EC8651
TRANSMISSION LINES AND RF SYSTEMS

EC8651 TRANSMISSION LINES AND RF SYSTEMS **L T P C 3 0 0 3**

OBJECTIVES:

- To introduce the various types of transmission lines and its characteristics
- To give thorough understanding about high frequency line, power and impedance measurements
- To impart technical knowledge in impedance matching using smith chart
- To introduce passive filters and basic knowledge of active RF components
- To get acquaintance with RF system transceiver design

UNIT I TRANSMISSION LINE THEORY 9

General theory of Transmission lines - the transmission line - general solution - The infinite line - Wavelength, velocity of propagation - Waveform distortion - the distortion-less line - Loading and different methods of loading - Line not terminated in Z0 - Reflection coefficient - calculation of current, voltage, power delivered and efficiency of transmission - Input and transfer impedance - Open and short circuited lines - reflection factor and reflection loss.

UNIT II HIGH FREQUENCY TRANSMISSION LINES 9

Transmission line equations at radio frequencies - Line of Zero dissipation - Voltage and current on the dissipation-less line, Standing Waves, Nodes, Standing Wave Ratio - Input impedance of the dissipation-less line - Open and short circuited lines - Power and impedance measurement on lines - Reflection losses - Measurement of VSWR and wavelength.

UNIT III IMPEDANCE MATCHING IN HIGH FREQUENCY LINES 9

Impedance matching: Quarter wave transformer - Impedance matching by stubs - Single stub and double stub matching - Smith chart - Solutions of problems using Smith chart - Single and double stub matching using Smith chart.

UNIT IV WAVEGUIDES 9

General Wave behavior along uniform guiding structures – Transverse Electromagnetic Waves, Transverse Magnetic Waves, Transverse Electric Waves – TM and TE Waves between parallel plates. Field Equations in rectangular waveguides, TM and TE waves in rectangular waveguides, Bessel Functions, TM and TE waves in Circular waveguides.

UNIT V RF SYSTEM DESIGN CONCEPTS 9

Active RF components: Semiconductor basics in RF, bipolar junction transistors, RF field effect transistors, High electron mobility transistors Basic concepts of RF design, Mixers, Low noise amplifiers, voltage control oscillators, Power amplifiers, transducer power gain and stability considerations.

TOTAL:45 PERIODS

OUTCOMES:

Upon completion of the course, the student should be able to:

- Explain the characteristics of transmission lines and its losses
- Write about the standing wave ratio and input impedance in high frequency transmission lines
- Analyze impedance matching by stubs using smith charts
- Analyze the characteristics of TE and TM waves
- Design a RF transceiver system for wireless communication

TEXT BOOKS:

John D Ryder, ―Networks, lines and fields‖, 2nd Edition, Prentice Hall India, 2015. (UNIT I-IV)
2. Mathew M. Radmanesh, ―Radio Frequency &Microwave Electronics‖, Pearson Education Asia, Second Edition,2002. (UNIT V)

REFERENCES:

1. Reinhold Ludwig and Powel Bretchko,‖ RF Circuit Design – Theory and Applications‖, Pearson Education Asia, First Edition,2001.
2. D. K. Misra, ―Radio Frequency and Microwave Communication Circuits- Analysis and Design‖, John Wiley & Sons, 2004.
3. E.C.Jordan and K.G. Balmain, ―Electromagnetic Waves and Radiating Systems Prentice Hall of India, 2006.
4. G.S.N Raju, "Electromagnetic Field Theory and Transmission Lines Pearson Education, First edition 2005.

COURSE NAME: TRANSMISSION LINES AND WAVEGUIDES (EC8651)

On completion of this course, students will able to

CO1	Analyze the line parameters and various losses in transmission lines. **(PO1,PO2 and PO3)**
CO2	Acquire knowledge about transmission lines used at radio frequencies **(PO1,PO2 and PO3)**
CO3	Design impedance matching network using smithchart.**(PO1,PO2and PO3)**
CO4	Using vector calculus to solve Maxwell's equations and analyze the electromagnetic fields in parallel plate waveguides and apply and analyze electromagnetic wave propagation through guiding structures. **(PO1,PO2 and PO3)**
CO5	Acquire basic knowledge of active RF components. **(PO1 and PO2)**
CO6	Design a RF transceiver system for wireless communication (**PO1,PO2 and PO3)**

UNIT I
TRANSMISSION LINE THEORY

4. 1. What are the primary constants and secondary constants of a transmission line? (Dec 2018) **[Remember]**

The four line parameters resistance(R), inductance (L), capacitance(C) and conductance (G) are termed as primary constants of a transmission line. Propagation constant and characteristic impedance are the secondary constants of a transmission line

2. When will a transmission line deliver maximum power to a load? **[Understand]**

A transmission line will deliver maximum power to the load when the load resistance is equal to the characteristic resistance.

3. Name the types of line distortion. **[Remember]**

Line distortion is usually of two types:

1. Frequency distortion
2. Delay distortion

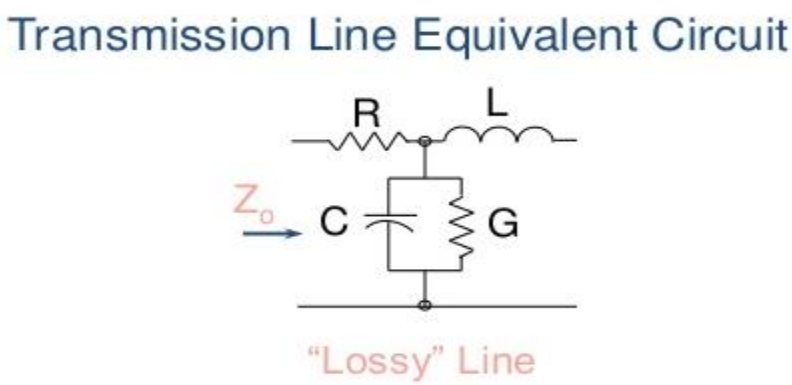
5. Give the condition for a distortion less line.
[Remember](Dec2011)(Dec2017)(April 2018) (Dec 2018)(May2019)

A line in which there is no phase or frequency distortion is called a distortion less line. The condition for a distortion less line is given as

The condition for a distortion less line is

$$\frac{R}{G} = \frac{L}{C}$$

5. Draw the equivalent circuit of a unit length of a transmission line. **[Remember]**



$$Z_o = \sqrt{\frac{R + j\omega L}{G + j\omega C}}$$

6. What are loaded lines? **[Remember]**

To achieve distortion less condition in transmission line, inductance L has to be increased, increasing the value by inserting inductance in series with line is termed as loading and such lines are called loaded lines

7. What is phase or delay distortion? **[Remember]**

When a signal having many frequency components are transmitted along the line, all the frequencies will not have same time of transmission, some frequencies being delayed more than others. So the received end waveform will not be identical with the input waveform at the sending end because some frequency

components will be delayed more than those of other frequencies. This type of distortion is called phase or delay distortion.

8. What is frequency distortion? **[Remember]**

A complex voltage transmitted on a transmission line will not be attenuated equally and the received waveform will not be identical with the input waveform at the transmitting end. This variation is known as frequency distortion.

9. How can distortion be reduced in a transmission line? **[Remember]**

Frequency distortion is reduced by the use of equalizers. Delay distortion is avoided by the coaxial cable.

10. What is meant by infinite line? **[Remember]**

It is an imaginary line of infinite length having input impedance equal to the characteristic impedance of the transmission line.

A line of finite length, terminated in a load equivalent to its characteristic impedance appears the sending end as an infinite line.

11.What are properties of Infinite line ? (Dec 12,13)**[Remember]**

a. As the line has infinite length, no waves will never reach the receiving end and hence threre no possibility to reflections at the receiving end. Thus there cannot be reflected waves returning to the sending end. The line absorbs the complete power applied at the sending end.
b. As the reflected waves are absent the characteristic impedance at sending end will decide the current flowing, when a voltage applied at the sending end. The current will not be affected by the terminating impedance Zr at the receiving end

12. **Determine the values of VSWR in the case of (a)Zr=0 (b) Zr=Zo** **[Remember]**

(a) Zr=0, |K|=1, SWR= ∞

(b)Zr=Zo, K=0, SWR=1

13. Define SWR. **(Dec 2008) (Dec 2009)[Remember]**

The ratio of the maximum to minimum value is known as the voltage standing wave ratio (VSWR) or standing wave ratio (SWR).

$$SWR = |V_{MAX}/V_{MIN}| = |Imax/Imin|$$

where:

V_{MAX} = maximum amplitude of the standing wave
V_{MIN} = minimum amplitude of the standing wave

14. Determine the Reflection coefficient values various load termination. (Nov-2014)[Remember]

Impedance of transmission line termination (Z_L)	Reflection Coefficient, K
$Z_L = 0$ (short circuit)	-1
$0 < \| Z_L \| < Z_0$	$-1 \leq K \leq 0$
$Z_L = Z_0$	0
$Z_0 < \| Z_L \| < \infty$	$0 \leq K \leq 1$
$Z_L = \infty$ (open circuit)	+1

15. How are practical lines made to appear as infinite lines? Or How finite line become as an infinite line? **[Understand]**

A finite line terminated in a load equivalent to the characteristic impedance appears to the sending end as an infinite line

16. Define reflection factor. **[Remember]**

Reflection factor indicates the change in current in the load due to reflection at the mismatched junction

$$k = \left|\frac{2\sqrt{Z_1 * Z_2}}{Z_1 + Z_2}\right|$$

17. What is meant by waveform distortion? **[Remember]**

If the received waveform on a transmission line is not identical with the input waveform at the sending end, it is called the waveform distortion. This id due to the fact that all frequencies applied on the transmitted line are not equally attenuated and are not delayed equally.

18. What is the need for loading? **[Remember]**

The condition for distortion less line is

$$\frac{R}{G} = \frac{L}{C}$$

To achieve this,L has to be increased. This can be done by loading. The need for loading is to make the transmission line a distortion less or Loss less line one

19. When does reflection take place on a transmission line? **[Understand]**

When the load impedance (Z_R) is not equal to characteristic impedance (Zo) of the transmission line, ($Z_R \neq Zo$) reflection takes place.

20. Define reflection coefficient. **[Remember]**

Reflection coefficient is defined as the ratio of reflected voltage to the incident voltage at the receiving end of the line

$$Reflection\ coefficient\ (K) = \frac{Reflected\ Voltage\ at\ the\ Load}{Incident\ Voltage\ at\ the\ Load} = \frac{V_R}{V_i}$$

$$Reflection\ coefficient\ (K) = \frac{Z_R - Z_0}{Z_R + Z_0}$$

21. Write the formula for reflection coefficient.

$$Reflection\ coefficient\ (K) = \frac{Z_R - Z_0}{Z_R + Z_0}$$ **[Remember]**

where:

Z_0 is the characteristic impedance of the transmission line
Z_R is the load impedance

22.A lossless line has a characteristics impedance of 400 ohms. Determine the standing wave ratio if the receiving end impedance is 800+ j 0.0 ohms. **Apply**

ANS:
Z_0=400ohm, Z_R=800+j0.0ohms.

$$(K) = \frac{Z_R - Z_0}{Z_R + Z_0} = \frac{800 - 400}{800 + 400} = \frac{1}{3}$$

$$SWR = \frac{1+|K|}{1-|K|} = \frac{1+\frac{1}{3}}{1-\frac{1}{3}} = 2$$

23. A transmission line whose characteristic impedance is 300 ohms is terminated in a load resistance of 100 ohms. What is the SWR? [Apply]

$$SWR = \frac{1+|K|}{1-|K|}$$

$$SWR = \frac{1+\left|\frac{Z_L - Z_0}{Z_L + Z_0}\right|}{1-\left|\frac{Z_L - Z_0}{Z_L + Z_0}\right|} = \frac{1+\left|\frac{100-300}{100+300}\right|}{1-\left|\frac{100-300}{100+300}\right|} = \frac{1+\left|\frac{-200}{400}\right|}{1-\left|\frac{-200}{400}\right|} = \frac{1+|-0.5|}{1-|-0.5|} = \frac{1+0.5}{1-0.5} = \frac{1.5}{0.5} = 3.0$$

24.The transmission line has Z0=745 ,<12 degree ohms and is terminated is ZR=100ohm calculate the reflection loss in dB. [Apply]Dec11

Answer: k=0.6475, 1/|k|=3.7751 dB

25.Define Characteristic impedance [Remember] May/June 16 , Dec 2017,April/May 2021

The characteristic impedance or surge impedance of a uniform transmission line, is the ratio of the amplitudes of a single pair of voltage and current waves propagating along the line in the absence of reflections. The SI unit of characteristic impedance is the ohm.

Characteristic impedance is the impedance measured at the sending end of the line. It is given by $Z_0 = \sqrt{\frac{Z}{Y}} = \sqrt{\frac{R + j\omega L}{G + j\omega C}}$

where $Z = R + j\omega L$ is the series impedance

$Y = G + j\omega C$ is the shunt admittance

26. Define Propagation constant [Remember]

Propagation constant is defined as the natural logarithm of the ratio of the sending end current or voltage to the receiving end current or voltage of the line. It gives the manner in the wave is propagated along a line and specifies the variation of voltage and current in the line as a Propagation Constant $\gamma = \sqrt{ZY} = \sqrt{(R + j\omega L)(G + j\omega C)}$ function of frequency.

Propagation constant is a complex quantity and is expressed as

$\gamma = \alpha + j\beta$

The real part is α called the attenuation constant whereas the imaginary part of Propagation constant is

called the phase constant β

23. What is a finite line? Write down the significance of this line? **[Remember]**

A finite line is a line having a finite length on the line. It is a line, which is terminated, in its characteristic impedance ($Z_R=Z_0$), so the input impedance of the finite line is equal to the characteristic impedance ($Z_S=Z_0$).

24. What is an infinite line? **[Remember]**

An infinite line is a line in which the length of the transmission line is infinite. A finite line, which is terminated in its characteristic impedance, is termed as infinite line. So for an infinite line, the input impedance is equivalent to the characteristic impedance.

