)

- The micro strip antenna are the low profile antennas. They are of smaller size, light weight antennas which occupy very less volume.
- Low fabrication cost, hence can be manufactured in larger quantities.
- It can be easily integrated with MICs
- It capable of dual and triple frequency operations

14. Draw the radiation pattern for isotropic ,directional and omnidirectional antenna.(A/M'17)



15. For a 20 turn helical antenna operating at 3 ghz with circumference C=10cm and the spacing between the turns 0.3 λ.calculate the directivity and half power beam width.(N/D'17)

Given

$$\mathrm{S} = 0.3\lambda, \mathrm{f} = 3\mathrm{GHz}, \mathrm{C} = 10\ \mathrm{cm}\ \ \mathrm{N} = 20$$

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{3 \times 10^9} = 0.1\ \mathrm{m}$$

Directivity,

$$\mathrm{D} = \frac{15\mathrm{NSC}^2}{\lambda^3}$$

$$D = \frac{15 \times 20 \times .3n \times (10 \times 10^{-2})^2}{\lambda^3}$$

$$= \frac{15 \times 20 \times .3 \times (10 \times 10^{-2})^2}{(.1)^2}$$

$$D = 90$$

Half power beam width, $\mathrm{HPBW} = \frac{52}{\mathrm{C}}\sqrt{\frac{\lambda^3}{\mathrm{NS}}}$ degree

$$\mathrm{HPBW} = \frac{52}{10 \times 10^{-2}}\sqrt{\frac{(0.1)^3}{20 \times 0.3 \times 0.1}}$$

$$\mathrm{HPBW} = 21.23$$

16. What is a frequency independent antenna. (A/M'18) (N/D'17)

A frequency independent antenna is physically fixed size and operate on can instantaneous basic over a wide bandwidth with relatively constant impedance, pattern ,polarization and gain.

17. State Rumsey principle on frequency independence. or state Rumsey principle (A/M'17) (M/J'16) (N/D'16)

Rumsey's principle suggests that the impedance and pattern properties of an antenna will be frequency independent if the antenna shape is specified only in terms of angles. To satisfy the equal-angle requirement, the antenna configuration needs to be infinite in principle, but is usually truncated in size in practice.

18. Find the terminal resistance of complementary slot for a cylindrical dipole with length to diameter ratio of 28 and length of 0.925λ having terminal impedance of $(710 + j0)$ ohms.

Since $Z_s = \frac{35{,}476}{710+j0} = \frac{35{,}476}{710} \simeq 49.966 \simeq 50\text{ohms}$

$Z_s \approx 50 + j0\text{ohms}$

Since $L = 0.925\lambda$ and $\frac{L}{D} = 28$

$$D = \frac{L}{28} = \frac{0.925\lambda}{28} = 0.033\lambda$$

$\omega = 2\text{D} = 2 \times 0.033\lambda = 0.066\lambda$

19. Determine the gain of a cassegrain antenna of diameter 70 m at a frequency 8.45 GHz. Assume as aperture efficiency of 80%.

$f = 8.45\text{GHz}, \text{D} = 70\text{ m}, \text{K} = 0.8$

$$\text{Gain} = \frac{4\pi \text{A}_O}{\lambda^2} = \frac{4\pi \text{KA}}{\lambda^2} = \frac{4\pi \text{K}}{\lambda^2}\left(\frac{\pi \text{D}^2}{4}\right)$$

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{8.45 \times 10^9} = 0.0355\text{ m}$$

$$\text{Gain} = \pi^2 K\left(\frac{D}{\lambda}\right)^2 = (3.14)^2 \times 0.8 \times \left(\frac{70}{0.0355}\right)^2$$

$$\text{Jain} = 30.66 \times 10^6$$

20. Estimate the diameter of a paraboloidal reflector required to produce a beam of 5^0 width at 1.2 GHz. How would you make this reflector?

$\text{BWFN} = 5°$

$f = 1.2\text{GHz}$; Then $\lambda = \frac{3\times10^8}{1.2\times10^9} = \frac{3}{12} = \frac{1}{4}$

