# JEPPIAAR
## ENGINEERING COLLEGE

**DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING**

# EC3551 – TRANSMISSION LINES AND RF SYSTEMS

**(Regulation 2021)**

# QUESTION BANK

**Batch: (2022 – 2026)**

**Year/ Semester: III/V**

# JEPPIAAR ENGINEERING COLLEGE

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| **Vision of the Institute** | To build Jeppiaar Engineering College as an institution of academic excellence in technological and management education to become a world class University | |
| **Mission of the Institute** | **M1** | To excel in teaching and learning, research and innovation by promoting the principles of scientific analysis and creative thinking |
| | **M2** | To participate in the production, development and dissemination of knowledge and interact with national and international communities. |
| | **M3** | To equip students with values, ethics and life skills needed to enrich their lives and enable them to meaningfully contribute to the progress of society |
| | **M4** | To prepare students for higher studies and lifelong learning, enrich them with the practical and entrepreneurial skills necessary to excel as future professionals and contribute to Nation's economy |

# DEPARTMENT: ELECTRONICS AND COMMUNICATION ENGINEERING

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| **Vision of the Department** | To become a centre of excellence to provide quality education and produce creative engineers in the field of Electronics and Communication Engineering to excel at international level. | |
| **Mission of the Department** | **M1** | Inculcate creative thinking and zeal for research to excel in teaching-learning process |
| | **M2** | Create and disseminate technical knowledge in collaboration with industries |
| | **M3** | Provide ethical and value based education by promoting activities for the betterment of the society |
| | **M4** | Encourage higher studies, employability skills, entrepreneurship and research to produce efficient professionals thereby adding value to the nation's economy |

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| | **PO 1** | **Engineering knowledge**: **Apply** the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems. |

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| PROGRAM OUTCOMES (PO) | **PO 2** | **Problem analysis**: **Identify, formulate, review** research literature, and **analyze** complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| | **PO 3** | **Design/development of solutions**: **Design solutions** for complex engineering problems and **design** system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations |
| | **PO 4** | **Conduct investigations of complex problems**: **Use** research-based knowledge and research methods including **design** of experiments, **analysis** and **interpretation** of data, and **synthesis** of the information to provide valid conclusions. |
| | **PO 5** | **Modern tool usage**: **Create**, **select**, and **apply** appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| | **PO 6** | **The engineer and society**: **Apply** reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| | **PO 7** | **Environment and sustainability**: **Understand** the impact of the professional engineering solutions in societal and environmental contexts, and **demonstrate** the knowledge of, and need for sustainable development. |
| | **PO 8** | **Ethics**: **Apply** ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| | **PO 9** | **Individual and team work**: **Function effectively** as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| | **PO 10** | **Communication**: **Communicate effectively** on complex engineering activities with the engineering community and with society at large, such as, being able **to comprehend** and **write** effective reports and **design** documentation, **make** effective presentations, and **give** and **receive** clear instructions. |
| | **PO 11** | **Project management and finance**: **Demonstrate** knowledge and understanding of the engineering and management principles and **apply** these to one's own work, as a member and leader in a team, to **manage** projects and in multidisciplinary environments. |
| | **PO 12** | **Life-long learning**: **Recognize** the need for, and have the preparation and ability to **engage** in independent and life-long learning in the broadest context of technological change. |
| | **PEO I** | Produce technically competent graduates with a solid foundation in the field of Electronics and Communication Engineering with the ability to analyze, design, develop, and implement electronic |

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| **PROGRAM EDUCATIONAL OBJECTIVES (PEOS)** | | systems. |
| | **PEO II** | Motivate the students for choosing the successful career choices in both public and private sectors by imparting professional development activities. |
| | **PEO III** | Inculcate the ethical values, effective communication skills and develop the ability to integrate engineering skills to broader social needs to the students. |
| | **PEO IV** | Impart professional competence, desire for lifelong learning and leadership skills in the field of Electronics and Communication Engineering. |
| **PROGRAM SPECIFIC OUTCOMES (PSOs)** | **PSO 1** | Design, develop and analyze electronic systems through application of relevant electronics, mathematics and engineering principles. |
| | **PSO 2** | Design, develop and analyze communication systems through application of fundamentals from communication principles, signal processing, and RF System Design & Electromagnetics. |
| | **PSO 3** | Adapt to emerging electronics and communication technologies and develop innovative solutions for existing and newer problems. |

**EC3551 TRANSMISSION LINES AND RF SYSTEMS L T P C 3 0 0 3**

**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, One Eighth wave line, Half wave line- Impedance matching by stubs - Single stub and double stub matching - Smith chart – Application of smith chart, Solutions of problems using Smith chart - Single and double stub matching using Smith chart.

**UNIT IV WAVEGUIDES 9**

Waves between parallel planes of perfect conductors- Transverse Electric waves and Transverse Magnetic waves, Characteristics of TE and TM waves, Transverse Electromagnetic waves, TM and TE waves in Rectangular waveguides, 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, Fundamentals of MMIC, Basic concepts of RF design, Filters, couplers, power dividers, Amplifier power relations, Low noise amplifiers, Power amplifiers.