25. How to avoid the distortion that occurs in the line? **[Understand]**

In order to reduce frequency distortion occurring in the line, By using equalizers at the line terminals by which minimize the delay distortion. Equalizers are networks whose frequency and phase characteristics are adjusted to be inverse to those of the lines, which result in a uniform frequency response over the desired frequency band, and hence the phase is equal for all the frequencies.

In order to reduce delay distortion occurring in the line,

a) The phase constant β should be made dependent of frequency.

b) The velocity of propagation is independent of frequency.

26. How the telephone line can be made a distortion less line? **[Understand]**

For the telephone cable to be distortion less line, the inductance value should be increased by placing lumped inductors along the line.

27. What is continuous loading? **[Remember]**

Continuous loading is the process of increasing the inductance value by placing a iron core or a magnetic tape over the conductor of the line.

28.What is Impedance matching? **[Remember]**

If the load impedance is not equal to the source impedance, then all the power that are transmitted from the source will not reach the load end and hence some power is wasted. This is called impedance mismatch condition. So for proper maximum power transfer, the impedances in the sending and receiving end are matched. This is called impedance matching.

[Remember]

29.When reflection occurs in a line?

Reflection occurs because of the following cases:

1) when the load end is open circuited

2) when the load end is short-circuited

3) when the line is not terminated in its characteristic impedance When the line is either open or short circuited, then there is not resistance at the receiving end to absorb all the power transmitted from the source end. Hence the entire power incident on the load gets completely reflected back to the source causing reflections in the line. When the line is terminated in its characteristic impedance, the load will absorb some power and some will be reflected back thus producing reflections.

30. What are the conditions for a perfect line? What is a smooth line? Nov-12, May-10[Remember]

For a perfect line, the resistance and the leakage conductance value were neglected. The conditions for a perfect line are R=G=0.

A smooth line is one in which the load is terminated by its characteristic impedance and no reflections occur in such a line. It is also called as flat line.

31.What do you mean by a transmission line? [Remember]

Transmission lines are considered to be impedance-matching circuits designed to deliver power from the transmitter to the antenna and maximum signal from antenna to the receiver.

32. Define propagation constant. [Remember]

Propagation constant (γ) is defined as the natural logarithm of the ratio of sending end current to the receiving end current.

$\gamma=\ln(I_S / I_R)$

$\gamma=\alpha+j\beta$

where,$\alpha\rightarrow$attenuation constant in neper

$\beta\rightarrow$phase constant in radian

33. Give the equations for voltage and current at any point on the transmission line at a distance S from receiving end. [Understand]

$$E_S = E_R \cosh \gamma S + I_R R_0 \sinh \gamma s$$

$$I_S = I_R \cosh \gamma S + \frac{E_R}{R_0} \sinh \gamma s$$

Where, $Z_0\rightarrow$characteristic impedance

$S\rightarrow$distance from the receiving end

E_R&I_R are the receiving end voltage and current respectively

34. Define phase velocity [Remember]

Phase velocity or velocity of propagation(v) is defined as the velocity which the wave is transmitted in the transmission line. It is given by,

$V=\omega/\beta$

35.What are the advantages of continuous loading? **[Remember]**

i)The attenuation is independent of frequency and it is same for all frequencies

ii) The value of α can be reduced by increasing L provided R is not increased greatly

iii) The increase in the inductance up to 100mH per unit length of the line is possible.

36. State the disadvantages of reflection? **[Remember]**

- Reflected wave appears as echo at the sending end
- The efficiency is reduced
- The output reduces as load rejects part of the energy
- If generator impedance is not Z0, then reflected wave is again reflected at sending end as new incident wave. This continuous back and forth till all the energy is dissipated as the line losses

37. What are the disadvantages of continuous loading? **[Remember]**

i) This method is very expensive. The existing lines cannot be modified by this method

ii) Extreme precision care should be taken while manufacturing continuous loaded cable. Otherwise it becomes irregular

iii)for an AC signal there will be large eddy current and hysteresis loss. Eddy current loss varies directly with square of frequency while the hysteresis loss varies directly with frequency.

38. A resonant transmission line carries 81 watts in the forward direction and 9 watts in the reverse direction. What is the SWR on the line? **[Apply]**

$$SWR = \frac{\sqrt{P_F} + \sqrt{P_R}}{\sqrt{P_F} - \sqrt{P_R}} = \frac{\sqrt{81} + \sqrt{9}}{\sqrt{81} - \sqrt{9}} = \frac{9+3}{9-3} = \frac{12}{6} = 2$$

39.What are the advantages of lumped loading? **[Remember]**

i)There is no practical limit to the value by which the inductance can be increased

ii)The cost involved is small

iii)With this method, the existing lines can be tackled and modified

iv)Hysteresis and eddy current losses are small

40.What are the disadvantages of lumped loading? **[Remember]**

i)After particular frequency the line acts as a low pass filter and above the cutoff frequency the attenuation increases

ii)The cutoff frequency must be at the top of voice frequency. Hence fractional loading must be used. Care must be taken while installing the lumped inductors so as to maintain the exact balancing of the circuit

43. Define group velocity **MAY 21** **[Remember]**

The velocity which is produced by a group of frequency traveling along the system is called group velocity. It is defined as,

$$Vg=d\omega/d\beta$$

44. State the disadvantages of reflection? **[Remember]**

1. Reflected wave appears as echo at the sending end

2. The efficiency is reduced

3. The output reduces as load rejects part of the energy

4. If generator impedance is not Z_0, then reflected wave is again reflected at sending end as new incident wave. This continuous back and forth till all the energy is dissipated as the line losses

45. What is wavelength of a line? **[Remember]**

The distance the wave travels along the line while the phase angle is changing through 2π radians is called a wavelength.

46. What is the drawback of using ordinary telephone cables? **[Remember]**

In ordinary telephone cables, the wires are insulated with paper and twisted in pairs, therefore there will not be flux linkage between the wires, which results in negligible inductance, and conductance. If this is the case, there occurs frequency and phase distortion in the line.

47. What is patch loading? **[Remember]**

It is the process of using sections of continuously loaded cables separated by sections of unloaded cables which increases the inductance value

48. What is lumped loading? **[Remember]**

Lumped loading is the process of increasing the inductance value by placing lumped inductors at specific intervals along the line, which avoids the distortion

49.Define reflection loss (May 2018) **[Remember]**

Reflection loss is defined as the number of nepers or decibels by which the current in the load under image matched conditions would exceed the current actually flowing in the load

50. Define the term insertion loss **[Remember]**

The insertion loss of a line or network is defined as the number of nepers or decibels by which the current in the load is changed by the insertion .Insertion loss=Current flowing in the load without insertion of the network/Current flowing in the load with insertion of the network

51.What are the different types of transmission lines used in practice? **[Remember]**

1. open wire line
2. cables
3. co-axial cables
4. wave guides

52.What is meant by distortion less line.(Dec 2016) (May 2018) **[Remember]**

A line in which there is no phase or frequency distortion is called a distortion less line and is terminated correctly. The condition for a distortion less line is

$$\frac{R}{G}=\frac{L}{C}$$

53.What is the drawback of using telephone cable? (Ap-15) **[Remember]**

In ordinary telephone cables, the wires are insulated with paper and twisted in pairs, therefore there will not be flux linkage between the wires, which results in negligible inductance, and conductance. If this is the case, there occurs frequency and phase distortion in the line.

54.Define Smooth line

When the line is terminated in an impedance Z_R=Z_O the reflection coefficient and reflected waves becomes zero,then that line is called as Smooth line (**Ap-17**) **[Understand]**

PART -B

1. Derive the expression for voltage and current at any point on a transmission line in terms of receiving end voltage and current.[Marks 10]
[Remember](May -2009) (Nov -2010)(May 2016)(Nov-2017)(May 2018)(May 2019)

2. A line has the following primary constants R=100 ohm/km L=0.001 H/km, G=1.5 µS/km C=0.062 µF/km. Find the characteristic impedance and the propagation constant.
[Apply](Nov -2011) (Nov -2012)

3. A generator of 1V,1kHz supplies power to a 100km transmission line terminated in 200 ohm resistance. The line parameters are R=10/km, L=3.8 mH/km, G=1µv/km, C=0.0085 µF/km Calculate the input impedance and reflection coefficient.[Marks 16] **[Apply](May -2009) (May 2019)**

4. Explain in detail about the reflection on a line not terminated in its characteristic impedance (8) [Understand]**May-10(Nov -2015)(May 2019)**

5.A cable has the following parameters R= 48.75 ohm/km, L= 1.09 mH/km, G= 38.75 mho/km and C= 0.059 microf/km.Determine the characteristic impedance, propagation constant and wavelength for a source of f: 1600 Hz and V_s= 1.0 volts. **[Apply]**

6. A transmission line has the following per unit length parameters : L = 0.1µ H, R =5 ohms, C = 300 pF and G = 0.01 mho. Calculate the propagation constant and characteristic impedance at 500 MHz. (8)
[Apply]Nov-11,Dec-10

7.Derive the conditions required for a distortion less line. **[Understand]**(8)

8.The characteristic impedance of a uniform transmission line is 2309.6 ohms at a frequency of 800 MHz. At this frequency, the propagation constant is 0.054(0.0366 + j 0.99). Determine R and L. (6)
[Apply]Nov -11

10. If Z=R+jωL and Y= G+jωC, show that the line parameter values fix the velocity of propagation for an ideal line. **[Understand]**(8)**Nov-12**

11.Deduce the expressions for characteristic impedance and propagation constant of a line of cascaded identical and symmetrical T sections of impedance. **[Understand]Nov- 12**

12. The characteristic impedance of a uniform transmission line is 2309.6 ohms at a frequency of 800 MHz. At this frequency, the propagation constant is 0.054(0.0366 + j 0.99). Determine Rand L.
[Apply]Nov-10

13. Explain the reflection on lines not terminated in characteristic impedance with phasor diagrams. Define reflection coefficient and reflection loss. (10) **[Understand]Nov-10**

14. Explain in detail about the reflection on a line not terminated by its characteristic impedance Z0 (8)[Remember]

15.Derive the condition for minimum attenuation in a distortionless line (8) [Remember]

16.A communication line has L=3.67mH/km, G=0.08x10^-6 mhos/km,C=0.0083µF/km and R=10.4ohms/km.Determine the charecteristics impedance ,propagation constant,phaseconstant,velocity of propagation, sending and receiving end current for given line length is 100Km (16) **June 16, May 2017,May 2018** [Apply]

17.Prove that infinite line equal to finite line terminated in its characteristic impedance(10)
[Understand]June 16

18.Discuss the general solution of transmission line in detail(10) **[Understand]** **May 2017**

19.Discuss in detail about lumped loading and derive the Cambell's equation (8) **[Understand] May 2017**

20.Derive the input impedance Z0 from the transmission line equation and also find voltage reflection ratio at the load **[Understand]** **May 2017**

21.Derive the equation of attenuation constant and phase constant of transmission lines in terms of line constant R,L,C,G **[Understand]** **DEC 2018**

22.Explain the theory of open and short circuited lines and also derive all expressions for input impedance

[Understand] **DEC 2018**

23. Define wave form distortion on a transmission line. Determine the condition for distortion less transmission line. How can a transmission line be made distortion less **[Understand] (13)** **MAY 2021**

24. 50 Ω line is terminated into an infinite line. If it is fed by a 10V, 50Ω source, find the reflected and power transmitted into infinite line. **[Apply]** **(13)** **MAY 2021**

Reflected voltage =0 (Infinite line)

Power $=\frac{v2}{Ro}=\frac{50^2}{50}$=50 Watts

UNIT 1 Assignments

1. A lossless transmission line is terminated with a 100 Ω load. If the SWR on the line is 1.5, find the two possible values for the characteristic impedance of the line.(Analysis)
2. Let Zsc be the input impedance of a length of coaxial line when one end is short circuited and let Zoc be the input impedance of the line when one end is open circuited. Derive an expression for the characteristic impedance of the cable in terms of Zsc and Zoc. (Understand)
3. A 100 Ω transmission line has an effective dielectric constant of 1.65. Find the shortest open-circuited length of this line that appears at its input as a capacitor of 5pF at 2.5 GHz. Repeat for an inductance of 5 nH. (Analysis)
4. A radio transmitter is connected to an antenna having an impedance 80 + j40 Ω with a 50 Ω coaxial cable. If the 50 Ω transmitter can deliver 30 W when connected to a 50 Ω load, how much power is delivered to the antenna? (Analysis)
5. The transmission line circuit shown below has Vg= 15 V rms, Zg=75 Ω, Zo =75 Ω, Z_L= 60-j40Ω, and ℓ = 0.7λ. Compute the power delivered to the load using three different techniques:(Analysis)

(a) find Γ and compute
(b) find Zin and compute
(c) find VL and compute
(d) Discuss the rationale for each of these methods. Which of these methods can beused if the line is not lossless?

6. For a purely reactive load impedance of the form Z_L= jX, show that the reflection Coefficient magnitude lf mag(K) is always unity. Assume the characteristic impedance Zo is real.C = 0.059μ F per k.m. Determine the characteristic impedance propagation constant and wave length for a source of f = 1600Hz and Es = 1V .(8 Marks)(MAY 2013)
7. A transmission line has the following parameters
   R = 5 per k.m

G = 0.01mho per k.m
L = 0.1μH per k.m
C = 300 pF per k.m. Determine the characteristic impedance propagation constant and wave length for a source of f = 500MHz .(Design)

8. Characteristic impedance of a transmission line at 8MHZ is 40−j2 and the propagation constant is 0.01 + j0.18 per m. Find the primary constants.(8 Marks)(NOV2012)

9. A generator of 1.0 volt, 1000 cycles, supplies power to a 100-mile open-wire line terminated in 200 ohms resistance. The line parameters are

R = 10.4 ohms per mile

L = 0.00367 henry per mile

G = 0.8X10−4 mho per mile

C = 0.00835μF per mile.