$BWFN = 5° = \frac{140\lambda}{D}$; $D = \frac{140\times1}{4\times5} = 7$ metres

PART B

1. Explain in detail about loop antenna. Derive the expression for fields at Far region. (N/D'20)
2. Explain how a loop antenna is utilized for determining the direction of incoming radio signal. (N/D'20)
3. With neat necessary diagrams, explain the parabolic antenna and its different types of feeding systems. (N/D'20)
4. Briefly explain about frequency independent planar log spiral antenna. (N/D'20)
5. Compare uniform and tapered aperture antennas. Give examples.(N/D'19)
6. With neat diagram ,explain parabolic reflector antenna and its cassegrain feeding systems.(N/D'19)
7. Explain the radiation mechanism of microstrip antenna (N/D'19)
8. Write short notes on slot antenna.(N/D'19)
9. Discuss the principle working of parabolic reflectors. Explain the various feed techniques their relative merits and demerits. Discuss the role of f/d ratio in the parabolic reflectors(f-focal length,D-diameter of reflector). (A/M'19) (M/J'16)
10. Explain the principle operation of horn antenna and discuss the various forms of horn antenna .obtain the design equations of horn antenna.(A/M'19) (A/M'18)
11. With suitable diagram, explain the construction and principle operation of log periodic antenna.(A/M'19)
12. Explain the radiation mechanism of a microstrip antenna with suitable illustrations. With suitable figure explain the various feed techniques.(A/M'18)
13. Design a 50 to 200MHz log periodic dipole antenna for gain corresponds to scale factor 0.8 and space factor 0.15.assume the gap spacing at the smallest dipole is 3.6mm.(A/M'18) (N/D'17)
14. Explain in detail about radiation mechanism of slot antenna and derive the impedance of a infinitesimally thin $\lambda/2$ slot antenna. What are the difference between slot and its complementary antenna.(N/D'18)
15. (i) Write short notes on microstrip antenna .list the advantages and disadvantages of microstrip antenna .
    Discuss the ways to improve the bandwidth of microstrip antenna.
    (ii) Explain the different feeding techniques for microstrip antenna. (N/D'18)
16. (i) Explain the principle of reflector antenna and the different types of feed used in a reflector
    antenna. (N/D'16)
    (ii) Explain the working principle of microstrip patch antenna. (A/M'17)
17. A pyramidal horn antenna with the aperture length of 10λ cm is fed by a rectangular waveguide in TE_{10} mode .determine the design parameters of the antenna operating at 2.5GHz. (A/M'17)

18. (i) Explain the principle of parabolic reflector antenna and the different types of feed used in a reflector antenna.
(ii) The diameter of a parabolic reflector is 2cm .for operation at 6GHz ,find the beam width between first null and the gain. (N/D’17)
19. Write short notes on:
    (i) Slot antenna
    (ii) Microstrip antenna (N/D’17)
20. Explain in detail the radiation from a slot antenna and their feed systems.(N/D’16)
21. Explain the operation and design of a helical antenna. (N/D’16)
22. Explain in detail about log periodic antenna. What is the need for feeding from end with shorter dipoles and the need for transposing the line ?also discuss the effect of decreasing α (N/D’16)

UNIT III

ANTENNA ARRAYS AND APPLICATIONS

Two-element array, Array factor, Pattern multiplication, Uniformly spaced arrays with uniform and non-uniform excitation amplitudes, Smart antennas.

PART A

1. **What is pattern multiplication.(N/D'20)**
   (OR) State pattern multiplication.((A/M'18) (N/D'17)

   The principle of pattern multiplication states that, 'The total field pattern of an array of non isotropic but similar point sources is the multiplication of the individual source patterns and the pattern of an array of isotropic point sources, each located at the phase center of individual source and having the same relative amplitude and phase while the total phase pattern is the addition of the phase pattern of the individual sources and the array of isotropic point sources'

2. **What is reconfigurable antenna? (N/D'20)**
   A reconfigurable antenna is an antenna capable of modifying its frequency and radiation properties.

3. **What is binomial array? (N/D'19) What are the disadvantages of binominal array?(N/D'18)**
   It is an array in which the amplitudes of the antenna elements in the array are arranged according to the coefficients of the binomial series.
   Disadvantages:
   1.HPBW increases and hence the directivity decreases
   2.For the design of large array ,the larger amplitude ratio of source is required

4. **Find the minimum element spacing of a 10 element linear uniform broadside array of isotropic radiators achieve 7Db directivity. (N/D'19)**

   $$(D)_{dB} = 9\ dB\ , n = 10$$
   $$(D)_{dB} = 10\log_{10} D$$

   $9 = 10\log_{10} D.$
   D=7.94
   Directivity of a broadside array is given by ;
   D=$\frac{2L}{\lambda}$ = $\frac{2nd}{\lambda}$
   7.94 =$\frac{2\times 10\times d}{\lambda}$
   d= $\frac{7.94\lambda}{\lambda}$
   d=0.397 λ

5. **What is meant by uniform linear array?(N/D'18)**
   An uniform linear array is one in which the elements are fed with a current of equal magnitude with uniform phase shift along a line.

6. **How we can eliminate minor lobes?(N/D'16)**
By using Uniform arrays we get the desired radiation pattern by changing the phase, but we get the side lobes due to equal amplitudes. Where as in case of Binomial arrays, we can reduce or eliminate minor lobes by giving non uniform amplitudes to radiating sources but it leads to cost of directivity.

7. **What is tapering of arrays? (N/D'17)**
Tapering is simple the manipulation of the amplitude contribution of an individual element to the overall antenna response.