**TOTAL: 45 PERIODS**

**TEXT BOOKS:**

1. John D Ryder, “Networks lines and fields”, Prentice Hall of India, New Delhi,2005.(Unit I - IV)
2. Mathew M. Radmanesh, “Radio Frequency & Microwave Electronics”, Pearson Education Asia, Second Edition, 2002 (Unit – V)
3. Annapurna Das, Sisir K. Das, “Microwave Engineering”, McGraw Hill Education (India) private limited, Third edition, 2000. (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. Richard Chi-Hsi Li -, “RF Circuit Design” – A John Wiley & Sons, Inc, Publications
4. W.Alan Davis, Krishna Agarwal, “Radio Frequency Circuit Design”, John willy & Sons,2001

## COURSE OBJECTIVES

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| To introduce the various types of transmission lines and its characteristics |
| To give thorough understanding about high frequency line, power and impedance measurement |
| 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 |

## COURSE OUTCOMES

### TRANSMISSION LINES AND WAVEGUIDES (EC3551)

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|---|---|
| **C303.1** | To introduce the various types of transmission lines and its characteristics |
| **C303.2** | To give thorough understanding about high frequency line, power and impedance measurements |
| **C303.3** | To impart technical knowledge in impedance matching using smith chart |
| **C303.4** | To introduce passive filters and basic knowledge of active RF components |
| **C303.5** | To get acquaintance with RF system transceiver design |

## UNIT –I TRANSMISSION LINE THEORY

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

## PART A

1. **Define characteristic impedance. What determines the characteristic impedance of a transmission line? (Nov/Dec 2021) (Apl/ May 2022) (Apl/ May 2023)**

   The characteristic impedance or surge impedance (usually written Z0) of a uniform transmission line is the ratio of the amplitudes of voltage and current of a single wave propagating along the line; that is, a wave travelling in one direction in the absence of reflections in the other direction. Alternatively, and equivalently, it can be defined as the input impedance of a transmission line when its length is infinite.
   General expression for the characteristic impedance of a transmission line is:

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

2. **State the condition for a distortion less line.(Apr/May 2019) (May/June 2018)(Nov/Dec 2017) (Nov/Dec 2016)(Nov/Dec 2015) (Apl/ May 2023)**

   A distortion less line is one which has neither frequency nor delay distortion. The attenuation constant and velocity of propagation cannot be functions of frequency. The condition for a distortion less line is, LG = RC

3. **What is Loading? (Apl/ May 2022) (Nov/Dec 2022)**

   Loading is the process of increasing the inductance value by placing lumped inductors at specificIntervals along the line, which avoids the distortion.

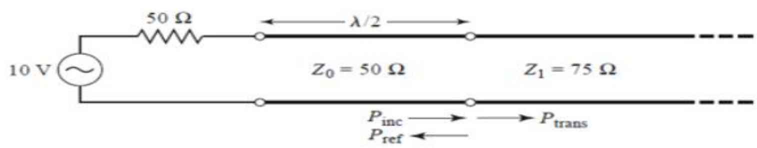
4. **What do you mean by reflection factor? (Nov/Dec 2022)**

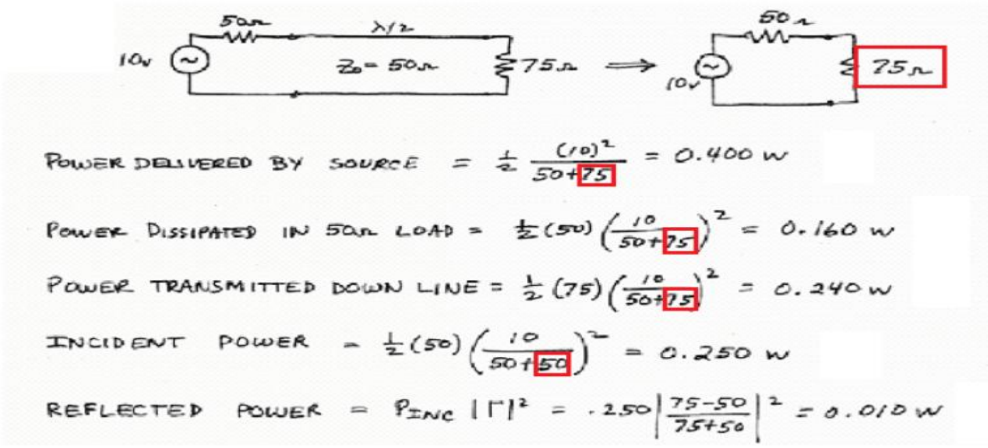
   The change in current in the load due to reflection at the mismatched junction is called the reflection factor and is given by reflection factor, k = $\left|\frac{2\sqrt{Z_R Z_O}}{Z_R + Z_O}\right|$

5. **Define reflection loss. (Nov/Dec 2022)**

   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. Reflection loss, nepers = 10 log$\left(\frac{|Z_R + Z_o|^2}{4Z_R Z_O}\right)$, Reflection loss, dB = 20 log $\left(\frac{|Z_R + Z_o|}{2\sqrt{Z_R Z_O}}\right)$
   Where $Z_R$ = Receiving end impedance, $Z_o$ = characteristic impedance

6. **A50Ω 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. (Nov/Dec 2021)**




7. **Find the characteristic impedance of the line at 1600 Hz if $Z_{oc} = 750\angle -30^\circ \Omega$ and $Z_{sc} = 600\angle -20^\circ \Omega$ (May 2019).**
   - **a.** Solution: Characteristic impedance, $Z_o = \sqrt{Z_{oc} Z_{sc}}$