Determine the reflection coefficient, power and transmissionefficiency.(Analysis)

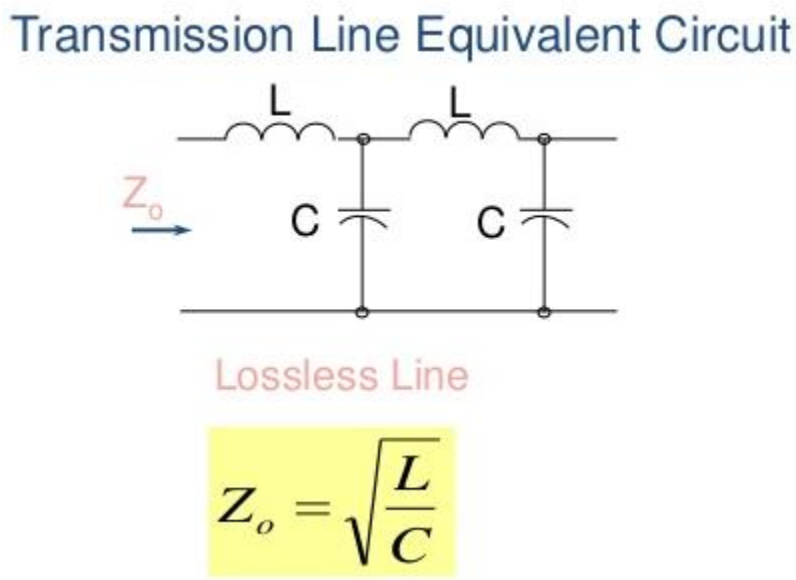
10. A low loss transmission of 100 characteristic impedance is connected to a load of 200Calculate the voltage reflection coefficient and SWR,(Design)
11. The characteristic impedance of a uniform transmission line is 2309.6 at a frequency of 800MHz.At this frequency , the propagation constant is 0.054(0.0366+j0.99).Determine R and L. (Design)

UNIT II
HIGH FREQUENCY TRANSMISSION LINES

1.What is dissipation less line? **[Remember]**

A line for which the effect of resistance R is completely neglected is called dissipation less line.

Draw the equivalent circuit of Lossless line



2.What are nodes and antinodes on a line? Dec 2017,May2019 **[Remember]**

The points along the line where magnitude of voltage or current is zero are called nodes, while the points along the lines where magnitude of voltage or current is maximum are called antinodes or loops.

3.What is standing wave ratio? May2019 **[Remember]**

The ratio of the maximum to minimum magnitudes of voltages or currents on a line having standing waves is called standing wave ratio.

$$SWR\ (S) = \frac{|E_{MAX}|}{|E_{MIN}|} = \frac{|I_{MAX}|}{|I_{MIN}|} = \frac{1+|K|}{1-|K|}$$

4.What is the range of values of standing wave ratio? **[Remember]**

The range of values of standing wave ratio is theoretically 1 to ∞.

5.Distinguish clearly between open and shorted line. **[Remember]**

A shorted line means having zero receiving end voltage and impedence i.e. $Z_R = 0$ and $E_R = 0$.

And open circuited line means having infinite receiving end impedence and zero receiving end current i.e. $Z_R = -\infty$ and $I_R = 0$.

6.What are the advantages of dissipation line? **[Remember]**

The advantages of properly terminate line are as follows.

i)The line acts as a smooth line.

ii)No reflection takes place at the receiving end.

iii)The standing waves are not produced.

7.If VSWR of line is 1.5 then calculate its reflection coefficient. Nov -10,Dec 2012 [Apply]

VSWR = **[**1+|K|**]/[**1-|K|**]** = 1.5

1+|K| = 1.5-1.5|K|

2.5|K| = 1.5-1 = 0.5

|K| = 0.2

8.What are the values of SWR for open circuit, short circuit & matched load?[Remember]

When a load is either open circuit or short circuit, the value of |K| = 1.

Hence the value of SWR is given by,

SWR = **[**1+|K|**]/[**1-|K|**]** = **[**1+1**]/[**1-1**]** = ∞

When load is matched with characteristic impedance, the value of |K| is

Hence the value of SWR is given by,

SWR = **[**1+|K|**]/[**1-|K|**]** = **[**1+0**]/[**1-0**]** = 1

9.Why are short circuited stubs preferred over open circuited stub? [Apply]

At high frequencies, open circuited stubs radiated some energy which is note the case with short circuited stub. Hence over open circuited stubs are preferred.

10.What is meant by electrical length of the line? [Remember]

The length of transmission line expressed interms of wavelength is called an electrical length of line. (eg) Eighth wave line(λ/8), quarter wave line (λ/4), etc.

11.What are called standing waves? [Remember]

The points of minimum and maximum voltage or current are called nodes and antinodes respective. A line reflected back from the load consisting nodes and antinodes is called standing wave. If the transmission is not terminated in its characteristic impedance, then there will be two waves traveling along the line which gives rise to standing waves having fixed maxima and fixed minima.

14.**A 50Ω line is terminated in load ZR = 90 + j60Ω. Determine VSWR due to this Load. May 2017 [Apply]**

K = $[Z_R-Z_0]/[Z_R+Z_0]$ = [90+j60-50]/[90+j60+50] = [40+j60]/[140+j60]

= [72.111∠56.3o]/[152.315∠23.2o] = 0.473∠33.1o

∴VSWR = [1+|K|]/[1-|K|] = 1+0.473/1-0.473 = 2.795

15. State the assumptions for the analysis of the performance of the radio frequency line. May 2018 [Understand]

1. Due to the skin effect, the currents are assumed to flow on the surface of the conductor. The internal inductance is zero.

2. The resistance R increases with f while inductance L increases with f .

Hence ωL>>R.

3.The leakage conductance G is zero

16. State the expressions for inductance L of open wire line and coaxial Line. [Understand]

For open wire line ,

$$L = \frac{\mu_0}{2\pi} \ln \frac{d}{a}$$

L= $4\times10^{-7} \ln \frac{d}{a}$ H/M

L= $9.21\times10^{-7} \log \frac{d}{a}$ H/M

For coaxial line,

$$L = \frac{\mu_0}{2\pi} \ln \frac{b}{a}$$

$$L = 2\times10^{-7} \ln \frac{b}{a} \text{ H/M}$$

$$L = 4.6\times10^{-7} \ln \frac{b}{a} \text{ H/M}$$

17. State the expressions for the capacitance of an open wire line and coaxial Line.

For open wire line , **[Remember] Dec-11,Dec-12**

$$C = \frac{\pi\varepsilon_v}{\ln \frac{d}{a}} \text{ F/m}$$

$$C = \frac{27.7}{\ln \frac{d}{a}} \text{ μμF/m}$$

$$C = \frac{12.07}{\log \frac{d}{a}} \text{ μμF/m}$$

for coaxial Line

$$C = \frac{2\pi\varepsilon}{\log \frac{b}{a}} F/m$$

18. What is the nature and value of Z0 for the dissipation less line? **[Remember]**

For the dissipation less line, the Z0 is purley resistive and given by,

$$Z_0 = R_0 = \text{Re}\,al = \sqrt{\frac{L}{C}}$$

19.State the values of α ,β and v(velocity of propagation) for the dissipation less line.[Remember]

α=0 , $\beta = \omega\sqrt{LC}$, $v = \frac{\omega}{\beta} = \frac{1}{\sqrt{LC}}$ m/sec

20.What is standing wave ratio?

The ratio of the maximum to minimum magnitudes of voltage or current on a line having standing waves called standing waves ratio.

$$S = \left|\frac{E_{MAX}}{E_{MIN}}\right| = \left|\frac{I_{MAX}}{I_{MIN}}\right|$$

$$S = \frac{1+|K|}{1-|K|}$$

21.What is the range of values of standing wave ratio? [Remember]

The range of values of standing wave ratio is theoretically 1 to infinity.

22.State the relation between standing wave ratio and reflection coefficient.

$S = \frac{1+|K|}{1-|K|}$ and $|K| = \frac{S-1}{S+1}$

23. How will you make standing wave measurements on coaxial lines? [Understand]

For coaxial lines it is necessary to use a length of line in which a longitudinal slot, one half wavelength or more long has been cut. A wire probe is inserted into the air dielectric of the line as a pickup device, a vacuum tube voltmeter or other detector being connected between probe and sheath as an indicator. If the meter provides linear indications, S is readily determined. If the indicator is non linear, corrections must be applied to the readings obtained.

24.Give the input impedance of a dissipation less line. [Remember]

The input impedance of a dissipation less line is given by,

$$Z_{in} = \frac{E_S}{I_S} = R_0\frac{Z_R\cos\beta S + jI_R R_0\sin\beta S}{R_0\cos\beta S + jZ_R\sin\beta S} = R_0\frac{Z_R + jI_R R_0\tan\beta S}{R_0 + jZ_R\tan\beta S}$$ or

$$Z_{in} = R_0\frac{[1\angle 0 + |K|\angle(\Phi - 2\beta S)]}{[1\angle 0 - |K|\angle(\Phi - 2\beta S)]}$$

25.Give the maximum and minimum input impedance of the dissipation less line.[Remember]

Maximum input impedance, $Z_{S(\max)} = R_0\left[\frac{1+|K|}{1-|K|}\right] = SR_0$

Minimum input impedance, $Z_{S(\min)} = R_0\left[\frac{1+|K|\angle-\pi}{1-|K|\angle-\pi}\right] = \frac{R_0}{S}$

26.Give the input impedance of open and short circuited lines.(May 2018) [Remember]

The input impedance of open and short circuited lines are given by,

$Z_{OC} = -j R_0 \cot(\frac{2\pi}{\lambda}) S$ and $Z_{SC} = j R_0 \tan(\frac{2\pi}{\lambda}) S$

27. Why the point of voltage minimum is measured rather than voltage maximum? [Understand]

The point of a voltage minimum is measured rather than a voltage maximum because it is usually possible to determine the exact point of minimum voltage with greater accuracy.

28. What are the advantages of dissipation line? [Remember]

The advantages of properly terminate line are as follows.

The line acts as a smooth line.

No reflection takes place at the receiving end.

i) The standing waves are not produced.

29. If VSWR of line is 1.5 then calculate its reflection coefficient. [Apply]

VSWR = [1+|K|]/[1-|K|] = 1.5

1+|K| = 1.5-1.5|K|

2.5|K| = 1.5-1 = 0.5

|K| = 0.2

30. What are the values of SWR for open circuit, short circuit & matched load?[Remember]

When a load is either open circuit or short circuit, the value of |K| = 1.

Hence the value of SWR is given by,

SWR = [1+|K|]/[1-|K|] = [1+1]/[1-1] = ∞

When load is matched with characteristics impedance, the value of |K| is

Hence the value of SWR is given by,

SWR = [1+|K|]/[1-|K|] = [1+0]/[1-0] = 1

31. A 50Ω line is terminated in load ZR = 90 + j60Ω. Determine VSWR due to this Load. [Apply]

K = [ZR-Z0]/[ZR+Z0] = [90+j60-50]/[90+j60+50] = [40+j60]/[140+j60]

= [72.111∠56.3o]/[152.315∠23.2o] = 0.473∠33.1o

∴VSWR = [1+|K|]/[1-|K|] = 1+0.473/1-0.473 = 2.795

32.Define skin effect? [Remember]

Mention its significance.

The phenomenon whereby field intensity in a conductor rapidly decreases is known as skin effect. Skin depth is defined as that depth in which the wave has been attenuated to 1/e or approximately 37% of its original value.

$$\delta = \frac{1}{\alpha}$$

At very high frequency, skin effect is considerable. Skin effect is defined as the effect in which the current may flow on the surface of conductor. Now the internal inductance of conductor becomes zero.

33.What is an effective cross section of a conductor?. [Remember]

$$\delta = \frac{1}{\sqrt{\pi f \mu \sigma}}$$

μ--conductor permeability

σ--conductivity of the conductor.

34.What is standing wave ratio? **Nov/Dec 2016,May/June 2016 /May 2017 [Remember]**

If the transmission is not terminated in its characteristic impedance ,then there will be two waves traveling along the line which gives rise to standing waves having fixed maxima and fixed minima.
The ratio of the maximum to minimum magnitudes of voltage or current on a line having standing waves called standing waves ratio.

$$S = \left|\frac{E_{MAX}}{E_{MIN}}\right| = \left|\frac{I_{MAX}}{I_{MIN}}\right|$$

$$S = \frac{1+|K|}{1-|K|}$$

The range of values of standing wave ratio is theoretically 1 to infinity.

35. Define Insertion loss **Dec 2018[Remember]**

Insertion loss of a line is defined as the number of nepers or decibels by which the current in the load is changed by the insertion.

36.Define propagation constant **Dec 2018[Remember]**

It is defines as natural logarithm of the ratio of sending end current or voltage to the receiving end current or voltage of the line

37. A λ/8 transmission line is terminated by 25 + j50Ω. If the characteristic impedance of the line is 100 Ω. Find input impedance of the line. **May 21 [understand]**

$Z_S = Z_O = \left(\frac{Z_R + JZ_O}{Z_O + JZ_R}\right)$

Z_O=100 Ω

$Z_R = 25 + j50\ \Omega$

$Z_S = 100\left(\frac{25+J50+J100}{100+J25-50}\right) = 100\left(\frac{25+J150}{50+J25}\right)$

Z_S = 160+j220 Ω

38. 50 Ω line operating at 1 GHz is terminated by a load of 20Ω. Find the values of maximum and minimum impedance and their location on the line.