8. **Using pattern multiplication find the radiation pattern for the broadside array of 4 elements ,spacing between each element is $\frac{\lambda}{2}$ (A/M'17)**
N=4 ,d=$\frac{\lambda}{2}$
L=(n-1)d =(4-1) $\frac{\lambda}{2}$
L=$\frac{3\lambda}{2}$=1.5λ
Directivity D = $\frac{2L}{\lambda}$ = $\frac{2x\ 1.5\lambda}{\lambda}$
D=3

9. **A linear broadside array consists of four culwidth. $n = 4, d = \lambda/3$ spacing .Find the diectivity and beam width .**
→ Total length of the array $L = (n-1)d = (4-1)\frac{\lambda}{3}$

$$L = \frac{3\lambda}{3} = \lambda$$

$$\rightarrow \text{ Directivity } \mathrm{D} = \frac{2\mathrm{~L}}{\lambda} = \frac{2\lambda}{\lambda} = 2$$

$$\rightarrow \mathrm{BWFN} = \frac{114.6}{\mathrm{L}/\lambda} = \frac{114.6}{\lambda/\lambda} = 114.6^\circ$$

$$\rightarrow \text{ HPBW} = \frac{\mathrm{BWFN}}{2} = \frac{114.6^\circ}{2} = 57.3^\circ$$

10. **Calculate the directivity of a given linear broadside, uniform array of 10 isotropic elements with a separation of $\lambda/4$ between the elements.**
Ans:

$$n = 10, d = \lambda/4$$

$$\begin{cases} L = nd & \text{if } n \text{ is large} \\ L = 10\left(\frac{\lambda}{4}\right) & \end{cases}$$

$$\rightarrow \text{Directivity D} = \frac{2\mathrm{~L}}{\lambda} = 2\left(\frac{10\lambda}{4}\right)\left(\frac{1}{\lambda}\right) = 5$$

$$= (\mathrm{D})_{d\mathrm{B}} = 10\log_{10}\mathrm{~D} = 10\log_{10}5 = 10 \times 0.6990 = 6.99\text{ dB}$$

11. **Define beam width of major lobe?**

It is defined the angle between the first nulls (or) it is defined as twice the angle between the first hull and the major lobe maximum direction.

12. **What is point source?**
It is a fictitious volume less emitter source located at the center of an observation circle

13. **Differentiate broadside and end fire array.**

Broad side array	**End fire array**
Array elements are fed with the currents of equal amplitude and in phase.	Array elements are fed with the currents of equal amplitude and out
Maximum radiation is perpendicular to the direction of array axis.	Maximum radiation is directed along the array axis

14. **Give the expression of directivity for broadside array and end fire array.**
For broadside array, $2\left(\frac{L}{\lambda}\right)$
For end fire array, $4\left(\frac{L}{\lambda}\right)$
Where $L = \text{nd}, n =$ number of antennas and d is the spacing between the element

15. **A uniform linear array contains 50 isotropic radiators with an inter element spacing of $\lambda/2$. Find the directivity of broadside forms of array. AU: $M[a\} - 2013$**
The directivity of broadside array is given by:

$$D = G_{1Dmax} - 2\left(\frac{nd}{\lambda}\right) = 2\left[\frac{50(\lambda, 12)}{\lambda}\right] = 50$$

16. **What is Hansen-Woodyard Array?**
Hansen-Woodyard array is nothing but an end fire array with increased directivity obtained fy applying certain conditions on the phase shift between closely spaced radiators without affecting other characteristics of array.

17. **What is the need for the Binomial Array?**
The need for a binomial array is :
(i) In uniform linear array ns the array length is increased to increase the directivity, the secondary lobes also occurs.
(ii) For certain applications, it is highly desirable that secondary lobes should be eliminated completely or reduced to minimum desirable level compared to main lobes

18. **Compare directivities of broadside, end fire and Hansen-Woodyard array.**

Broadside Array	**Endfire Array**	**Hansen-woodyard Array**
Directivity $D = 2\left(\frac{L}{\lambda}\right)$	$D = 4\left(\frac{L}{\lambda}\right)$	$D = 1.789\left[4\left(\frac{L}{\lambda}\right)\right]$

19. **Calculate the distance between the elements of a broadside array whose beamwidth between first Null is found to be 45^0 at a frequency of 10Mhz .There are 8 elements in the array.**

$$n = 8$$

$$n = 8$$
$$BWFN = 45°, f = 10\text{MHz} = 10 \times 10^8 \text{ Hz.}$$
$$\rightarrow \lambda = \frac{c}{f} = \frac{3 \times 10^8}{10 \times 10^5} = 30 \text{ m}$$
$$\rightarrow L = nd = 8 \times d = 8d$$
$$\rightarrow BWFN = \frac{114,6}{\left(\frac{L}{\lambda}\right)} \Rightarrow \frac{114.6}{\left(\frac{8d}{30}\right)} = 45$$
$$d = \frac{(114.6)(30)}{45 \times 8} = 9.55 \text{ m}$$