     **1.** $= \sqrt{750\angle -30^\circ X 600\angle -20^\circ}$
   - **b.** $670.8\angle -25^\circ \Omega$

8. **A transmission line has $Z_o = 745\angle -12^\circ$ ohms and is terminated by $Z_R = 100$ ohms. Calculate the reflection loss in dB and reflection factor. (May 2017)**

   **Solution:** Reflection loss, dB = 20 log $\left(\frac{|Z_R + Z_o|}{2\sqrt{Z_R Z_O}}\right)$ = 3.776 dB

   Reflection factor, k = $\left|\frac{2\sqrt{Z_R Z_O}}{Z_R + Z_O}\right|$ = 0.648

9. **Define reflection loss (APRIR/MAY'-08)(MAY/JUNE 2016) (MAY/JUNE 2018)**
   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.
10. **Define the term insertion loss. (APR/MAY 2015) (MAY/JUNE2014) (Nov'18)**
    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.
11. **Define reflection loss (APRIR/MAY'-08)(MAY/JUNE 2016) (MAY/JUNE 2018)**
    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.
12. **Describe the different parameters of a transmission line. (Nov 2018)**
    The parameters include resistance, which is uniformly distributed along the length of the conductors. Since current will be present, the conductors will be surrounded and linked by magnetic flux, and this phenomena will demonstrate its effect in distributed inductance along the line.(2)The conductors are separated by insulating dielectric, so that capacitance will be distributed along the conductor length.(3)The dielectric or the insulators of the open wire line may not be perfect, a leakage current will flow, and leakage conductance will exist between the conductors.

13. **Define propagation constant. (Nov 2018) (MAY/JUN'13)( NOV/DEC'07)**
Under the condition of $Z_o$ termination, propagation constant $\gamma$ is defined as the natural logarithm of the ratio of input to output currents or input to output voltages. $\gamma$ is a complex number defined as $\gamma = \alpha + j\beta$, where $\alpha$ is known as the attenuation constant, since it determines the magnitude ratio between input and output quantities, or the attenuation produced in passing through the network.

14. **What is characteristic impedance? (Nov 2017)**
The characteristic impedance of a uniform transmission line is the ratio of the amplitudes of voltage and current of a single wave propagating along the line; that is, a wave travelling in one direction in the absence of reflections in the other direction.

15. **A lossless line has an characteristic impedance of 400Ω. Determine the standing wave ratio if the receiving impedance is 800+j0.0Ω. (May 2017)**

Reflection co-efficient, $K = \dfrac{Z_R - Z_o}{Z_R + Z_o}$

$$= \frac{800-400}{800+400} = \frac{400}{1200} = \frac{1}{3} = 0.33$$

$$\text{Standing wave ratio, } S = \frac{1+|K|}{1-|K|}$$

$$= \frac{1+0.3333}{1-0.3333} = 1.999 = 2$$

16. **Find the reflection coefficient of a 50 ohm transmission line when it is terminated by a load impedance of 60+j40 ohm.(Nov 2015)**
Solution: Given $Z_o$ = 50 ohms, $Z_R$ = 60+j40 ohms

Reflection co-efficient, $K = \dfrac{Z_R - Z_o}{Z_R + Z_o}$

$$= \frac{60+j40-50}{60+j40+50} = \frac{10+j40}{110+j40} = \frac{41.23\angle 75.9^\circ}{117.047\angle 19.98^\circ}$$

$$= 0.3523\angle 55.9169^\circ$$

17.

$$\text{Standing wave ratio, } S = \frac{1+|K|}{1-|K|} \qquad = \frac{1+0.3523}{1-0.3523} = 2.08$$

18. **Define transmission Line.What are the different types of transmission lines?**
A transmission line is a system of conductors that transfers electrical signals from one place to another.The different types of transmission lines are
1.Open wire line 2. Cable 3. Coaxial line 4. Waveguide

19. **Distinguish lumped parameters and distributed parameters.**
Lumped parameters are individually concentrated or lumped at discrete points in the circuit and can be identified definitely as representing a particular parameter.
Distributed parameters are distributed along the circuit, each elemental length of the circuit having its own values and concentration of the individual parameters is not possible.

20. **Give the general equations of a transmission line**.
The general equations are,
$E = E_R \cosh\sqrt{ZY}\, s + I_R Z_o \sinh \sqrt{ZY}\, s$
$I = I_R \cosh\sqrt{ZY}\, s + (E_R / Z_o) \sinh \sqrt{ZY}\, s$ where $Z = R + j\omega L$ = series impedance, ohms per unit length of line and $Y = G + j\omega C$ = shunt admittance, mhos per unit length of line.

21. **Give the general equations of a transmission line**.

The general equations are,

$E = E_R \cosh\sqrt{ZY}\, s + I_R Z_o \sinh \sqrt{ZY}\, s$

$I = I_R \cosh\sqrt{ZY}\, s + ( E_R / Z_o ) \sinh \sqrt{ZY}\, s$ where $Z= R + j\omega L$ = series impedance, ohms per unit length of line and $Y = G + j\omega C$ = shunt admittance, mhos per unit length of line.

22. **What is the advantage in terminating a line with its characteristic impedance?**

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

23. **Define wavelength of the line.**

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

24. **What is cut off frequency? (NOV/DEC'07)**

The frequency at which the network changes from a pass band to stop band or vice- versa is called cut-off frequency

25. **What is frequency distortion?(MAY/JUN'07)**

When a signal having many frequency components are transmitted along the line, all the frequencies will not have equal attenuation and hence the received end waveform will not be identical with the input waveform at the sending end because each frequency is having different attenuation. This type of distortion is called frequency distortion.