K=(Zr-Zo)/ (Zo-Zr)= 20-50/50-20 = -0.429

K=|0.429|

$$S = \frac{1+|K|}{1-|K|}$$

$S = \frac{1+0.429}{1-0.429} = 2.5$

Rmax= SRo= 125 Ω

Rmin= Ro/S=20 Ω

II Unit Part -B

1. Define standing wave ratio and obtain the expression of VSWR in terms of reflection Coefficient. **[Remember]**[8] **(MAY -2010) (MAY -2011)(Nov/Dec 16)**

2.A 30cm long loss less transmission line with characteristic impedance of 50Ω is terminated by a load impedance = 60 + j 40Ω. The operating wavelength is 90m. Find the reflection Coefficient , standing wave ratio and input impedance. **[Apply](May -2010)**

3.A 30 m lossless line with Z_0 = 50 Ω operating at 2 MHz is terminated with a load Z_L = 60 + j 40 Ω. The velocity of the light is 0.6C. Find reflection coefficient, Standing wave ratio and input impedance. **[Apply]**(16) **(Nov-10, Nov-12,Nov 2017)**

4.Derive the expression that input permit easy measurements of power flow on a line of neglible losses.(10) **[Understand]Nov-11**

5.Derive the expression for input impedance of open and short circuited lines(6)**[Understand] Nov-11**

6. Discuss the various parameters of open-wire and co-axial lines at radio frequency.(16) **[Understand]Nov-11, May -12,Dec 2018**

7.Explain Standing Waves and Reflection loss(8) **[Remember]Nov-16, May 18,May 2019**

8.Derive an expression for the input impedance of a dissipationless line and also find the input impedance is maximum and minimum at a distance S **[Remember]Nov-16, May 18**

9. Find the sending end line impedance for a HF line having charecteristics impedance of 50Ω. Yhe line is of length 1.185λ and is terminated in a load of (110+j80)Ω **[Apply]Nov-16**

10. Derive the line constant of a Zero dissipation line**[Remember]**(8)**May/June 16, May 18 , May 2019**

11. Discuss in detail about the variation of input impedance along open and short circuit lines with relevant graphs **[Remember]**(10)**May/June 16**

12.A lossless line has SWR=4.The R0 is 150 and the max voltage is 135v.Find the power delivered to the line **[Apply]**(6)**May/June 16**

13. Discuss in detail about the voltage and current on the dissipation less line **[Remember](16)**(**May 17)**

14. Derive the expression that permit easy measurements of power flow on a line of negligible losses **[Remember](16)**(**May 17,May 2019)**

15.A radio frequency line with Z0=70Ω is terminated by Z_L = 115 - j 800 Ω. at λ=205m.Find VSWR and the max and min line impedance **[Apply] (10)**(**May 17) (DEC 18)**

16. Draw the input pattern for a lossless line when short and open circuited **[Remember](6)**(**Dec 17)**

17. Calculate the average input power at a distance from the load 'l' and find the impedance when the load is short circuited,open circuited and for a matched line **[Understand] (13) Nov-11**

18. Describe an experimental setup for the determination of VSWR of an RF transmission**[Understand] (13) May 18**

19. Define input impedance of a transmission line. Alossless transmission line of length 1 meter and characteristic impedance 100Ω is terminated in a load ZL= 100 – j200 Ω. Determine the line impedance at a distance of 25 cm from the load if it is fed by a matched source operating at 10 MHz. **[Apply] (13) May 21**

20. Define Reflection coefficient and VSWR. A100Ω line is terminated in a load 50 + j1000 Ω. If the line is 0.4λ find the reflection coefficient at the load, reflection coefficient at the input and VSWR **[Apply] (13) May 21**

Unit 2 Assignment

1. Consider the transmission line circuit shown below. Compute the incident power, the reflected power, and the power transmitted into the infinite 75 Ω line. Show that power conservation is satisfied. (Understand)
2. A generator is connected to a transmission line as shown below. Find the voltage as afunction of z along the transmission line. Plot the magnitude of this voltage for$-\ell \leq s \leq 0$How can distortion be reduced in a transmission line?(Analysis)

3. A transmission line has Z0 = 745<(−12)degree and is terminated is ZR = 100. Calculate the reflection loss in dB.(Understand)
4. A 50 coaxial cable feeds a 75 + j20 dipole antenna. Find reflection coefficient and standingwave ratio. (Understand)
5. At a frequency of 80MHZ a lossless transmission line has a characteristic impedance of 300 anda wave length of 2.5m. Find L and C? (Design)
6. Find the reflection coefficient of a 50 transmission line when it terminated by a load impedance of 60 + j40.(Analysis)
7. A lossless line has a characteristic impedance of 400 ohms. Determine the standing wave ratio if the receiving end impedance is 800 +j 0.0 ohms.(Analysis)
8. Design a Quarter wave transformer to match a load of 200 to a source resistance 50. Theoperating frequency is 200MHZ.(Analysis)
9. A cable has the following parameters
   R = 48.75 per k.m
   G = 3.8μmho per k.m
   L = 31.09mH per k.m

UNIT III
IMPEDANCE MATCHING IN HIGH FREQUENCY LINES

1. List the applications of Smith chart. **May2018,Dec 2018 [Remember]**

i)Plotting an impedence.

ii)Measurement of VSWR.

iii)Measurement of reflection coefficient K.

iv)Measurement of input impedance of the line.

v)Impedance to admittance conversion.

2. Give the applications of half-wave length transmission line. (May 2012) **[Remember]**

The main application of a half-wave line is to connect a load to a source where both of them can't be made adjacent. In such a case, we may connect a parallel half wave line at load point. We can then take suitable measurement as half-wave line repeats its impedance.

3. What is the use of eighth wave line? **[Remember]**

An eighth wave line is used to transform any resistance RR to impendence Zin with a magnitude equal to Characteristic impedance R0 of the line.

4. Give the input impendence of eighth wave line terminated in a pure resistance RR.[Remember]

The input impendence of the eighth wave line is

$$Z_{in} = R_0\left[\frac{Z_R + jR_0}{R_0 + jZ_R}\right]$$

The input impendence of the eighth wave line is terminated by pure resistance RR.

$$Z_{in} = R_0\left[\frac{R_R + jR_0}{R_0 + jR_R}\right] = R_0$$

5. Why is a quarter wave lines called as impendence inverter? MAY – 2011/Dec 2017 [Understand]

A quarter wave lines may be considered as an impendence inverter because it can

transform a low impendence into a high impendence and vice versa.

6. For a symmetrical network, define propagation constant and characteristics impedance. [Remember]

The current ratio or voltage ratio is expressed in exponential term under the condition of Z0 termination. Characteristic impedance of a symmetrical network is the impedance measured at the input terminals of the first network in a chain of infinite networks in cascade and is denoted as Z0.

7. What are the disadvantages of m-derived filters? [Remember]

- Attenuation rises sharply at cut off frequency.
- In the pass band output of the filter remains constant which means the characteristic impedance remains constant throughout the pass band.

8. How can distortion be reduced in a transmission line? [Understand]

A line in which there is no phase or frequency distortion is called a distortion less line. The condition for a distortion less line is given as RC=LG.

9. A transmission line has Z0=745 12degree ohms and is terminated is ZR=100ohm calculate the reflection loss in Db.

Answer: k=0.6475, 1/|k|=3.7751 dB

10. Express standing wave ratio in terms of a reflection coefficient. May 2019 [Remember]

S= 1+|K|/1-|K|
(OR)
|K|=S-1/S+1.

11. Mention the application of quarter waveline. May 2017,Dec 2018 [Remember]

A quarter wave line is used for impedance matching.(i.e) it matches the load with the sources and ensures that maximum power is being transferred to the load.
Application:
i). used as a transformer to match a load ZR ohms.
ii). Used as impedance matching inverter.
iii). Used as couple a transmission line to a resistive load such as an antenna.

12.The electric field in free space is given by E=50cos[10T+BX] V/M. find the direction of wave propagation and Beta. [Apply]

the wave is propagating along –a
beta=w/c=1/3=0.333rad/m.

13. What is the application of the quarter wave matching section? May 21 [Remember]

An important application of the quarter wave matching section is to a couple a transmission line to a resistive load such as an antenna .
If the antenna resistance is Ra and the characteristic impendence of the transmission line is R0, Then a quarter wave impedance matching section designed to have a characteristic impendence Ro' transforms antenna resistance Ra to the characteristic impedance of the line R_0 is given by $R_0' = \sqrt{R_a R_0}$

14. What do you mean by copper insulators? [Remember]

An application of the short circuited quarter wave line is an insulator to support

an open wire line or the center conductor of a coaxial line .This application has the fact that the input impendence of a quarter –wave shorted line is very high Such lines are sometimes referred to as copper insulators.

15. Bring out the significance of a half wavelength line. **[Remember]**

A half wavelength line may be considered as a one- to – one transformer. It has its greatest utility in connecting load to a source in cases where the load source cannot be made adjacent.

16. Give some of the impendence –matching devices. **[Remember]**

The quarter – wave line or transformer and the tapered line are some of the

impendence –matching devices.

17. Explain impendence matching using stub. **[Remember]May/June 16,May 2018,May 19**

In the method of impendence matching using stub ,an open or closed stub line of suitable length is used as a reactance shunted across the transmission line at a designated distance from the load ,to tune the length of the line and the load to resonance with an anti-resonant resistance equal to Ro.

18.Give reasons for preferring a short- circuited stub when compared to an open –circuited stub. **[Understand]**

A short circuited stub is preferred to an open circuited stub because of greater ease in constructions and because of the inability to maintain high enough insulation resistance at the open –circuit point to ensure that the stub is really open circuited .A shorted stub also has a lower loss of energy due to radiation, since the short –circuit can be definitely established with a large metal plate, effectively stopping all field propagation.

19. What are the two independent measurements that must be made to find the location and length of the stub? **[Remember]**

The standing wave ratio S and the position of a voltage minimum are the independent measurements that must be made to find the location and length of the stub.

20. Give the formula to calculate the distance of the point from the load at which the stub is to be connected(location) and the length of the short circuited stub. **[Remember]**

The formula to calculate the distance of the point from the load at which the

stub is to be connected is,

$S1 = \frac{\emptyset + \pi - cos^{-1}(|K|)}{2\,\beta}$ $S1' = \frac{\emptyset + \pi + cos^{-1}(|K|)}{2\,\beta}$

The formula to calculate the length of the short circuited stub is,

$L = \frac{\lambda}{2\pi} \tan^{-1}\left(+\frac{\sqrt{1-K^2}}{2\ |k|}\right) L' = \frac{\lambda}{2\pi} \tan^{-1}\left(-\frac{\sqrt{1-K^2}}{2\ |k|}\right)$

This is the length of the short – circuited stub to be placed d meters towards the load from a point at which a voltage minimum existed before attachment of the stub.

21. What is the input impendence equation of dissipation less line?

NOV / DEC 2010 **[Remember]**

The input impendence equation of dissipation less line is given by

(Zs/Ro)=(1+|K|)/ (1-|K|)

22.Write the expressions for the input impedance of open and short circuited dissipationless line. Dec 2010 **[Understand]**

Zoc = -j R0 cot (2π/lambda)s.

Zsc = jR0 tan (2π/lambda)s.

23.List the applications of the smith chart. **[Remember]**

The applications of the smith chart are,

(i) It is used to find the input impendence and input admittance of the line.

(ii) The smith chart may also be used for lossy lines and the locus of points on a

line then follows a spiral path towards the chart center, due to attenuation.

(iii) In single stub matching

24. What are the difficulties in single stub matching? MAY / JUNE 2012

Write the disadvantages of single stub matching. **[Remember]**

The difficulties of the **single stub matching** are

- Single stub matching requires the stub to be placed at a definite point on the line.
- it requires two adjustment to be made, these being the location and the length of the stub.
- Single stub matching is adequate for open wire lines. But for coaxial lines this is not suitable because it is difficult to obtain the location of voltage minimum without slotted line section. That is coaxial line placement of a stub at exact point is difficult.

25. What is double stub matching? **[Remember]**

Another possible method of impedance matching is to use two stubs in which the

location of the stub are arbitrary, the two stub lengths furnishing the required

adjustments. The spacing is frequently made $\lambda/4$.This is called double stub matching.

26. Give reason for an open line not frequently employed for impedance matching. **[Understand]**

An open line is rarely used for impedance matching because of radiation losses from the open end, and capacitance effects and the difficulty of a smooth adjustment of length.

27. State the use of half wave line . **[Remember]**

The expression for the input impendence of the line is given by Zs = Zr

Thus the line repeats is terminating impedance .Hence it is operated as one to one transformer .Its application is to connect load to a source where they cannot be made adjacent.

28. Why Double stub matching is preferred over single stub matching. **[Understand]**

Double stub matching is preferred over single stub due to following disadvantages of single stub.

1. Single stub matching is useful for a fixed frequency. So as frequency changes

the location of single stub will have to be changed.

2. The single stub matching system is based on the measurement of voltage minimum Hence for coaxial line it is very difficult to get such voltage minimum, without using slotted line section.

29. Distinguish clearly between open and shorted line. **[Remember]**

A shorted line means having zero receiving end voltage and impedance i.e. $Z_R = 0$ and $E_R = 0$.

And open circuited line means having infinite receiving end impedance and zero receiving end current i.e. $Z_R = -\infty$ and $I_R = 0$.

30.Distinguish between single stub and double stub matching. (Dec-16), May2019 **[Remember]**

Single stub matching	Double stub matching
Stub location is at definite point	The location of stubs are arbitrary
It has one stub to match the transmission line impedance	It requires two stub for impedance matching
Final adjustments cannot be made on the location of the stubs only length of the stub can be adjustable.	Both the length and location of the stubs can be adjust for matching

For Co axial lines single stub is not suitable since the stub locations are difficult to locate	Double stub matching can be used without any difficulty on the coaxial lines.

31.List the applications of the smith chart.(Ap-15) **[Remember]**

The applications of the smith chart are,

(i) It is used to find the input impendence and input admittance of the line.

(ii) The smith chart may also be used for lossy lines and the locus of points on a line then follows a spiral path towards the chart center, due to attenuation.

(iii) In single stub matching (iv) Measurement of input impedance and load impedance (v)Measurement of standing wave ratio (SWR)(vi) Measurement of reflection coefficient k in polar form

(v)location of voltage minimum, maximum

32.Give reasons for preferring a short- circuited stub when compared to an open –circuited stub.(Dec15) **[Remember]**

A short circuited stub is preferred to an open circuited stub because of greater ease in constructions and because of the inability to maintain high enough insulation resistance at the open –circuit point to ensure that the stub is really open circuited .A shorted stub also has a lower loss of energy due to radiation ,since the short –circuit can be definitely established with a large metal plate ,effectively stopping all field propagation.