20. **A broadside array operating at 100 cm wavelength consists of four half wave dipses spaced 0 cm. Each element curries radio frequency carrent in the samc phuse and maguitude 0. 5 amps calculate. (i) Radiated power, (ii) Half power beamwidth of the major lobe.**

$$d = 50 \text{ cm} = 0.5 \text{ m}, \lambda = 100 \text{ cm} = 1 \text{ m}$$
$$n = 4, \text{I} = 0.5 \text{ amps}, \text{R}_r = 73 \text{ ohms (Half wavedipole)}$$

$$\rightarrow \text{ Radiated power } \text{P}_\text{n} = n\text{I}^2\text{R},$$
$$= 4 \times (0.5)^2 \times 73$$
$$\text{P}_\text{m} = 73\text{Watts}$$

→ Length of the array $= nd = 4 \times 0.5 = 2$ m.

$$\rightarrow BWFN = \frac{2\lambda}{L} = \frac{2 \times 1}{2} = \text{I radian } = 57.3°$$

$\rightarrow HPBW = \frac{BWFN}{2} = \frac{1}{2} = 0.5$ radian

$$\text{HPBW} = 0.5 \times 57.3^4 = 28.65°$$

21. **Calculate the directivity of an end fire array of 10 elements with a separations of WA between the elements,**

$$n = 10, d = \lambda/4$$

$$\text{Directivity D} = \frac{4\text{ L}}{\lambda} = 4 \times 10 \times \frac{\lambda}{4} \times \frac{1}{\lambda} = 10$$

$$\rightarrow (D)_{dB} = 10\log_{10} D = 10\log_{15} 10 = 10 \text{ dB}$$

PART B

1. i) What is broad side array? Deduce the expression for the radiation pattern of a broadside array with n-vertical dipoles
   ii) Design a 4 element broadside array $\lambda/2$ spacing between elements. (N/D '20)
2. i) What is non -uniform excitation amplitudes? Draw the pattern of 10 elements binomial array with spacing's between the elements of $\lambda/2$.

   ii) Write short note about active antenna. (N/D'20)
3. (i) What are broadside and end fire array (N/D'19)
   (ii) Derive the expression for field pattern and array factor of n isotropic point sources of broad side array.
4. Briefly explain the following antenna arrays. (N/D'19)
   i) Phased arrays.
   ii) Adaptive arrays.
5. (i) Arrive the array factor of a two-element array. For this array ,find the nulls of the total field when
   d=$\lambda/4$ and the cases $\beta = 0, \beta = 90^{\circ}, \beta = -90^{\circ}$
   (ii) Define uniform linear array and grating lobes. (A/M'19)
6. Explain pattern multiplication. Using the principles of pattern multiplication determine the radiation
   pattern for eight element linear array and speed $\lambda/2$ apart with equal currents fed in-phase .specify the
7. limitations of this method.(OR) Using pattern multiplication determine the radiation pattern for 8 element array, separated by the distance $\frac{\lambda}{2}$ (A/M'19) (M/J'16)
8. Derive the filed equations for array of two point source with spacing $\lambda/2$ with equal amplitude and phase. Also derive the array factor ,direction of maximum ,minimum and half power point directions.Draw the radiation pattern.(OR) Derive the expression for the array factor of a linear array of four isotropic element spaced $\frac{\lambda}{2}$ apart fed with signals of equal amplitude and phase obtain the direction of maxima and minima. (N/D'18) (N/D'17)
9. (i) Discuss the properties of linear broadside array
   (ii) A linear array consists of four equal isotropic inphase point sources with $\frac{\lambda}{3}$ b spacing (overall length of the array = λ) calculate the directivity,BWFN,HPBE. (N/D'18)
10. Discuss about modern antennas and their applications.(N/D'18)
11. Derive and draw the radiation pattern of 4 isotropic sources of equal amplitude and same phase.(OR) Derive and plot the radiation from a broadside array of 4 point sources.(N/D'17)(N/D'16)
12. Obtain the expression for the filed and the radiation pattern produced by a N element array of infinitesimal with distance of separation $\frac{\lambda}{2}$ and current of unequal magnitude and phase shift 180 degree. (M/J'16)

UNIT IV

PASSIVE AND ACTIVE MICROWAVE DEVICES

Microwave Passive components: Directional Coupler, Power Divider, Magic Tee, attenuator, resonator, Principles of Microwave Semiconductor Devices: Gunn Diodes, IMPATT diodes Schottky Barrier diodes, PIN diodes, Microwave tubes: Klystron, TWT, Magnetron.

PART A

1 Give two examples for reciprocal microwave passive device. (N/D'20)

Examples of reciprocal networks include cables and standard transmission lines, attenuators.