26. **How can you reduce frequency distortion?**

Frequency distortion is reduced in the transmission of high quality radio broadcast programs over wire lines by use of equalizers at the line terminals. These circuits are networks whose frequency and phase characteristics are adjusted to be inverse to those of the lines, resulting in an over-all uniform frequency response over the desired frequency band.

27. **How can you overcome delay distortion?**

Coaxial cables are used to overcome delay distortion. In such cables, the internal inductance is low at high frequencies because of skin effect, the resistance is small because of the large conductors, and capacitance and leakages are small because of the use of air dielectric with a minimum of spacers. The velocity of propagation is raised and made more nearly equal for all frequencies.

28. **Give the expressions for attenuation constant, phase constant and velocity of propagation in a telephone cable.**

Attenuation constant, $\alpha = \sqrt{(\omega RC) / 2}$ Phase constant, $\beta = \sqrt{(\omega RC) / 2}$

Velocity of propagation, $v_p = \omega / \beta = \sqrt{(2\omega) / RC}$

29. **What are the types of loading?**

a) Continuous loading b) Patch loading c) Lumped loading

30. **What is continuous loading?**

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

31. **What is patch loading?**

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

32. **What is lumped loading?**

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

33. **What is the need for inductance loading of telephone cables?**

The condition for a distortion less line is, LG = RC. In order to achieve this condition, L/C ratio has to be increased. To increase this ratio, the value of L must be increased which in turn is increased by adding lumped inductors spaced at regular intervals along the telephone cables.

34. **How much inductive loading is required to make a 16 gauge cable distortion less? The line Parameters are R=42.1Ω/km, G=1.5µ℧/km, C=0.062µf/km and L=1mh/km. (NOV/DEC'06)**

The distortion less condition is RC=L'GL'=1.74H/KM.The required loading is L =L'-L=1.739H/km

**35. What are the primary & secondary constants of a transmission line?**

The primary constants of a transmission line are resistance R, ohm/unit length, inductance L, henry/unit length, capacitance C, farad/unit length and conductance G, mho/unit length.

The secondary constants of a transmission line are characteristic impedance and propagation constant.

**36. How much inductive loading is required to make a 16 gauge cable distortion less? The line Parameters are R = 42.1Ω/km, G = 1.5µƱ/km , C =0.062µf/km and L= 1mh/km. [NOV/DEC'06]**

The distortion less condition is RC=L'G L'=1.74H/KM.

The required loading is L =L'-L=1.739H/km

**37. When does a finite line appear as an infinite line?**

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

**38. Write the equation for the input impedance of a transmission line.**

The equation for the input impedance of a transmission line is

$$Zin = Z_o \left[ \frac{Z_R \cosh \gamma l + Z_o \sinh \gamma l}{Z_o \cosh \gamma l + Z_R \sinh \gamma l} \right]$$

**39. Define the line parameters?**

The parameters of a transmission line are: Resistance (R) Inductance (L) Capacitance (C) Conductance (G) Resistance (R) is defined as the loop resistance per unit length of the wire. Its unit is ohm/Km Inductance (L) is defined as the loop inductance per unit length of the wire. Its unit is Henry/Km Capacitance (C) is defined as the loop capacitance per unit length of the wire. Its unit is Farad/Km Conductance (G) is

**40. What are the secondary constants of a line? Why the line parameters are called distributed elements?**

The secondary constants of a line are: Characteristic Impedance, Propagation Constant Since the line constants R, L, C, G are distributed through the entire length of the line, they are called as distributed elements. They are also called as primary constants.as the loop conductance per unit length of the wire. Its unit is mho/Km

**41. What is a finite line? Write down the significance of this line?**

A finite line is a line having a finite length on the line. It is a line, which is terminated, in its characteristic impedance (ZR=Z0), so the input impedance of the finite line is equal to the characteristic impedance (Zs=Z0).

**42. What is an infinite line?**

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.

**43. What is an infinite line?**

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.

**44. How to avoid the frequency distortion that occurs in the line?**

In order to reduce frequency distortion occurring in the line,a) The attenuation constant _ should be made independent of frequency.b) By using equalizers at the line terminals which minimize the frequency 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 attenuation is equal for all the frequencies.

**45. A transmission line has a characteristic impedance of 400 Ω and is terminated by a load**

**impedance of (650-j475) Ω . Determine the reflection coefficient.**

$K = ZR - ZO = 781. j608 = 0.367 - j0.28$ ;

$ZR + ZO$ 2125

**46. A 50 ohms coaxial cable feeds a 75+j20 ohms dipole antenna. Find reflection coefficient and standing wave ratio.**

Solution: Given $Z_o = 50$ ohms, $Z_R = 75+j20$ ohms

Reflection co-efficient, K = $\frac{Z_R - Z_o}{Z_R + Z_o} = \frac{75 + j20 - 50}{75 + j20 + 50} = \frac{25 + j20}{125 + j20} = \frac{32\angle 38.65^\circ}{126.58\angle 9.09^\circ}$

$= 0.25\angle 29.56^\circ$ $\quad SWR, S = \frac{1+|K|}{1-|K|} \frac{1+0.25}{1-0.25} = 1.666$

**47. Find the attenuation constant and phase constant of a wave propagating along the line Whose** $\gamma = 1.048\text{x}10^{-4}\angle 88.8^\circ$

Solution: Propagation constant, $\gamma = \alpha + j\beta$

that is, $\gamma = 1.048\text{x}10^{-4}\angle 88.8^\circ$

In rectangular form, $\gamma = 2.194\text{x}10^{-6} + j1\text{x}10^{-4}$, Equating the real and imaginary parts, we get, $\alpha = 2.194\text{x}10^{-6}$ nepers per unit length and $\beta = 1\text{x}10^{-4}$ rad per unit length.