III unit Part -B

1. Derive the input impedance of a quarter wave line and discuss its applications.[8]**[Remember]Nov-16,may 18**

2. Obtain the length and the location of a short circuited stub for impedance matching on a transmission line. **[Understand]**[10] **(May -2010) Nov-11**

3.A load (50-j100) ohm is connected to a 50ohm line. Design a short circuited stub to provide matching between the two at signal frequency of 30MHz using Smith Chart. **[Analyze]** [6]

4. Discuss the application of quarter wave line in impedance matching **[Understand]**(6)

5. A 50Ω transmission line is connected to a load impedance 60 + j 80Ω.The operating frequency is 300Mhz.A single stub is used to match the line find the length of the stub. **[Apply] (May -2011)**

6.Draw and explain the operation of quarter wave line. (8) **[Understand]Nov-11,Nov-16,June 16,Dec 2018**

7.It is required to match a 200 ohms load to a 300 ohms transmission line to reduce the SWR along the line to 1. What must be the characteristic impedance of the quarter wave transformer used for this purpose if it is directly connected to the load? (4)

8.What are the drawbacks of single stub matching and open circuited stubs? (4)**[Apply]**

9.Draw and explain the principle of double stub matching.**[Understand]** (8) **Nov-11**

10. A UHF lossless transmission line working at 1 GHz is connected to an unmatched line producing a voltage reflection coefficient of 0.5(0.866 + j 0.5). Calculate the length and position of the stub to match the line. (8) **[Apply]**

11. Find the sending end impedance of a line with negligible losses when characteristics impedance is 55Ω and the load impedance is 115+j75Ω length of the line is 1.183 wave length by using smith chart (8) **[Apply] Dec 2016**

13.A load 50-j100 ohms is connected across a 50ohms line. Design a short circuited stub to provide matching between the two at a single frequency 30Mhz using Smith chart **[Apply]May 16**

14.A 300Ω transmission line is connected to a load impedance of 450-j600 at 10Mhz.Find Calculate the length and position of the stub to match the line using Smith Chart **[Apply] (16) (May -2017)**

15. A load impedance of 90-j50Ω is to be matched to the line of 50Ω using single stub matching.Find Calculate the length and position of the stub to match**[Apply] (10)** **(May -2017)**

16. Design a Quarter wave transformer to match a load of 200Ω to a source resistance of 500Ω.The operating frequency is 200MHz. **[Apply] (6)** **May16, May 17,May 18**

17. Antenna with impedance 40+j30Ω is to be matched to a100Ω lossless line with a shorted stub.Determine the following using smith chart a)The required stub admittance b)Distance betwwen stub and the antenna c)The stub length d)SWR on each of the system **[Analyse] (13)** **(May -2017)**

18. Explain the technique of single stub matching and discuss operation of quarter wave transformer.**[Understand]Dec 2018**

19. Explain the procedure for obtaining the smith chart using R and X circles.**[Understand]Dec 2018**

20.Explain the significance of smith chart and its application in a transmission lines .**[Understand]May 2018**

21. Describe quarter wave transmission line. Discuss the applications of quarter wave transmission line. .**[Understand] (13)** **May 2021**

22. An antenna, as load on a transmission line, produces a standing wave ratio of 3, with a voltage minimum of 0.12λ from antenna terminals. Find the antenna impedance and reflection factor at the antenna, if R_o is 300 ohms on the line (Use smith chart). **[Apply] (13)** **May 2021**

23. A line of Ro = 300 ohms is connected to a load of 73 ohms. For a frequency of 45 MHz, find the length and location of a single stub nearest the load to produce an impedance match using smith chart**[Apply] (16)** **May 2021**

UNIT 3 ASSIGNMENT

1. A 30m long loss less transmission line with Z0 = 50 operating at 2MHz is terminated with a load ZL = 60 + j40 if U = 0.6C on the line find

(i) Reflection Coefficient.(5Marks)
(ii) SWR. (5Marks)
(iii) Input impedance.(6Marks) (NOV 2012,MAY 2011)

2. Design a single stub matching network (use Smith Chart) for a Transmission line functioning at500MHz terminated with a load impedance Z0 = 100. Use short circuited stubs. Determine theVSWR before and after connecting the stub.(Design)
3. Input impedance of a 8 long, 50 transmission line are

Z1 = 25 + j100
Z2 = 10 − j50
Z3 = 100 + j0 and
Z4 = 0 + j50. When various load impedance are connected at other end in each case, determine the load impedance and the reflection coefficient at the input and load ends. (Analysis)

4. An ideal loss less quarter wave transmission line of characteristic impedance of 60 is terminated in a load impedance ZL, give the value of the input impedance of the lineZL = 0,1, and 60. (Analysis)
5. A 100, 200 m long loss less transmission line operates at 10MHz and is terminated into an impedance of 50 − j200 the transit time of the line 1μs. Determine the length and location of a 3short circuited stub lines.(Design)
6. It is required to match a 200 load to a 300 transmission line to reduce the SWR along the line to 1. What must be the characteristic impedance of the quarter wave transformer used forthis purpose, if it is directly connected to the load? (Design)
7. A UHF loss less transmission line working a 1GHz is connected to unmatched line producing a voltage reflection coefficient of 0.5 (0.866 + j 0.5) calculate the length and

position of the stub to match the line.(8 design)

UNIT IV
WAVE GUIDES

1. What are guided waves? Give examples. **[Remember]**

The electromagnetic waves that are guided along or over conducting or dielectric surfaces are called guided waves.Examples. Parallel wires and transmission lines

2. What are TE waves or H wave? **[Remember]**

TE wave is a wave in which the electric field strength is E is entirely transverse. It has a magnetic field Hz in the direction of propagation and no component of electric field Ez in the same direction.

3. **What is meant by dominant mode? What is the dominant mode for parallel plate wave guide? Dec 2017** **[Remember]**

The mode which has the lowest cutoff frequency is called dominant mode.TE_{10} is the dominant mode in TE waves.

4. **What is the dominant mode of a rectangular waveguide? Why?** **[Remember]May 16**

The wave which has the lowest cutoff frequency is called the dominant wave. In rectangular wave guide, the lowest order TE wave, TE10 mode has the lowest cutoff frequency and so TE10 wave is the dominant wave.

5. What is cut-off frequency? (Nov-11) **[Remember]**

The frequency bellow which the wave is attenuated exponentially and above which the wave propagation occurs is called cutoff frequency.

The frequency at which wave motion ceases is called critical frequency or cutoff frequency fc of a wave guide. At cutoff frequency fc.

6. For a frequency of 6GHz and plane separation of 3 cm, find the group and phase velocities for the dominant mode. Nov -10 **[Apply]**

$$C^2 = Phase\ Velocity(v_p)\ *\ Group\ velocity\ (v_g\ )$$

$$Phase\ Velocity(v_p) = 5.42\ m/s$$

$$Group\ Velocity(v_g) = 1.659\ m/s$$

7. **Calculate the cut-off wavelength for the TM11 mode in a 5 cm X 2 cm rectangular waveguide if (Nov 10, Nov 2015)[Apply]**

TM 11 mode, hence m=1 andn=1 , a= 5 cm b=2 cm

$$\lambda_0 = \frac{2}{\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}} = 3.74\ cm$$

8. Write down the expression for cut-off frequency when the wave which is propagated in between two parallel plates? Dec 17 **[Remember]**

The cut-off frequency, fc= mv/2a

9. Write down the expression for cut-off frequency when the wave which is propagated in between two parallel plates? **[Remember]**

The cut-off wavelength= 2a/m

10.What is TEM wave or principal wave? **[Remember]**

TEM wave is a special type of TM wave in which an electric field E along the direction of propagation is zero.

11.Mention the characteristic of TEM waves? **[Remember]**

It is a special type of TM wave

It does not have either Ez or Hz component

It velocity is independent of frequency

12.Give the relation between phase and group velocity? **[Remember]**

Vp Vg=C^2

13.What are microstrip lines? **[Remember]**

A microstrip line consists of a single ground plane and a thin strip conductor on a low loss dielectric substrate above the ground plate.

14.What are the losses associated with microstrip line? **[Remember]**

The two types of losses that exists in a microstrip are

Dielectric loss in substrate

Radiation loss

Ohmic loss in a strip conductor and the ground plane due to final conductivity

15.What are the different types of strip lines? **[Remember]**

(1) parallel strip line

(2) co-planar strip line

(3) shielded strip line

16.What are the advantages of microstrip lines? **[Remember]**

The basic advantages of microstrip lines are

Small size and weight

Increased reliability

Easy access for component mounting

17.What are strip line ? **[Remember]**

Strip lines consists of a thin conducting strip placed inside a low loss dielectric substrate between the two wide ground plates.

18.Define wave impedance? **[Remember]**

Wave impedance is defined as the ratio of electric to magnetic field strength

Zxy= Ex/Hy in positive direction

Zxy= - Ex/Hy in the negative direction

19.Define attenuation factor? **[Remember]**

Attenuation constant α = power lost per unit length/ 2* power transmitted

20.At cut-off frequency the wave impedance for TM waves becomes? **[Remember]**

It becomes zero

21.**An air filled resonant cavity with dimensions a= 5 cm, b= 4 cm, c= 10 cm is made of copper. Find the resonator frequency for lowest order mode.** **[Apply]**

f101 = v/2 = 3.335 GHz.

22.Comparison between Transmission Line and Waveguides (Nov-10) **[Remember]**

S.No	Wave Guide	Transmission line
1	Wave having frequency greater than cut off frequency Fc only will be propagated. Hence waveguide acts as a high pass filter.	All frequency can be passed through
2	One conductor system. The Whole body of the waveguide acts as ground and the wave propagates through multiple reflections from the walls of the waveguide.	Two conductor system.
3	Wave impedance is a direct function of frequency.	Characteristic impedance is determined only by its geometry and independent of frequency.
4	Propagation of waves in waveguide is accordance with field theory	Propagation of waves in Transmission line is accordance with Circuit theory
5	Any irregularity in waveguide produces reflection	Any irregularity in Transmission line produces reflection
6	At Lower frequencies the dimensions of the waveguide is large, which is not practically possible. Hence Wave Guides operates only high frequencies	Transmission line works only less than 3 GHz. Since losses are more in High Frequencies.

23.State Maxwell's Equations for Time varying fields **[Remember]**

Maxwell's equations are nothing but a set of four expressions derived from

Ampere's Circuit Law,

Faraday law
Gauss's Law for electric field
Gauss's Law for magnetic field

Law / Theorem	Integral form	Point form or differential form
Ampere's Circuit Law, The line integral of magnetic field intensity $\overline{H}$ around a closed path equal to the current enclosed by the path	$\oint \overline{H} \bullet d\overline{L} = I_{Enclosed}$ $\oint \overline{H} \bullet d\overline{L} = \int_S \left[\overline{J} + \frac{\partial \overline{D}}{\partial t} \right] \bullet d\overline{S}$ By stokes theorem $\int_s (\nabla \times \overline{H}) \bullet d\overline{S} = \int_S \left[\overline{J} + \frac{\partial \overline{D}}{\partial t} \right] \bullet d\overline{S}$	$\nabla \times \overline{H} = \left[\overline{J} + \frac{\partial \overline{D}}{\partial t} \right]$
Faraday law Rate of change of flux linkage induces E.M.F in a circuit	$\oint \overline{E} \bullet d\overline{L} = -\int_S \frac{\partial \overline{B}}{\partial t} \bullet d\overline{S}$ By stokes theorem $\int_S \nabla \times \overline{E} \bullet d\overline{S} = -\int_S \frac{\partial \overline{B}}{\partial t} \bullet d\overline{S}$	$\nabla \times \overline{E} = -\frac{\partial \overline{B}}{\partial t}$
Gauss's Law (Electric field) The total flux out of the closed surface is equal to the net charge within the surface.	$\oint_S \overline{D} \bullet d\overline{S} = Q_{enclosed} = \int_V \rho_V dV$ By divergence theorem $\int_V (\nabla \bullet \overline{D}) dV = \int_V \rho_V dV$	$\nabla \bullet \overline{D} = \rho_V$
Gauss's Law (Magnetic field) The surface integral of $\overline{B}$ Zero, due to non existence of monopole in the magnetic fields. (No isolated magnetic charges)	$\oint_S \overline{B} \bullet d\overline{S} = 0$ By divergence theorem $\int_S (\nabla \bullet \overline{B}) dV = 0$	$\nabla \bullet \overline{B} = 0$

24.State Maxwell's equation for free space **[Remember]**

Fields are present in free space, which is a non conducting medium in which charge density ρ_V is Zero and σ is also Zero.

S.No	Integral form	Point form or differential form
1	$\oint \overline{H} \bullet d\overline{L} = \int_S \left[\overline{J} + \frac{\partial \overline{D}}{\partial t} \right] \bullet d\overline{S}$	$\nabla \times \overline{H} = \left[\overline{J} + \frac{\partial \overline{D}}{\partial t} \right]$
2	$\oint \overline{E} \bullet d\overline{L} = -\int_S \frac{\partial \overline{B}}{\partial t} \bullet d\overline{S}$	$\nabla \times \overline{E} = -\frac{\partial \overline{B}}{\partial t}$
3	$\oint_S \overline{D} \bullet d\overline{S} = 0$	$\nabla \bullet \overline{D} = 0$

4	$\oint_S \overline{B} \bullet d\overline{S} = 0$	$\nabla \bullet \overline{B} = 0$

H- Magnetic field Intensity
E- Electric field intensity
B- Magnetic flux density
D-electric flux density
J- Current density
ρ_v- Volume Charge density
σ – Conductivity
B=μH , $\mu=\mu_0\mu_r$ μ= Permeability of material,
(1) μ_0= Permeability of free space or air =$4\pi*10^{-7}$,
μ_r =Relative Permeability of material
D=εE, $\varepsilon=\varepsilon_0\varepsilon_r\varepsilon$= Permittivity of material
ε_0 = Permittivity free space or air= $8.856*10^{-12}$
ε_r= Relative Permittivity of material

25.Definition of Wave Guide **[Remember]**

A hollow conducting metallic tube of uniform cross-section for transmitting electromagnetic waves of Successive reflections from the inner walls of the tube is called a waveguide.