2 A Reflex Klystron is operated at 10GHz with a dc beam voltage of 600V for 134 mode, repeller space length of 1mm and dc beam current of 12mA. The beam coupling co-efficient is assumed to be 1. Calculate the repeller voltage. (N/D'20)

$$|V_R| = 6.74 \times 10^{-6} \times 1 \times 10^{-3} \times 9 \times 10^{9} \times \frac{\sqrt{600}}{13/4} - 600$$

$$= 249 \text{ V.}$$

$$\mathrm{P_{xFmar}} = \frac{0.398\ \mathrm{V_0 I_0}}{\mathrm{N}} = \frac{0.398 \times 600 \times 10 \times 10^{-3}}{13/4}$$

$$= 0.2274 \times 600 \times 10 \times 10^{-3}$$

$$= 1.3644 \text{ watts.}$$

$$\eta_{\max} = \frac{\mathrm{X}_{ji}(\mathrm{X})}{\pi \mathrm{N}} = \frac{0.398}{\mathrm{N}} = \frac{0.398}{1^{3/4}} = 22.74\%$$

3 What is meant by impedance matching? List the different impedance matching techniques.(N/D'19)

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

TYPES:

- Reflection-less matching.
- Maximum power transfer matching.

4 Give the significance of E – plane and H – plane bends?(N/D'19)

- Bends are used to change the direction in a waveguide run.
- They are classified as E & H bends. A bend whose plane is parallel to the plane of the magnetic vector is called H bend while whose plane is parallel to the plane of the electric vector is called E bend.

5 What are the different modes of operation realizable with gunn diode? (N/D'19)

- Gunn Oscillation Mode.
- Stable Amplification Mode.
- LSA Oscillation Mode.
- Bias Circuit Oscillation Mode.

6 State the two parameters that describe a directional coupler ? Define them. (A/M'18)

COUPLING FACTOR :

The coupling factor of a directional copuler is defined as the ratio os rer to the forward power, P_f measured in dB.

$$\text{Coupling factor (db)} = 10\log_{10}\frac{\mathrm{P}_f}{\mathrm{P}_f}$$

DIRCTIVITY :

a) The directivity of a directional coupler is defined as the ratio of forward power, P,to the back power, P_b expressed in dB.

$$\mathrm{D(dB)} = 10\log_{10}\frac{\mathrm{P}_f}{\mathrm{P}_b}$$

(b) It is a measure of how directional coupler distinguishes between forward and reverse travelling powers.

7 What is the purpose of slow wave structures in TWT ? Name them.(A/M'18)

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.

8 List the applications of magic-Tee. (A/M'17) (N/D'15)

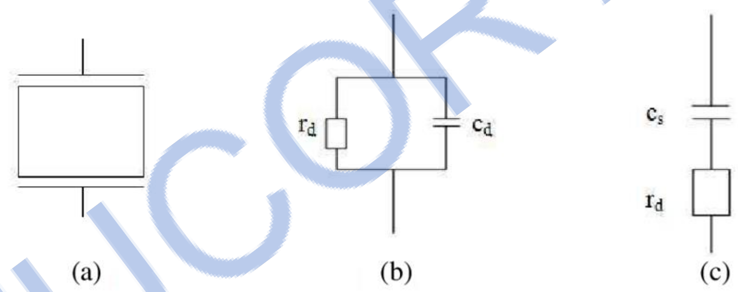
- Magic Tee junction is used to measure the impedance.
- Magic Tee is used as a duplexer
- Magic Tee is used as a Mixer
- Magic Tee junction is also used as Microwave Bridge, Microwave discriminator etc

9. Compare TWT anti Klystron (A/M'17)

TWT	Klystron Amplifier
The interaction of electron beam and RF beam in the TWT is continuous over the entire length of the circuit.	The interaction in Klystron amplifier occurs only in the gaps of few resonant cavities.
The wave in TWT is propagating wave.	In Klystron amplifier, it is not a propagating wave.
In coupled cavity TWT, there is coupling effect between the cavities.	Here each cavity in the Klystron operates independently.
Wide band device.	Narrow band device.

10. Draw the equivalent circuit of a Gunn diode.(N/D'18)

(a) Schematic diagram of Gunn diode; (b) Parallel equivalent circuit; (c) Series equivalent circuit.



11. Compare PIN and PN diode. (N/D'16)

PIN DIODE	PN
PIN diode is a heavily doped n-region separated by a layer	PN Diode Doping is normal in both P and of high resistivity n sides.
Preferred semiconductors is silicon	Preferred semiconductors are
because of its power handling capacity.	germanium and silicon.

12. List the radio frequency bands available in microwave and radio frequency ranges. (N/D'16)

Electromagnetic wave spectrum	Frequency band	Wavelength
Radio waves	Very high frequency (VHF) (30–300 MHz)	10–1 m
Microwaves	Ultrahigh frequency (UHF) (300–3000 MHz)	(100–10 cm)
	P band (230 MHz–1 GHz)	130–30 cm
	L band (1–2 GHz)	30–15 cm

13. What is magnetron? (N/D'16)

A magnetron is a device that generates high power electromagnetic wave. It is basically considered as a self-excited microwave oscillator.

14. What is tetrodes and pentodes?

Tetrodes contains cathode, two grids and an anode. Pentodes contain 5 elements, (i.e.) cathode, 3 grids and anodes.