**48. What are the conditions for a perfect line? What is a smooth line?**

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.

**49. Define input impedance.**

The characteristic impedance of a transmission line is the ratio of the voltage and current of a wave travelling along the line. When the wave reaches the end of the line, in general, there will be a reflected wave which travels back along the line in the opposite direction. When this wave reaches the source, it adds to the transmitted wave and the ratio of the voltage and current at the input to the line will no longer be the characteristic impedance. This new ratio is called the input impedance

**50. What is open circuited transmission line?**

When the transmission line is opened from the load end it is known as open circuited line.

**51. What is short circuited transmission line?**

When the transmission line is short circuited from the load end it is known as short circuited line.

**52. What is the drawback of using ordinary telephone cables?**

The drawback of using ordinary telephone cables is that the attenuation and velocity are functions of frequency and there will be very considerable frequency and delay distortion.

**53. What is the advantage in terminating a line with its characteristic impedance?**

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

## PART B&C

1. **Derive the transmission line equation and hence obtain expression for voltage and current on a transmission line (APRIL/MAY 2019(MAY/JUNE 2018)( NOV/DEC 2017) (MAY/JUNE'16 (Nov/ Dec 2022) (Apl/ May 2022) (Apl/May 2023)**

   Refer Page No:236- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010

2. **What is a loading? Specify the types of loading in transmission lines (Apl/May 2023)**

   Refer Page. No 249- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010.

3. **Derive the reflection loss of a transmission line.(APR/MAY 2015) (Apl/May 2023)**

   Refer Page. No 265- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010.

4. **Explain in detail about the waveform distortion. Also derive the condition for a distortion less line? (NOV/ DEC 2021) (Nov/ Dec 2022) (NOV/DEC'15,16)(MAY/JUNE'14)(MAY/JUNE'13)(NOV/DEC'12)(NOV/DEC'13).**

   Refer Page. No 249- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010.

5. **A transmission line has the following parameters per km R=15ohm, C=15µf, L=1mh and G=1µ℧. Find the additional inductance to give distortion less transmission. Calculate attenuation and phase constant for the loaded line. (Nov/ Dec 2022)**

   Refer Page. No 24-Umesh Sinha "Transmission Lines and Networks" ,TechIndia Publications,8th Edition

6. **Generator of 2 volt and 10 MHz frequency is connected to a transmission line which has series impedance of 50+j50 ohms/km and shunt admittance of (2+j4) x 10-6 ohms/km. Find the characteristic impedance and propagation constant. Find the power delivered to the load impedance of impedance 100+j 100 ohms. (Apl/ May 2022)**

   Refer Page. No 24-Umesh Sinha "Transmission Lines and Networks" ,TechIndia Publications,8th Edition

7. **A50Ω line is matched to a 10 V source and feeds a load of 100Ω. If the line is 2.3λ long, λ being the wavelength and has an attenuation α = 0.5 dB/λ, find the power delivered to the load. (NOV/ DEC 2021)**

   Refer Page. No 69- Reinold ludwig, "RF circuit design", Prentice Hall India, 2000.

8. **Explain in detail about the reflection on a line not terminated in its characteristic impedance $Z_o$. (APR/MAY 2019) (MAY/JUNE'13)(NOV/DEC '16)**

   Refer Page No:239- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010

9. **A generator of 1 V, 1 KHz supplies power to a 100km open wire line terminated in Z0 and having the following line parameters : R = 10.4 ohm/km, L = 3.8 mH/km, G = 0.8 µmho/km and C = 0.0085µF/km. Calculate the characteristic impedance, attenuation constant, phase constant, velocity of propagation, wavelength. Also find the received power. (May 2019)**

   Refer notes.

10. **A communication line has L=3.67 mH/km, G=0.08 *10-6 mho/km, C=0.0083µF/km and R=10.4 Ω /km. Determine the characteristic impedance, phase constant, velocity of propagation, wavelength, sending and receiving end current for given frequency f=1000 Hz, sending end voltage is 1 volt and transmission line length is 100 kilometers. (MAY/JUNE 2018)**

Refer Page. No 1.37- Dr.P.Dananjayan, “Transmission Lines and Waveguides”,Lakshmi Publications.

**11. 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. (NOV/DEC 2017)**

Refer Page. No 299- John D Ryder, “Networks, lines -and fields”, 2nd Edition, Prentice Hall India, 2010.

**12. Derive the input impedance $Z_0$ from the transmission line equation and also find voltage reflection ratio at the load. (NOV/DEC 2017)**

Refer Page. No 249- John D Ryder, “Networks, lines -and fields”, 2nd Edition, Prentice Hall India, 2010.