26.Find the Broad wall dimensions of a rectangular waveguide when the cut off frequency for TE_{10} modes i) 3 GHz ii) 30GHz **[Apply]**

$$(f_c)_{mn} = \frac{1}{2\pi\sqrt{\mu\varepsilon}}\sqrt{\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2}$$

given m=1, n=0

fc = 3 GHz f $f_c = \frac{c}{2}\left(\frac{m}{a}\right)$

$$a = \frac{c}{2}\left(\frac{m}{f_c}\right) = 50 \text{ mm}$$

ii) fc = 30 GHz f $f_c = \frac{c}{2}\left(\frac{m}{a}\right)$

$$a = \frac{c}{2}\left(\frac{m}{f_c}\right) = 5 \text{ mm}$$

27.Mention the dominant modes in rectangular and circular waveguide. **[Remember]**

Rectangular waveguide TE01
Circular waveguide TE11

28.Why is TM01 mode preferred to the TE01 mode in circular waveguide? (Dec -12)[Understand]

TM01 mode is preferred to the TE01 mode since it requires a smaller diameter for the cut –off wavelength .

29.**What is the resonant frequency of a microwave resonator?** **Nov-10[Remember]**

Resonant frequency of a microwave resonator is the frequency at which the energy in the resonator attains maximum value. ie, twice the electric energy or magnetic energy.

30.Why transmission line resonator is not usually used as a microwave resonator?
(Dec-12)[Understand]

At very high frequencies the transmission line resonator does not give very high quality factor Q due to skin effect and radiation loss in braided cables .So, the transmission line resonator is not used as a microwave resonator.

31.Why rectangular or circular cavities can be used as a of a microwave resonator?[Understand]

Rectangular or circular cavities can be used as of a microwave resonator because they have natural

resonant frequency and behave like LCR circuit.

32.**Name three basic configurations of coaxial resonators.** **[Remember]**

The basic configurations of coaxial resonators are:
quarter wave coaxial cavity,
half wave coaxial cavity,
Capacitive end coaxial cavity.

33.what is the dominant mode for a rectangular resonator? **[Remember]**

The dominant mode of a rectangular resonator depends on the dimensions of the cavity. For b<a<d, the dominant mode is TE101 mode.

34.What is the dominant mode for circular resonator? **[Remember]**

The dominant mode for circular resonator will depend on the dimensions of the resonator
For d>a, the dominant mode is TE010
For d>=2a, the dominant mode is TE111

35.What is the dominant mode for semicircular resonator? **[Understand]**

The dominant mode for semicircular resonator will depend on the dimensions of the resonator
For d>a, the dominant mode is TE111

36.What are the performance parameters of a microwave resonator? **[Remember]**

The performance parameters of a microwave resonator are
1.) Resonant frequency
2.) Quality factor
3.) input impedance

37.What is the maximum value of the quality factor of a rectangular cavity? **[Remember]**

Qmax = 1.11 η/R[1+a/2b]

38.Find the Q factor of a cubic cavity whose surface resistance is $1*10^{-2}$ohms. **[Apply]**

39.Q=0.74η/r
40.Q=0.74*120pi/1*10^-2
41.Q=27897

42.What is unloaded Q factor? **[Remember]**

When a cavity is assumed to be not connected to any load or external circuit, quality factor accounts to the internal losses and it is known as unloaded Q factor.

43.What is loaded Q and external Q? **[Remember]**

When a cavity is assumed to be connected to any load or external circuit, the energy will be dissipated in an external load the power loss due to this known as external Q.

44.What is meant by cavity resonator? **[Remember]**

It is a resonator which has its own resonating frequency. For excitation of a mode in resonator a source of power is always needed to be coupled and this power is commonly supplied to a coaxial line or through wave guides.

45.Define coaxial cable. **[Remember]**

The coaxial cable is used for probe or loop instruction.

46.What is the drawback of circular wave guide? or why are rectangular waveguides preferred over circular waveguides? **[Remember]**

1)It is the frequency difference between the dominant mode and next higher order mode, which is smaller when compared to rectangular wave guide.
2) For same operational frequency and circular wave guide is bigger in size than a rectangular wave guide

47.What is the application of circular waveguide? **[Remember]**

It is used in case of rotating joint in radar, attenuators and Phase shifters

48.What is known as dominant mode? **[Remember]**

Dominant mode is defined as which as got lower cut off frequency.

49.What are the applications of Bessel function? **[Remember]**

It is used in wave propagation within a cylinder, or circular cross section, the field distribution along the long wire of infinite length.

50.Write the formula for cut off frequency and cut off wavelength rectangular wave guide TEmn and TM mn. **[Remember]**

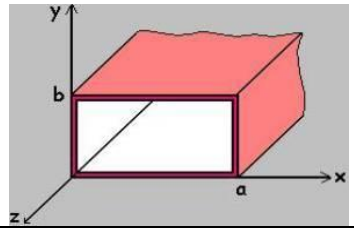
The lower cutoff frequency (or wavelength) for a particular mode in rectangular waveguide is determined

by the following equations:

$$(f_c)_{mn} = \frac{1}{2\pi\sqrt{\mu\varepsilon}}\sqrt{\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2} \quad \textbf{(Hz)}$$

$$(\lambda_c)_{mn} = \frac{2}{\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}}$$

51.Draw the schematic diagram rectangular waveguides, relation between a,bandm,n[Remember]



where

a= Inside width
b= Inside height
m= Number of ½-wavelength variations of fields in the "a" direction
n= Number of ½-wavelength variations of fields in the "b" direction
ε = Permittivity
μ = Permeability

52.**Give the applications of cavity resonators. Nov 2015,Nov 2014,May 18[Remember]**

Used in cavity meters.
Used in klystron amplifiers.
Used in Reflex klystron oscillators and cavity magnetrons.
Used in duplexers in radar systems.

53.**Calculate the cutoff wavelength for the TM11 mode in a standard rectangular waveguide if a=4.5cm. [Apply]**

54.Given TM 11 so m=1 n=1 ,a=4.5 cm b=a/2 =2cm [Apply]

$$(\lambda_c)_{mn} = \frac{2}{\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}}$$

λ 0=4.02 cm.

55.Write the expression TM wave in rectangular waveguides. [Remember]

Electric field

$$E_x^0(x,y) = -\frac{\gamma}{h^2}\left(\frac{m\pi}{a}\right)E_0 \cos\left(\frac{m\pi}{a}x\right)\sin\left(\frac{n\pi}{b}y\right)$$

$$E_y^0(x,y) = -\frac{\gamma}{h^2}\left(\frac{n\pi}{b}\right)E_0 \sin\left(\frac{m\pi}{a}x\right)\cos\left(\frac{n\pi}{b}y\right)$$

$$E_z^0(x,y) = E_0 \sin\left(\frac{m\pi}{a}x\right)\sin\left(\frac{n\pi}{b}y\right)$$

Magnetic Field

$$H_x^0(x,y) = \frac{jw\varepsilon}{h^2}\left(\frac{n\pi}{b}\right)E_0 \sin\left(\frac{m\pi}{a}x\right)\cos\left(\frac{n\pi}{b}y\right)$$

$$H_y^0(x,y) = -\frac{jw\varepsilon}{h^2}\left(\frac{m\pi}{a}\right)E_0 \cos\left(\frac{m\pi}{a}x\right)\sin\left(\frac{n\pi}{b}y\right)$$

$H_z = 0$

Where

$$h^2 = \left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2$$

$$\gamma = j\beta = j\sqrt{w^2\mu\varepsilon - \left(\frac{m\pi}{a}\right)^2 - \left(\frac{n\pi}{b}\right)^2}$$

Here, m and n represent possible modes and it is designated as the TM_{mn} mode.
m denotes the number of half cycle variations of the fields in the x-direction and
n denotes the number of half cycle variations of the fields in the y-direction.

56. Why TM_{00} mode is not possible in rectangular waveguide? Or Which is the dominant mode or lowest mode in rectangular waveguide ? Why? [Understand]

TM modes in rectangular waveguides, neither m nor n can be zero. This is because of the fact that the field expressions are identically zero if either m or n is zero. Therefore, the lowest mode for rectangular waveguide TM mode is TM_{11} .

Here, the cut-off wave number is

$$k_c = \sqrt{\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2}$$

57. What is meant by cut-off or evanescent modes? Dec-2010, Dec 2018[Remember]

At a given operating frequency f, only those frequencies, which have $f_c<f$ will propagate. The modes with $f<f_c$ will lead to an imaginary **b** which means that the field components will decay exponentially and will not propagate. Such modes are called *cut-off* or *evanescent* modes.

58. What is meant by dominant mode? Nov-2011,May 2018[Remember]

The mode with the lowest cut-off frequency is called the *dominant mode*. Since TM modes for rectangular waveguides start from TM_{11} mode, the dominant frequency is

$$(f_c)_{11} = \frac{1}{2\sqrt{\varepsilon\mu}}\sqrt{\left(\frac{1}{a}\right)^2 + \left(\frac{1}{b}\right)^2}\ (Hz)$$

59. What is meant by wave impedance? Write expression for wave impedance of TM. (Dec -2013)[Remember]

The wave impedance is defined as the ratio of the transverse electric and magnetic fields. Therefore, we get from the expressions for E_x and H_y

$$Z_{TM} = \frac{E_x}{H_y} = \frac{\gamma}{jw\varepsilon} = \frac{j\beta}{jw\varepsilon} \Rightarrow Z_{TM} = \frac{\beta\eta}{k}$$

60.

61.What is guide wavelength? **Nov -2010[Remember]**

The guide wavelength is defined as the distance between two equal phase planes along the waveguide and it is equal to

62. $$\boxed{\lambda_g = \frac{2\pi}{\beta}} > \frac{2\pi}{k} = \lambda$$

which is thus greater than λ , the wavelength of a plane wave in the filling medium

63.What is the phase velocity of waveguide? **Nov -2010,May 21[Remember]**

The phase velocity is

$$u_p = \frac{w}{\beta} > \frac{w}{k} = \frac{1}{\sqrt{\mu\varepsilon}}$$

which is greater than the speed of light (plane wave) in the filling material.

64.Write the expression for attenuation constant **[Remember]**

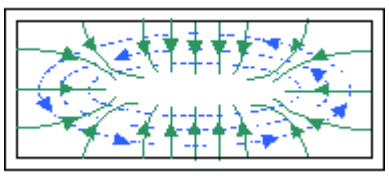
The attenuation constant due to the losses in the dielectric can be found as follows:

$$\gamma = j\beta = j\sqrt{k^2 - k_c^2} = jk\sqrt{1-\left(\frac{f_c}{f}\right)^2} = jw\sqrt{\mu\varepsilon}\sqrt{1-\left(\frac{f_c}{f}\right)^2} = jw\sqrt{\mu}\sqrt{\varepsilon + \frac{\sigma}{jw}}\sqrt{1-\left(\frac{f_c}{f}\right)^2}$$

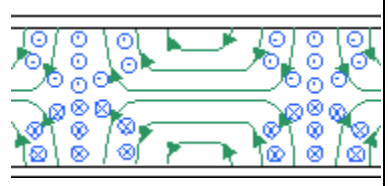
65.Draw the field distribution of TM mode in rectangular waveguide. **[Remember]**

66.TM (Transverse Magnetic) Mode

For TM modes, m=0 and n=0 are not possible, thus, TM_{11} is the lowest possible TM mode.

67. 

End View (TM_{11})



Side View (TM_{11})

____ Electric field lines

_ _ _ Magnetic field lines

68.Write the expression TE wave in rectangular waveguides. **[Remember]**

Electric field

$$E_x^0(x,y) = \frac{jw\mu}{h^2}\left(\frac{n\pi}{b}\right)H_0 \cos\left(\frac{m\pi}{a}x\right)\sin\left(\frac{n\pi}{b}y\right)$$

$$\boxed{E_y^0(x,y) = -\frac{jw\mu}{h^2}\left(\frac{m\pi}{a}\right)H_0 \sin\left(\frac{m\pi}{a}x\right)\cos\left(\frac{n\pi}{b}y\right)}$$

$E_z = 0$

Magnetic field

$$H_x^0(x,y) = \frac{\gamma}{h^2}\left(\frac{m\pi}{a}\right)H_0 \sin\left(\frac{m\pi}{a}x\right)\cos\left(\frac{n\pi}{b}y\right)$$

$$H_y^0(x,y) = \frac{\gamma}{h^2}\left(\frac{n\pi}{b}\right)H_0 \cos\left(\frac{m\pi}{a}x\right)\sin\left(\frac{n\pi}{b}y\right)$$

$$H_z^0(x,y) = H_0 \cos\left(\frac{m\pi}{a}x\right)\cos\left(\frac{n\pi}{b}y\right) \quad \text{(A/m)}$$

Where

$$h^2 = \left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2 \qquad \gamma = j\beta = j\sqrt{w^2\mu\varepsilon - \left(\frac{m\pi}{a}\right)^2 - \left(\frac{n\pi}{b}\right)^2}$$

69. What is the cut off frequency and cut off wavelength of rectangular waveguide? Write its significance. **[Remember]**

The cut-off frequency is at the point where **g** vanishes. Therefore,

$$f_c = \frac{1}{2\sqrt{\varepsilon\mu}}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2} \ (Hz)$$

Since λ=u/f, we have the cut-off wavelength,

$$\lambda_c = \frac{2}{\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}} \ (m)$$

At a given operating frequency f, only those frequencies, which have f>fc will propagate. The modes with f<fc will not propagate.

70. What is meant by dominant mode? Which is the dominant mode TE in rectangular waveguide?
Dec-2012, May 2011[Remember]

The mode with the lowest cut-off frequency is called the dominant mode. Since TE10 mode is the minimum possible mode that gives nonzero field expressions for rectangular waveguides, it is the dominant mode of a rectangular waveguide with a>b and so the dominant frequency is

$$(f_c)_{10} = \frac{1}{2a\sqrt{\mu\varepsilon}} \ (Hz)$$

The TE_{10} mode is the dominant mode of a rectangular waveguide with a>b, since it has the lowest attenuation of all modes. Either m or n can be zero, but not both.