15. A reflex Klystron is operated at 5 GHz with de beam voltage 50 V, repeller spacing 0.5 cm for N = 33/4 mode. Calculate bandwidth over $V_R = 1$ V.

$N = 3^3/4 = \frac{15}{4}$

$\Delta V_Q = 6.7438 \times 10 - {}^{-} \times L_{ul} \times \Delta f_{H_x} \frac{\sqrt{V_o}}{N}$

$1 = 6.74 \times 10^{-5} \times 0.5/100 \times \Delta f_{11z} \times \sqrt{300} \times 4/15$

$\Delta f = 5.948$MHz.

16. In a two cavity Klystron operates at 10GHz with $1_6 = 3.6$ mA, $V_0 = 10$KV. The drift space length is cm, the output cavity total shunt conductance is $G_{ak} = 20$u mho and beam-coupling coefficient $\beta_2 = 0.92$. Find the maximum voltage and power gain.

Ans: Maximum voltage gain $A = \frac{B^2\theta_0 I_0 J_1(X)_{\max}}{XV_0 G_{sh}}$

DC bcam velocity

$$u_0 = 0.593 \times 10^5 \sqrt{V_0} = 0.593 \times 10^5 \sqrt{10} \times 10^3 = 0.593 \times 10^4 \text{ m/s}$$

Transit angle in drift space

$$\theta_0 = \frac{\omega L}{\mu 0} = \frac{2\pi \times 10 \times 10^6 \times 2 \times 10^{-2}}{0.593 \times 10^8}$$
$$= 21.19\text{rad.}$$
$$\mathrm{A_{max}} = \frac{0.92 \times 0.92 \times 21.19 \times 36 \times 0.582}{1.841 \times 10 \times 10^3 \times 20 \times 10^{-6}}$$
$$= 102.1$$

17. What is directional coupler?

(a) Directional coupler are transmission line device that couple together two circuits in one direction, while providing a great degree of isolation in the opposite direction.

(b) It is used to measure incident reflected power, SWR values, provide a signal path is a receiver or to perform a desirable operations.

18. What do you mean by isolation?

- Isolation is definod as the ratio of the incident power, $'P_1'$ to the back power $'P_b'$ expressed dB.
- Isolation (dB) $= 10\log_{10} \frac{P_S}{P_b}$

19. What is circulator?

A circulator is a multi-port junction in which the wave can travel from one port to next immediate port in one direction only

20. A reflex Klystron is to be operated at frequency of 10GHz, with de beam voltage 300 V, repeller space 0.1 cm for 13/4 mode. Calculate $P_{\mathrm{uv_{mex}}}$ and corresponding repeller voltage for bean current of 0 mA .

$$P_{\overline{ZF}=} = \frac{0.398\ \mathrm{V_0 I_0}}{\mathrm{N}} = \frac{0.398 \times 300 \times 20 \times 10^{-3}}{1^{3/4}}$$
$$= 1.365 \quad \text{wat}$$

$$|\mathrm{V_k}| = 6.74 \times 10^{-6} f_{\mathrm{kZ}} \mathrm{L}_{(m)} \frac{\sqrt{\mathrm{V}_o}}{\mathrm{N} - \mathrm{V_o}}$$

$$L(m) = 0.1 \times 10^{-2}\ \mathrm{m}$$
$$= 10^{-3}\ \mathrm{m}$$
$$\mathrm{N} = 13/4$$
$$= 1.75$$

$$|\mathrm{V_R}| = 6.74 \times 10^{-6} \times 10 \times 10^9 \times 10^{-1} \times \frac{\sqrt{300}}{1.75 - 300}$$
$$|V_{\mathrm{R}}| = -367.08 \quad \text{volts.}$$