**13. Draw the input impedance pattern for a lossless line when short circuited and open circuited(NOV/DEC 2017)**

Refer Page. No 298- John D Ryder, “Networks, lines -and fields”, 2nd Edition, Prentice Hall India, 2010.

**14. Discuss the following**

**i. a)reflection on a line not terminated in Z0 b)open and short circuited lines. (NOV/DEC’15)(NOV/DEC’12)**

Refer Page. No 239- John D Ryder, “Networks, lines -and fields”, 2nd Edition, Prentice Hall India, 2010**.**

15. **Derive the conditions required for a distortion less line.(NOV/DEC 2008)**

Refer Page. No 250- John D Ryder, “Networks, lines -and fields”, 2nd Edition, Prentice Hall India, 2010.

**16. Explain in detail the different types of loading a cable? Derive the attenuation and Phase constant and velocity of propagation for a loaded cable.**

Refer Page. No 249- John D Ryder, “Networks, lines -and fields”, 2nd Edition, Prentice Hall India, 2010.

**17. A parallel – wire transmission line is having the following line parameters at 5 KHz. Series resistance R = 2.59 x $10^{-3}$ ohm/m, Series inductance L = 2 micro H/m, Shunt conductance G = 0 mho/m and capacitance between conductors C = 5.56 nF/m. Find the characteristic impedance, attenuation constant, phase shift constant, velocity of propagation and wavelength.**

**Refer notes**

**18. A 2 meter long transmission line with characteristic impedance of 60+j40 ohm is operating at $\omega = 10^6 \text{ rad/sec}$ has attenuation constant of zero neper/m. If the line is terminated by a load of 20+j50ohms, determine the input impedance of this line.**

**Refer notes**

**19. For a transmission line terminated in Z0, prove that $Z_o = \sqrt{Z_{oc} Z_{sc}}$ . The following Measurements are made on a 25km line at a frequency of 796 Hz, $Z_{SC} = 3220\angle -79.29°, Z_{OC} = 1301\angle 76.67°$ . Determine the primary constants of the line.**

**Refer notes**

**20. Characteristic impedance of a uniform transmission line is 2309.6 ohms at 800 Hz. At this frequency, the propagation constant is 0.054(0.0366+j0.999) per km. Determine R and L.**

**Refer notes**

**21. A transmission line has a characteristic impedance of (683-j138). The propagation constant is ((0.0074+j0.0356)per Km. Determine the values of R and L of this line if the frequency is 1000Hz.**

**Refer notes**

## UNIT- II HIGH FREQUENCY TRANSMISSION LINES

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.

## PART A

1. **Write the expression for the standing wave ratio in terms of reflection co-efficient. (May 2019) (Apl/ May 2023)**

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

2. Find the input impedance of an open circuited line. **(Apl/ May 2023)**

The input impedance of a line of length $l$ is

$$Z_s = Z_0 \left( \frac{Z_R \cosh \gamma l + Z_0 \sinh \gamma l}{Z_0 \cosh \gamma l + Z_R \sinh \gamma l} \right).$$

For open circuit case, $Z_R = \infty$.

$$Z_{oc} = Z_0 \frac{\cosh \gamma l}{\sinh \gamma l}$$

$$= Z_0 \coth \gamma l.$$

3. **For the line of zero dissipation what will be the values of attenuation constant and characteristic impedance. (NOV/DEC 2015) (NOV/DEC 2022)**
   Characteristic impedance, Z0=SQRT(L*C)
   Attenuation Constant ,α =0
4. **Open circuited lossless transmission line has Z0=100 ohms is of length λ/8. Find input impedance (Apl/may 2022)**

For lossless line $\gamma = j\beta$

$$Z_{in} = Z_0 \left[ \frac{Z_R + jZ_0 \tan \beta l}{Z_0 + jZ_R \tan \beta l} \right]$$

5. **A 50 ohms line is terminated in load ZR = 90+j60 ohms. Determine the reflection coefficient.**

**Solution: Reflection co-efficient, K =** $\frac{Z_R - Z_o}{Z_R + Z_o}$ **= 0.473** $\angle 33.11^\circ$

6. **A transmission line of characteristic impedance 75 ohms is terminated by resistance which has VSWR of 3. Find reflection coefficient at the load and load resistance. (NOV/DEC 2022)**

$$VSWR = \frac{1+|K|}{1-|K|}$$ **K =** $$\frac{Z_R - Z_o}{Z_R + Z_o}$$

7. **A50Ω 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. (NOV/DEC 2021)**

Maximum input impedance, $Z_{S\max} = R_o\ S$

Minimum input impedance, $Z_{S\min} = R_o/S$

8. **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. (NOV/DEC 2021)**

$$Z_S = R_O\left(\frac{1+|K|\underline{|\phi-2\beta l}}{1-|K|\underline{|\phi-2\beta l}}\right)$$

9. **What do the nodes and antinodes on a standing wave represent? (April/May 2019) NOV/DEC 2017)**
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 first maximum are called antinodes or loops.
Node: Nodes are points of zero voltage or current in the standing wave systems.
Antinodes: Antinodes or loops are points of maximum voltage or current in standing wave systems.

10. **What are the assumptions to simplify the analysis of line performance at high frequencies? (MAY/JUNE'16)(MAY/JUNE '18)**
a)At very high frequencies, the skin effect is very considerable so that currents may be assumed as Flowing on conductor surfaces, internal inductance then being zero.
b) Conductance may be considered as zero.