71. What is meant by wave impedance? Write expression for wave impedance of TM.
(Dec -2013)[Remember]

The wave impedance is defined as the ratio of the transverse electric and magnetic fields. Therefore, we get from the expressions for Ex and Hy

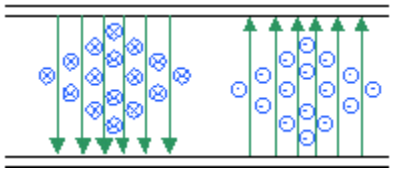
$$Z_{TE} = \frac{E_x}{H_y} = \frac{jw\mu}{\gamma} = \frac{jw\mu}{j\beta} \Rightarrow Z_{TE} = \frac{k\eta}{\beta}$$

72. What is meant by attenuation constant? **[Remember]**

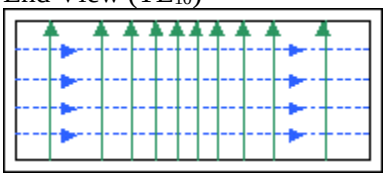
The attenuation constant due to the losses in the dielectric is obtained as follows:

$$\gamma = j\beta = j\sqrt{k^2 - k_c^2} = jk\sqrt{1-\left(\frac{f_c}{f}\right)^2} = jw\sqrt{\mu\varepsilon}\sqrt{1-\left(\frac{f_c}{f}\right)^2} = jw\sqrt{\mu}\sqrt{\varepsilon + \frac{\sigma}{jw}}\sqrt{1-\left(\frac{f_c}{f}\right)^2}$$

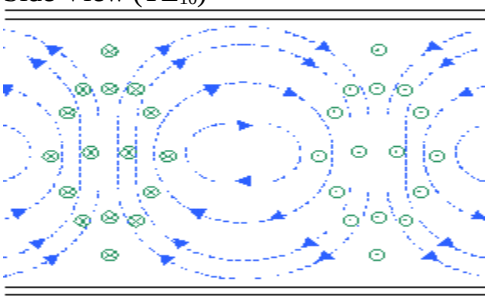
73.Draw the field distribution of TE mode in rectangular waveguide. **[Remember]**



End View (TE_{10})



Side View (TE_{10})



Top View (TE_{10})

____ Electric field lines

_ _ _ Magnetic field lines

74.Consider a length of air-filled copper X-band waveguide, with dimensions a=2.286cm, b=1.016cm. Find the cut-off frequencies of the first four propagating modes. (Nov -2012, Nov-2013) **[Remember]**

Solution:

From the formula for the cut-off frequency

$$f_c = \frac{1}{2\sqrt{\varepsilon\mu}}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2} \xrightarrow{air-filled} \frac{c}{2}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}\ (Hz)$$

75.Why is TM01 mode preferred to the mode in a circular waveguide? **Nov -10,[Remember]**

TM01 mode is preferred to the TE10 mode , since it requires a smaller diameter for the same cut off frequency or wavelength

76.Define Quality factor of microwave resonator. **Dec -11,Nov-12 ,Dec-09[Remember]**

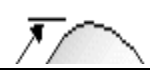
The quality factor Q is a measure of the frequency selectivity of the resonator.

Q=2π x (Maximum energy stored/Energy dissipated per cycle) =F_0/Bandwidth

77.A waveguide is generally operated at f = 1.5 fc where fc is the cutoff frequency. Assuming that the broader dimension is twice the other dimension in a rectangular waveguide, calculate the dimension if it operates in TE10 mode at 6 GHz. May 21 [understand]

78.Circular Waveguide dimensions' and TE mode and TM mode cutoff frequency

Nov-09,Dec-10[Remember]

Circular Waveguide	
Table of TE and TM mode field equations for circular waveguides.	
TE (Transverse Electric) Mode	
The lower cutoff frequency (or wavelength) for a particular **TE mode** in	

circular waveguide is determined by the following equation: $\lambda_{c,mn} = \frac{2\pi r}{p'_{mn}}$ (m), where p'_{mn} is

m	p'_{m1}	p'_{m2}	p'_{m3}
0	3.832	7.016	10.174
1	1.841	5.331	8.536
2	3.054	6.706	9.970

TM (Transverse Magnetic) Mode

The lower cutoff frequency (or wavelength) for a particular **TM mode** in circular waveguide is determined by the following equation: $\lambda_{c,mn} = \frac{2\pi r}{p_{mn}}$ (m), where p_{mn} is

m	p_{m1}	p_{m2}	p_{m3}
0	2.405	5.520	8.654
1	3.832	7.016	10.174
2	5.135	8.417	11.620

PART -B

1.Obtain the solution of field components of a TE wave between parallel plate , propagating in Z direction.[10] **[Understand] May-12, Nov -11 , Nov-10,May 19, May 21**

2.A pair of perfectly conducting planes is separated by 3.6cm in air. For TM10 mode determine the cut-off frequency and cut-off wavelength, if the operating frequency is 5GHz. [6]

3. Derive the expressions for the field components of TEM waves between parallel conducting planes. Discuss the properties of TEM waves.[10] **[Understand] May-12, Nov -11, Nov-10**

ii) For a frequency of 10 GHz and plane separation of 5cm in air, find the cut-off wavelength, phase velocity and group velocity of the wave.[6]

4.Starting from Maxwell' equations derive the field expression for a TM_{10} wave traveling in a Parallel plane guide. **[Understand]** (12)**Nov-11**,

5.Derive the characteristics for the same. **[Understand]** (4)

6.With relevant equations obtain the attenuation factor for a TE_{10} wave traveling in a parallel plane guide. **[Understand] Nov-11, May-11**

7.For a frequency of 6 GHz and plane separation = 7 cm. Find the following for the TE_{10}mode (1) Cutoff frequency (2) Phase and group velocity. (6) **Nov-11, May-12**

8.Explain wave impedance and obtain the expressions of wave impedance, Attenuationfor TE and TM waves guided along parallel planes, Also sketch the variation of wave impedance with frequency, attenuation with frequency. **[Understand] Nov-11 .Dec-12**

9. Explain the various excitation methods of Rectangular waveguides. **[Understand]Nov-12,May-11,Dec 18**

10. Derive the expression for cut off frequency, phase constant and phase velocity of wave in parallel plates? **[Understand] (16)**

11.When a wave 6GHz is to be Propagated between two parallel conducting plates separated by 60 mm , find the modes that will propagate through the guide. **[Apply]Nov-12,May 19**

12.The parallel plate waveguide has plate separation 1cm and filled with a perfect dielectric of dielectric constant 9. Find the cut off frequencies and next higher TM modes. **[Apply]**

13. Explain the transmission of TE waves between parallel perfectly conducting planes with necessary expressions and diagrams for the field components. (12) **[Apply]Nov-10**

14.A TEM wave at 1 MHz propagates in the region between conducting planes which is filled with

dielectric material of r μ = 1 and ε r = 2. Find the phase constant and characteristic wave impedance. (4) **[Apply]Nov-10**

15. Explain the reasons for the attenuation of TE and TM waves between parallel planes with necessary expressions and diagrams. (10) **[Understand] Nov-10**

16Write a brief note on the manner of wave travel and their velocities between parallel planes. **[Understand]** (6) **Nov-11**

17.Derive the equations that are the result of introduction of restrictions on time to Maxwell's equations. **[Understand]**(8)**Nov-11**

18.Derive the field equations for TE waves between parallel planes.(8) **[Understand]Nov-11**

19.Explain TEM and TM cases for attenuation with planes of finite conductivity.(16) **Nov-11**

20.Derive the expression of wave impedance for TE and TM waves guided along rectangular waveguide.[Marks8] **[Understand]Dec-12,Nov-11,Nov-09,Dec-10, Dec-18**

21. A TE10 mode is propagated through a waveguide with a=10cm at a frequency of 2.5Ghz.Find the cut-off wavelength, phase velocity, group velocity and wave impedance.[Marks 8] **Nov-12,Nov-13**

22.Derive the expressions for the field components of TE waves guided along circular waveguide. **Dec-18 [Understand]** [10]

23.A circular waveguide has an internal diameter of 6cm.For a 9GHz signal propagated in the TE11mode,calculate the cut-off frequency and the characteristic impedance **[Apply]**[6]

24.Obtain the expression for the resonant frequency of a rectangular cavity resonator. 8]

25.Calculate the lowest resonant frequency of a rectangular cavity resonator of dimension a=2cm, b=1cm and d= 3cm.[8] **[Apply]**

26.Deduce the expressions for the field components of TM waves guided along rectangular waveguide. [16] **[Understand]Nov-12, Nov-10,**

27.An air filled circular waveguide is to be operated at a frequency of 6GHz and is to have dimensions such that cutoff frequency is 0.8 f for TE11 mode. Determine the diameter ofthe waveguideand guide wavelength. Dec-10**[Apply]**

28.State the reason why a TEM wave cannot propagate inside a rectangular waveguide. **[Understand]Dec-10, Nov-11,Nov-12**

29.Determine the solution of electric and magnetic fields of TM waves guided along circularwaveguide **[Understand]**(16)**Nov-12**

30.Determine the solution of electric and magnetic fields of TE waves guided along circularwaveguide. **[Understand](Nov -15)**

31.Obtain the field expressions for TE of circular Waveguides. **[Understand]** (8)

32.Calculate the resonant frequency of a rectangular resonator of dimensions a: 3 cm, b: 2 cm and d = 4 cm if the operating mode is TE_{101}. Assume free space within the cavity. **[Understand]** (8)

ii)What is meant by cavity resonator? Derive the expression for the resonant frequency of the rectangular cavity resonator? **[Understand] (16) Nov-12**

33.Derive the expression for cut off frequency, phase constant and phase velocity ofwave in a circular wave guide? **[Understand](16) Nov-12**

34. Discuss the propagation of TM waves in a rectangular waveguide with relevant expressions and diagrams for the field components. (10) **[Understand] Nov-14**

35.A rectangular waveguide measuring a = 4.5 cm and b = 3 cm internally has a 9 GHz signal propagated in it. Calculate the guide wavelength, phase and group velocities and characteristic impedance for the dominant mode. (6) **[Apply]Nov-10,Nov-14**

36. Explain the propagation of electromagnetic waves in a cylindrical waveguide with suitable expressions.(16) **[Understand]Nov-10, Nov -15**

37.Arectangulat air-filled copper waveguide with dimension 0.9inch*0.4inch cross section and 12" inch length is operated at 9.2GHZ with a dominant mode. Find cut-off frequency, guide wave-length, phase velocity, characteristics impedance and the loss.(16) **[Apply]Nov-11,Nov-15**

38.Find the resonant frequencies of first five lowest modes of an air-filled rectangular cavity of dimensions 5cm*4cm*2.5cm.List them in ascending order.(8) **[Apply]Nov-11**

39.An air-filled circular waveguides having an inner radius of 1cm is excited in dominant mode at10GHz.Find cut-off frequency of dominant mode, guide wavelength, wave impedance and the

bandwidth for operation in dominant mode only(Given X'_{11}=1.84; X_{01}=2.40) .(8) **[Apply]**

30.Find the resonant frequencies of dominant modes of an air-filled rectangular cavity of dimensions 2cm*4cm*6cm. **(Nov 2015)[Apply]**

31.Derive an expression for the transmission of TE wave between parallel perfectly conducting planes for the field components .(16) **[Understand] Nov -16**

32. Write a brief note on circular cavity resonator and its application .(8)**[Understand] Nov -16**

33.A TE11 wave is propagating through a circular waveguide.The diameter of the guide is 10cm and the guide is air-filled. Give X11=1.842 i) Find cutoff frequency,ii)Find the wavelength in the guide for a frequency of 3Ghz iii) Determine the wave impedance in the guide.(8) **[Apply] Nov -16**

34. Derive the field components of a TE wave in rectangular wave guide) **[Understand] May -16/May 2017**

35.For a frequency of 10Ghz and plane seperation of 5cm in air, find the cutoff frequency,cut off wavelength, phase velocity and group velocity of the wave **[Apply] May -16**

36. When dominant mode is transmitted through a circular waveguide the wavelength measured is to be 13.33cm.The frequency of the microwave signals is 3.75GHz.Calculate the cut off frequency,inner radius of guide,phase velocity,group velocity,phase constant,wave impedance,bandwidth for operation in dominant mode only **[Apply] May -17**

37.A air filled resonant cavity with dimensions a=5cm,b=4cm and c=10cm is made copper with conductivity5.8* 10^7 mhos/m.Find the resonance frequency of a)The five lowest order mode b)The quality factor TE101 mode **[Analyse] Dec -17**

38. Explain the wave behahaviour in a guiding structures **[Understand] May 2018**

39. Explain why TEM waves doed not exit in waveguides **[Understand] May 2018**

40. Write Bessel's differential equation and Bessel function and TM and TE waves in circular waveguides **[Understand] Dec 2018**

41. Determine possible modes of propagation for a rectangular waveguide of dimensions 7 cm × 3.1 cm at a frequency of 12 GHz. **[Apply] (13) May 21**

42. A rectangular waveguide is to be designed to operate at a frequency 10 GHz. It is desired that the frequency of operation be 15% above the cutoff frequency of the operating frequency and 20% below the cutoff frequency of the next higher mode, determine the dimensions of the waveguide. Determine the propagation constant, phase velocity and group velocity at 10 GHz. Represent the Electric and Magnetic field distribution at 10 GHz in the waveguide**[Apply] (16) May 21**

<u>UNIT 4 Assignment</u>

1. Arectangulat air-filled copper waveguide with dimension 0.9inch*0.4inch cross section and 12" inch length is operated at 9.2GHZ with a dominant mode. Find cut-off frequency, guide wave-length, phase velocity, characteristics impedance and the loss. **[Apply]**
2. A TE10 mode is propagated through a waveguide with a=10cm at a frequency of 2.5Ghz.Find the cut-off wavelength, phase velocity, group velocity and wave impedance**[Apply]**
3. A circular waveguide has an internal diameter of 6cm.For a 9GHz signal propagated in the TE11mode,calculate the cut-off frequency and the characteristic impedance**[Apply]**

UNIT V

RF SYSTEM DESIGN CONCEPTS

1. Why the S-parameters are used in microwaves? [Understand] [NOV/DEC - 2011]

The H, Y, Z and ABCD parameters are difficult at microwave frequencies due to following reasons.