PART B

1. Write short notes on the following microwave passive devices along with S parameters. Directional couplers and attenuators. (N/D'20)
2. i) With the help of two valley theory, explain how negative resistance is created in gunn diodes.
   ii) Describe the construction and operation of a basic magnetron.(N/D'20)
3. Describe with the neat sketch the construction details and principle of operation of klystron amplifier and derive the expression for its optimum bunching distance lopt. (N/D'20)
4. Discuss the operation of reflex klystron microwave oscillator with diagrams.(N/D'19)
5. What is an IMPATT diode? Discuss the operation of an IMPATT diode with neat diagram? Mention the applications of an IMPATT diode? (N/D'19)
6. With neat sketch explain how a travelling wave tube operates? Specify the role of slow wave structures in it. (N/D'19)
7. Derive the S matrix for a directional coupler and also verifying the properties of it. (A/M'18)
8. i) Derive the S matrix H plane TEE.
   ii) Explain the mode of oscillation of gunn diode. (A/M'18)
9. Draw the experimental set-up for S-parameter measurement of Magic Tee and explain. (A/M'18)
10. i) Explain the construction of Magic Tee and derive its S- matrix. (N/D'18)
    ii) Derive the S matrix for a directional coupler. (N/D'18)
11. i) Draw the schematic of two cavity klystron amplifier and explain the process of velocity modulation and bunching. Also derive the equation of velocity modulation. (N/D'18)
    ii) With neat diagram, explain how amplification of RF wave is accomplished in Helix type TWT. (N/D'18)
    (b) i) Draw the cross sectional view of Magnetron tube and explain the process of bunching. Derive the expression for Hull cut off voltage. (N/D'18)
    ii) Compare TWT and klystron. (N/D'18)
12. A two cavity klystron amplifier has the following parametres, (15)
    Vo = 1000 V, Ro = 35 KΩ, Io = 20 mA, f= 3 GHz, Gap spacing in either cavity, d= 1mm, spacing between the two cavities, L= 4 cm, Effective shunt impedance excluding beam loading, Rsh = 30 KΩ
    1. Find the input gap voltage to give maximum voltage V2.
    2. Find the voltage gain, neglecting the beam loading in the output cavity.
    3. Find the efficiency of the amplifier, neglecting beam loading. (N/D'18)
13. a) Explain the working principle and operation of multi-cavity Klystron amplifier and derive the expressions for its output power. (N/D'16)
    (b) A travelling wave tube (TWT) operates under the following parameter (N/D'16)
    Benm Voltage $V_0 = 3\text{kV}$

Bean Current $I_0 = 30$ mA
Characteristic impedance of helix $= Z_0 = 10\Omega$
Circuit length $= N^* = 50$ m
Frequency $f = 10$GHz
Determine :
(i) Gain parameters C,
(ii) Output power gain A_p in decibels.
(iii) All four propagation constants.

14. Explain the working principle of E plane Tee and derive its S parameters. (N/D'15)
15. Explain the working principle and operation of Gunn diode oscillator and its modes. (N/D'15)
16. Explain the working principle of IMPATT diode with neat diagram. (N/D'15)
17. Explain the working principle of Travelling wave Tube (TWTA). (N/D'15)
18. Explain the working principle of reflex klystron oscillator and derive the expression for power and efficiency. (N/D'15)
19. Draw the physical structure and droping profile of IMPATT diode and explain in detail (M/J'16)

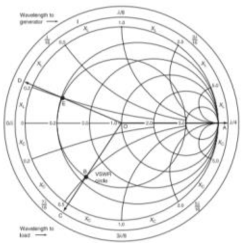
UNIT V

MICROWAVE DESIGN PRINCIPLES

Impedance transformation, Impedance Matching, Microwave Filter Design, RF and Microwave Amplifier Design, Microwave Power amplifier Design, Low Noise Amplifier Design, Microwave Mixer Design, Microwave Oscillator Design

PART A

1. **VSWR circle has a radius of 0.667 and a impedance is 0.25 – j0.5. Calculate the reflection co-efficient graphically.(N/D'20)**



Reflection co-efficient is 0.667 ∟ -124^o

2. **Define maximum available gain and noise figure (N/D'20)**

The noise figure of a microwave amplifier is defined as the ratio of the total available noise power at the output of the amplifier to the available noise power at the output due b thermal noise coming from input resistor at the standard room temperature T = 290°K

The transducer gain, GT which quantifies the gain of the amplifier placed between source id load

$$G_T = \frac{\text{Power delivered to the load}}{\text{Atailable power from the source}} = \frac{P_L}{P_A}$$

3. **Mention the sensors used for microwave power measurement. (A/M'19)**

Conventional microwave power sensors include three methods of diode, thermistor, and thermocouple

4. **Mention a few techniques used for measurement of an impedance at microwave frequency? (A/M'19)**

   Bolometric technique

   Calorimeter technique

   Calorimeter Watt meter

5. **What is the need of Rollet factor K? Write its expressions. (A/M'18)**
   Rollet factor is a stability factor is used check whether the transistor amplifier is unconditional stable or not and it can be expressed as

$$K = \frac{1 - |S_{11}|^2 - |S_{22}|^2 + |\Delta|^2}{2|S_{12}||S_{21}|} > 1$$

   Where,$\Delta = S_{11}S_{22} - S_{12}S_{21}$
   If $K < 1$ and $|\Delta| < 1$ the transistor amplifier is unconditional stuble.
6. **Define Transducer gain (Apr/May 17) (Nov/Dec 13)**

   The transducer gain, GT which quantifies the gain of the amplifier placed between source id load

$$G_T = \frac{\text{Power delivered to the load}}{\text{Atailable power from the source}} = \frac{P_L}{P_A}$$

7. **Define unconditional stability with regard to microwave transistor amplifier (N/D' 17)**

   The network is unconditionally stable if $|\, \Gamma_{\text{in}}\, k1$ and $|\Gamma_{\text{out}}| < 1$ for all. Passive source and load impedance (ie.) $|\Gamma_s| < 1$ and $|\, I_L k1$