11. **Write the expression for the input impedance of open and short circuited, dissipation less line.(MAY/JUNE'18)**
The input impedance of open and short circuited lines are given byZOC=-jR0cotβs ZSC=jR0tanβs

12. **What is dissipation less line?(NOV/DEC 2017)**
A line for which the effect of resistance R is completely neglected is called Dissipation less line.

13. **A lossless transmission line has a shunt capacitance of 100 pF/m and a series inductance of 4 micro Henry/m. Determine the characteristic impedance.(Nov 2015)**

$$Z_o = \sqrt{\frac{L}{C}}$$

$$= \sqrt{\frac{4\text{x}10^{-6}}{100\text{x}10^{-12}}}$$ **=200 ohm**

14. **What is standing wave ratio?(APR/MAY 2017)**
The ratio of the maximum to minimum magnitudes of voltage or current on a line having standing waves called standing waves ratio.

15. **What is called a line of small dissipation and a line of zero dissipation?** Line of small dissipation: If resistance R is small, the line is considered as one of small dissipation and this concept is useful when lines are employed as circuit elements or where The leakage conductance G is zero.
Since the line constants R, L, C, G are distributed through the entire length of the line, they are called as distributed elements. They are also called as primary constants.

16. **What is dissipation less line?(NOV/DEC'12)**
A line for which the effect of resistance R is completely neglected is called Dissipation less line.

17. **What is called a line of small dissipation and a line of zero dissipation? Line of zero dissipation:**
If resistance R is completely negligible, the line is considered as one of zero dissipation. This concept is useful in applications where losses may be neglected as in transmission of power at high efficiency.

18. **State the assumptions for the analysis of the performance of the radio frequency line. (MAY/JUNE'16)**

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 Ö f while inductance L increases with f.Hence ωL>>R.

**19. Write the condition to be satisfied for a dissipation less line. (NOV/DEC 2013)**
**For the dissipation less line, the Z0 is purely resistive and given by, Z0=R0 =0**

**20. What are the secondary constants of a line? Why the line parameters are called distributed elements?**
The secondary constants of
a line are: Characteristic
Impedance Propagation
Constant

**21. What is known as a standing wave?**
The actual voltage at any point on the transmission line is the sum of the incident and reflected wave voltages at that point. The resultant total voltage wave appears to stand still on the line, oscillating in magnitude with time but having field positions of maxima and minima. Such a wave is known as a standing wave.

**22. What is the range of values of standing wave ratio?**
The range of values of standing wave ratio is theoretically 1 to infinity.

**23. What is the nature and value of Z0 for the dissipation less line?**
For the dissipation less line, the Z0 is purely resistive and given by, Z0=R0 = 0

**24. What are the assumptions to be made for resistance and conductance to determine the line constants for zero dissipation?**
The assumptions to be made for resistance and conductance to determine the line constants
for zero dissipation are R=G=0

**25. What is significance of reflection coefficient?**
When ZR=0, k= -1(K=1,<180º) Reflection Maximum When ZR=∞, k= +1(K=1,<0º ) Reflection Maximum K Ranges from 0to1 in Mag.and 0ºto 180º in angle

**26. Find the VSWR and reflection co-efficient of a perfectly matched line with no reflection from load?(MAY/JUNE'07)**
VSWR = (1+K)/(1-K)

**27. What is significance of reflection coefficient?**
When ZR=ZO, k=0 Reflection

**28. What are the standard assumptions made for RF line?**
Very considerable skin effect, so that currents may be assumed as flowing on conductor surfaces, internal inductance then being zero. Assume ωL>> R. this assumption is justifiable because it is found that the R increases because of skin effect with (f)1/2
while the line reactance increases directly with frequency f.The lines are well enough constructed that G may be considered zero

**29. Define smooth line.**
A line terminated in Ro has no standing waves and thus no nodes or loops and this is called a smooth line.

**30. Define SWR.**
The ratio of the maximum to minimum magnitudes of current or voltage on a line having standing waves is called the standing wave ratio SWR S.

S = $\frac{|E_{max}|}{|E_{min}|}$ or S = $\frac{|I_{max}|}{|I_{min}|}$

**31. Name the devices used for the measurement of standing waves.**

Slotted line section and directional coupler are the devices used for the measurement of standing waves.

**32. Define reflection coefficient.**

The ratio of amplitudes of the reflected and incident voltage waves at the receiving end of the line is frequently called the reflection coefficient.

**33. Give the expression for the input impedance of the dissipation less line.**

**Zin=** $R_o\left(\frac{Z_R + jR_o \tan\beta l}{R_o + jZ_R \tan\beta l}\right)$ **, ohm**

**34. Explain the similarity of performance of open circuited and short circuited lines to that of series resonant or anti resonant circuits.**

The similarity suggests the use of lines as reactive circuit elements or as tuned circuits. The input of the quarter wave short circuited line appears similar to that of a parallel resonant circuit, and the input of the quarter wave open line as that of a series resonant circuit.