Equipment is not readily available to measure total voltage and total current at the ports of the networks.

Short circuit and open circuit are difficult to achieve over a wide range of frequencies.

Presence of active devices makes the circuit unstable for short (or) open circuit.

Therefore, microwave circuits are analyses using scattering (or) S parameters which linearly relate the reflected wave's amplitude with those of incident waves.

2**) Write the properties of [S] matrix. [NOV/DEC - 2012] [Remember]**

- [S] is always a square matrix of order (nxn) .
- [S] is a symmetric matrix i.e. Sij=Sji
- [S] is a unitary matrix i.e. [S][S*]=[I]
- Under perfect matched conditions, the diagonal elements of [s] are zero.

3) **State the reciprocity theorem. [Remember]**

The theorem state that when some amount of electromotive force (or voltage) is applied at one point (e.g., in branch k, vk) in a passive linear network, that will produce the current at any other point (e.g., branch m, im). The same amount of current (in branch k, ik) is produced when the same electromotive force (or voltage) is applied in the new location (branch m, vm); that is Vk/im = vm/ik

5) Define lossless network. [Remember]

In any lossless passive network, its containing no resistive elements, always the power entering the circuit will be equal to the power leaving the network which leads to the conserved in power.

6) What is the zero property of S-matrix? [Remember]

It states that, "for a passive lossless N-port network, the sum of the products of each term of any row or any column multiplied by the complex conjugate of the corresponding terms of any other row or column is zero".

7) Write the unitary property for a lossless junction. [Remember]

For any lossless network the sum of the products of each term of any one row or of any column of the S-matrix multiplied by its complex conjugate is unity.

8) Define non-reciprocal devices. [Remember]

A non-reciprocal device does not have same electrical characteristics in all direction.

9) What is wire? [Remember]

A wire is the simplest element having zero resistance, which makes it appear as a short circuit at DC and low AC frequencies.

10) Mention the many forms of wire. [Remember]

Wire in a circuit can takes on many forms,

- Wire wound resistors
- Wire wound inductors
- Leaded capacitors
- IV. Elements-to- element interconnection applications

11) Write about the skin effect in a wire. [Remember]

As frequency increases, the electrical signal propagates less and less in the inside of the conductor. The current density increases near the outside perimeter of the wire and causes higher impedance for the signal. This will act as resistance of the wire.

R=rl/A Where, A-Effective cross-sectional area. When area (A) decreases, the resistance of the wire will be increases.

12) Give a short note on straight-wire Inductance in wire. [Remember]

In the wire medium, surrounding any current carrying conductor, there exists a magnetic field. If the current (I) is AC, this magnetic field is alternately expanding and contracting. This produces an induced voltage in the wire that opposes any change in the current flow. This opposition to change is called “self inductance”.

13) Define a resistor. [Remember]

A resistor whose purpose is simply to produce a voltage drop by converting some of the electric energy into thermal energy (heat), when an electric current passes through it.

13) Mention the purpose of resistors. [Remember]

Purpose of Resistors:

In transistor bias networks, to establish an operating point.

In attenuators, to control the flow of power.

In signal combiners, to produce a higher output power.

In transmission lines, to create matched conditions.

14) Name the types of resistors. [Remember]

Types of resistors:

Carbon composition resistors, which have a high capacitance due to carbon granules parasitic capacitance.

Wire wound resistors, which have high lead inductance.

Metal film resistors of temperature-stable materials.

Thin-film chip resistors of aluminum or beryllium-based materials.

15) What do you meant by capacitors? [Remember]

A capacitor that consists of two conducting surfaces separated by an insulating material or dielectric. The dielectric is usually ceramic, air, paper, mica, or plastic. The capacitance is the property that permits the storage of charge when a potential difference exists between the conductors. It is measured in farads.

16) Define Quality-factor (Q) of Capacitor. [Remember]

It is defined as “the measure of the ability of an element to store energy, equal to 2p times the average energy stored divided by the energy dissipated per cycle".

17) What is an Inductor? [Remember]

A wire that is wound (or coiled) in such a manner as to increase the magnetic flux linkage between the turns of the coil. The increased flux linkage increases the wire’s self inductance.

18) Write the applications of inductors. [Remember]

Inductors have a variety of applications in RF circuits such as,

- Resonance circuits

- Filters
- Phase shifters
- Delay networks
- RF chokes

19) Which component is represented by the scattering matrix? [Remember] [MAY/JUNE - 2012]

$\begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$ The above scattering matrix represents the Isolator Component.

20) What are the advantages of the S – Parameters? [Remember] [MAY/JUNE - 2012]

The elements of scattering matrix are called scattering coefficients or scattering parameters. Scattering matrix is a square matrix which gives all the combinations of power relationships between the various input and output port of a microwave junction. Therefore, microwave circuits are analyses using scattering (or) S parameters which linearly relate the reflected wave's amplitude with those of incident waves.

21) Define reciprocal and symmetrical networks [Remember] [MAY/JUNE - 2013]

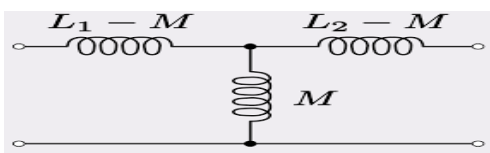
A passive, linear 2-port network is said to be symmetrical if the two ports can be interchanged (that is, the input port is made the output port and the output port is made the input port) without changing the port voltages and currents. The condition of symmetry is conveniently written in terms of z parameters as

z11 = z22

Or V1/I1|I2=0 = V2/I2|I1=0

22) Express power input and power output under matched conditions for a two port network in terms of wave components. [Remember] [MAY/JUNE - 2013]

23) Draw the equivalent circuit of an inductor at radio frequency[Remember] [NOV/DEC 2013]



24) What is ESR [Remember] [NOV/DEC 2013]

Electron cyclotron resonance is a phenomenon observed in plasma physics, condensed matter physics, and accelerator physics. An electron in a static and uniform magnetic field will move in a circle due to the Lorentz force. The circular motion may be superimposed with a uniform axial motion, resulting in a helix, or with a uniform motion perpendicular to the field, e.g., in the presence of an electrical or gravitational field, resulting in a cycloid. The angular frequency ($\omega = 2\pi f$) of this cyclotron motion for a given magnetic field strength B is given by

$$\omega_{ce} = \frac{eB}{m}.$$

25)List any four reasons for the wide use of RF[Remember] [MAY/JUNE - 2014]

RF Power Amplifiers are used in a wide variety of applications including Wireless Communication, TV transmissions, Radar, and RF heating.The basic techniques for RF power amplification can use classes as A, B, C, D, E, and F, for frequencies ranging from VLF (Very

Low Frequency) through Microwave Frequencies. RF Output Power can range from a few mW to MW, depend by application. The introduction of solid-state RF power devices brought the use of lower voltages, higher currents, and relatively low load resistances.

26) Give the relationship between [S] and [Z] [Remember] [MAY/JUNE - 2014]

$$[Z] = Z_{\circ}([S]+[E])([E]-[S])^{-1}$$

27) What are the high frequency limitations of conventional tubes? [Remember] [NOV/DEC 2014]

With increasing frequency > 1 GHz the conventional vacuum tubes are less useful in amplification and generation because of two reasons i) parasitic circuit elements such as inter electrode capacitances and lead inductances, ii) effects due to transit time of electrons between electrodes

28) Given $[y] = \begin{bmatrix} 3.2 & 1 \\ 1 & 3.2 \end{bmatrix}$ find S parameters. **[Understand] [NOV/DEC 2014]**

S11 = S22 = 3.2
S12 = S21 = 1

29) Mention any four differences between the low frequency and high frequency parameters? [Remember] [MAY/JUNE - 2015]

Low Frequency parameters The H, Y, Z and ABCD parameters are difficult at microwave frequencies due to following reasons.
Equipment is not readily available to measure total voltage and total current at the ports of the networks.
Short circuit and open circuit are difficult to achieve over a wide range of frequencies.
Presence of active devices makes the circuit unstable for short (or) open circuit.

High Frequency Parameters

Shorts and Open circuit terminations are difficult to implement over a broad range of frequencies and thus it cannot be used to characterize networks.
At high RF/Microwave frequencies, the net voltage (or net current) is a combination of two or more voltage (or current) travelling waves

30. Define Oscillator and Mixer? **[Remember]**
31. What are stability circles? **[Remember]**
32. Define mixer. Explain mixer with neat block diagram**[Remember]**
33. Distinguish between oscillator and Mixer? **[Remember]**
34. Define S- parameters. **[Remember]**
35. **Define s-matrix [Remember]**
    In a microwave junction there is intersection of three or more components.There will be an output port ,in addition there may be reflection from the junction of other ports.Totally there may be many combinations,these are represented easily using a matrix called S matrix.
36. **What are the .Properties of s-matrix? [Remember]**
    It possess symmetric property sij =sji It possess unitary property [s][s]*=[i]
37. **What are the various modes of transferred electron oscillators? [Remember]**

a)Transit time mode
b)Quenched and delayed domain modes
c)limited space charge accumulation mode.

38. **What is MESFET? [Remember]**
If the field effect transistor is constructed with metal semiconductor schottky barrier diode,the device is called metal-semiconductor field effect transistor.
39. **Why are FET's preferred to bipolar transistor at high frequencies? [Understand]**
FET's are preferred over Bipolar transistors at high frequencies as they easily lend themselves more readily to intrgration.
40. **Define unconditional stability. [Remember]**
Unconditional stability refers to the situation where the amplifier remains stable for any passive source and load at the selected frequency and bias conditions.
41. **Define Stability of an amplifier. [Remember]**

It is the ability of an amplifier to maintain effectiveness in its nominal operating characteristics in spite of large changes in the environment such as temperature, signed frequency or load conditions etc.

42. **Define a stability circle. [Remember]**

A stability circle is simply a circle on a smith chart which represents the boundary between those values of source or load impedance that cause instability and those do not.

43. **Distinguish between conditional stability & unconditional stability[Understand] [MAY/JUNE - 2012]**
Conditional Stability:
A Network is said to be conditionally stable or potentially stable in a frequency range if
$$|\alpha_{in}| < 1$$
$$|\alpha_{out}| < 1$$
Only for a limited range of values of passive source and load impedances, but not for all the values.
UnConditional Stability:
A Network is said to be conditionally stable or potentially stable in a frequency range if
$$|\alpha_{in}| < 1$$
$$|\alpha_{out}| < 1$$
44. **Define Power gain of an amplifier in terms of S – parameters & reflection coefficients. [NOV/DEC - 2012] [Remember]**

$$K = \frac{1 + |\Delta|^2 - |S_{11}|^2 - |S_{22}|^2}{2|S_{12}S_{21}|^2}$$
$$G_{Amax} = \left|\frac{S_{21}}{S_{12}}\right| \left|K - \sqrt{K^2 - 1}\right|$$

45. **Derive the expression for the noise figure of an amplifier. [NOV/DEC - 2012] [Remember]**
$$F = F_{min} + \frac{R_n}{G_s} |Y_s - Y_{opt}|^2$$

46. Define transducer power gain. [Remember]

It is the ratio of the power delivered to the load to the available power from the source.

47. Why are FET"s preferred to bipolar transistor at high frequencies?

FET"s are preferred over Bipolar transistors at high frequencies as they easily lend themselves more readily to integration

48. **What are the applications of low Q-oscillators and amplifier circuits?**

- Final output stage of FM telecommunication transmitter
- Up converter pump
- CW Doppler radar transmitter

49. What is MESFET? [Remember]

- If the field effect transistor is constructed with metal semiconductor schottky barrier diode, the device is called metal-semiconductor field effect transistor.

50 .What are the applications of low Q-oscillators and amplifier circuits? [Remember]

- Final output stage of FM telecommunication transmitter
- Up converter pump
- CW Doppler radar transmitter

51. Define Stability May 21 [Remember]

Stability in a network means when the magnitudes of reflection coefficients are less than unity

52. Mention the requirements and applications of low noise amplifiers May 21 [Remember]

Low Noise Amplifier (LNA) is the most critical part of a receiver front end, in term of the receiver performance. Many circuits with different configurations have been proposed for LNA, in different applications. After choosing proper circuit for LNA, this circuit must be designed and optimized.

Applications: LNAs are used in communications receivers such as in cellular telephones, GPS receivers, wireless LANs (WiFi), and satellite communications

PART -B

1. Explain the various stabilization methods and stability considerations for RF transistor amplifier design**[Understand]**
2. Explain the constructional details and principle of operation of GaAs MESFET with neat diagrams and characteristic curves. **[Understand]**
3. Give the physical structure and equivalent diagram of microwave field effect transistors.
4. Explain the operation of microwave bipolar transistor with neat diagrams. **[Understand]**
5. Explain the operation of HEMT with neat diagram and its characteristics curves**[Understand]**
6. Explain the operation of MOSFET with neat diagram and its characteristics curves**[Understand]**

7. Explain the Principle of oscillator design**[Understand]**
8. Explain the voltage-controlled oscillator**[Understand]**
9. List out Diode mixers and give detailed explanation about their topologies**[Understand]**
10. A microwave transistor has the following S parameters at 10 GHZ, with a 50 Ω reference impedance. S11 = .0 45 o 150 S12 = .0 01 o −10 S 21 = .2 05 o 10 S 22 = .0 40 o −150 The source impedance is Z s = 20Ω and load impedance is Z L = 30Ω . Compute the power gain, available gain and the transducer power gain.
11. Explain about the formulation of the S – Parameters.
12. Derive the expression for the S – matrix for a transition between a coaxial line and waveguide. **[Understand]**
13. Two transmission lines of characteristics impedances Z1 and Z2 are joined at the plane pp'. Express S – Parameters in terms of impedances. **[Understand]**
14. What is the S – parameters of a series element (Z). **[Understand]**
15. Explain the operation of BJT with its diagram**[Understand]**
16. Explain the power amplifiers used at RFfrequencies. **[Understand]** **MAY 21**
17. Explain the working of FET at RFfrequencies**[Understand]** **MAY 21**