8. **Define noise figure (N/D'16)**

   The noise figure of a microwave amplifier is defined as the ratio of the total available noise power at the output of the amplifier to the available noise power at the output due b thermal noise coming from input resistor at the standard room temperature T = 290°K

9. Calculate the VSWR of an amplifier if the amplifier has reflection coefficient 0.25333 (N/D'16)

$$\frac{1+|\Gamma_L|}{1-|\Gamma_L|}=\frac{1+0.2538}{1-0.2533}=1.6785$$

10. Distinguish between conditional and unconditional stabilities of an amplifier. (A/M '16) & (A/M'12)

Unconditional Stability:

The network is unconditionally stable if | $\Gamma_{\text{in}}\ k1$ a 1IΓ_{out} k1 for all passive source and load impedance (ie.) $|\Gamma_a|<1$ and $|\Gamma_L|<1$

Conditional stability: The network is conditionally stable | $\Gamma_{\text{in}}\ K_{\text{i and }|I_{\text{ou}}}$ ' 1 a certain range of passive source and load impedances. This case is also referred the instable

11. Define maximum available gain. (A/M 15) & (N/D' 15)

The available gain for load side matching,

$$G_A=\frac{\text{Power available from amplifier}}{\text{Pouer available from sourer}}$$

$$G_A=\frac{|S_{21}|^2(1-|\Gamma_S|^2)}{(1-|\Gamma_{\text{out}}|^2(1-S_{11}|\Gamma_S|^2)}$$

12. Define unilateral power gain (N/D'14)

The transducer power gain which neglects the feedback effect of the amplifier $(\mathrm{S}_{27}-0)$ is dled unilateral power gain, G_{nJ} It is given by

$$G_{TU}=\frac{(1-|\Gamma|^2)|S_{21}|^2\left(1-|\Gamma_g|^2\right.}{(1-\Gamma_L S_{22}^2\mid}$$

13. Define stability. (A/M'14)

It is the ability of an amplifier to maintain effectiveness in its nominal operating characteristics inspite of large changes in the environment such as physical temperature, signal frequency, source or load conduction, etc.

14. State the significance of microstrip matching networks? (N/D'14)

(1) Distributed microstrip lines and lumped capacitors
(2) Less susceptible to Parasitic
(3) Easy to tune
(4) Efficient PCB implementation
(5) Small size for high frequency

15. Define unilateral power gain (N/D'14)

The transducer power gain which neglects the feedback effect of the amplifier ($S_{27} = 0$) is called unilateral power gain, G_{TU} It is given by

$$G_{TU} = \frac{(1-|\Gamma|^2)|S_{21}|^2\left(1-|\Gamma_g|^2\right)}{(1-\Gamma_L S_{22}^2\ |}$$

16. Define Power gain of amplifier in terms of S-parameters. (N/D'12)

Is: : $G = \frac{\text{Pouer delivered to the lood}}{\text{Power sup plied to the amplifer}}$

$$G = \frac{(1-|\Gamma_L|^2|S_{21}|^2)}{(1-|\Gamma_{\text{in}}|^2)(1-S_{22}\Gamma_L)^2}$$

17. Define Power loss ratio, P_{LR}

$$\text{Ans: } P_{LR} = \frac{P_{InC}}{P_{\text{lood}}} = \frac{P_0}{P_c[1-|\Gamma(\omega)^2]}$$

$$P_{LR} = [1-|\Gamma(\omega)|^2]^{-1}$$

18. What is power amplifier?

Power amplifiers are used in final stages of radar and radar transmitter to increase the radiated Power Level.

19. Define mixer.

A mixer is a three port devices that used non-linear or time varying element to achieve" frequency conversion. Output is proportional to the product of two input signals.

20. State the steps for filter design

(1) Filter specifications

(2) Design a low pass prototype circuits

(3) Scale and conversion

PART B

1. For a broadband amplifier, it is required to develop a Pi- Type network that transforms a load impedance of $Z_l = (50 - j\ 100)$ into an input impedance $Z_{in} = 10 + j\ 20$. The design should involve the lowest possible nodal quality factor. Find the component values , assuming that matching should be achieved at a frequency of 2GHz. (N/D'20)
2. i) Write mathematical analysis of amplifier stability (N/D'20)

   ii) Design a microwave amplifier for maximum transducer power gain.
3. Explain in detail about impedance matching networks
4. Design a Rf and microwave amplifier, explain in detail
5. What is microwave power amplifier? Write short notes on it.
6. Write short notes on designing a LNA
7. Explain in detail about design microwave oscillator and mixer.

EC 8701 – ANTENNA & MICROWAVE ENGINEERING

Adhi College of Engineering & Technology

Trust Office:
No.25, Munu Adhi Illam,
Patel Nagar, 2nd Street, Near ESI Hospital
Tambaram West, Chennai - 600 025
Phone: +91-44-6499 4035
Email: **office@adhi.edu.in** Website: **www.adhi.edu.in**