**35. Calculate standing wave ratio and reflection coefficient on a line having the characteristic impedance Zo= 300 ohms and the terminating impedance ZR is 300+j400 ohms. (Nov 2016).**

**Solution:** $VSWR = \frac{1+|K|}{1-|K|}$ **;To find the magnitude of the reflection coefficient, use**

**K =** $\frac{Z_R - Z_o}{Z_R + Z_o}$ **= 0.55** $\angle 56.31^\circ$ **.Therefore, SWR** $S = \frac{1+0.55}{1-0.55}$ **= 3.49**

**36. Write the expressions for the input impedance of open and short circuited dissipation less line.**

$Z_{oc} = -jR_o \cot\beta l$ **and** $Z_{sc} = jR_o \tan\beta l$

**37. For the line of zero dissipation, what will be the values of attenuation constant and characteristic impedance.**

For the line of zero dissipation, series arm impedance Z = $j\omega L$ and shunt arm admittance Y = $j\omega C$ .

$Z_o = \sqrt{\frac{j\omega L}{j\omega C}} = \sqrt{\frac{L}{C}}$ = and $\gamma = \sqrt{(j\omega L)(j\omega C)}$ = $j\omega\sqrt{LC}$ . But, Propagation constant, $\gamma = \alpha + j\beta$ . This implies that, attenuation constant, $\alpha = 0$ and $\beta = \omega\sqrt{LC}$

**38. Write the conditions to be satisfied by dissipation less line.**

The standard assumptions for a dissipation less line at a high frequency are $\omega L$ >> R and $\omega C$ >>G. The value of characteristic impedance is real and resistive, it is represented by symbol Ro = $\sqrt{\frac{L}{C}}$ . Similarly, the propagation constant is found to be purely imaginary.

**39. Give the minimum and maximum value of SWR and reflection co-efficient.**

**Min value ofSWR = 1; Max. Value of SWR = infinity, Min. value of K = 0 and Max. Value of K =1**

**40. Find the characteristic impedance of the line with following constants L = 9 micro henry/m, C = 16pico farad/m working at radio frequencies.**

**Solution:** $Z_o = \sqrt{\frac{L}{C}}$ **= 866 ohms.**

**41. What is the significance of reflection coefficient?**

Reflection coefficient gives the ratio of reflected voltage/current to incident voltage/current. The value of reflection coefficient is a measure of mismatch of impedance between the line and the load.

A line having characteristic impedance 50 Ω is terminated with a load 75 + j 75Ω. Calculate the reflection coefficient.

Reflection co-efficient K = $\frac{Z_R - Z_o}{Z_R + Z_o}$

**42. For the line of zero dissipation, what will be the values of attenuation constant and characteristic impedance?**

For the line of zero dissipation, Series impedance, Z = $j\omega L$ and shunt admittance, Y = $j\omega C$ Propagation constant, $\gamma = \sqrt{ZY} = \sqrt{j\omega L \times j\omega C} = \sqrt{j^2\omega^2 LC} = j\omega\sqrt{LC}$, since $\gamma = \alpha + j\beta$, attenuation constant, $\alpha = 0$ and phase constant, $\beta = \omega\sqrt{LC}$

**43. What is open circuited transmission line?**

When the transmission line is opened from the load end it is known as open circuited line.

**44. What is short circuited transmission line?**

When the transmission line is short circuited from the load end it is known as short circuited line.

**45. Define input impedance.**

The characteristic impedance of a transmission line is the ratio of the voltage and current of a wave travelling along the line. When the wave reaches the end of the line, in general, there will be a reflected wave which travels back along the line in the opposite direction. When this wave reaches the source, it adds to the transmitted wave and the ratio of the voltage and current at the input to the line will no longer be the characteristic impedance. This new ratio is called the input impedance

**46. Why the line parameters are called distributed elements?**

Since the line constants R, L, C, G are distributed through the entire length of the line, they are called as distributed elements. They are also called as primary constants.

**47. What is meant by the wavelength of a line?**

The distance over which a wave travels along a line while the phase angle changes through 2π radians is called wavelength**.**

**48. When does reflection occur in a line?**

Reflection occurs in a line under the following conditions

i. When the load end is open circuited

ii.When the load end is short circuited

iii.When the line is not terminated in its characteristics impedance.

**49. What are the conditions for a perfect line?**

For a perfect line, the resistance and the leakage conductance values are neglected. The cond ition for a perfect line is R = G=0.

**50. What is a smooth line?**

A smooth line is one in which the load is terminated by its characteristic impedance. No reflection occurs in such a line . It i s also called a flat line.

**51. What is the nature and value of Z0 for the dissipation less line?**

For the dissipation less line , the Z0 is purely resistive

**52. Define Reflection Loss.**

Reflection loss is defined as the number of nepers or decibels by which the current in the load under image matched condition would exceed the current actually f lowing in the load.

**53. Name the devices used for the measurement of standing waves.**

Slotted line section and directional coupler are the devices used for the measurement of standing waves.

**54. Define reflection coefficient.**

The ratio of amplitudes of the reflected and incident voltage waves at the receiving end of the line is frequently called the reflection coefficient.

## PART B&C

1. **Explain the voltage and current on the dissipation less line. (Apl/ May 2023)**
   Refer Page. No 291- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010
2. **Discuss in detail about the variation of input impedance along open and short-circuited lines with relevant graphs. (Nov/Dec'12) (May/June'16)(May/June 2018) (Apl/ May 2023)**
   Refer Page. No 297- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010
3. **Describe the experimental setup for the determination of VSWR and wavelength of an RF transmission line. ( Nov/Dec'16) (Apl/ May 2023)**
   Refer Page. No 287- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010
4. **Discuss the λ/2 and λ/4 length transmission lines and list its applications (Apl/ may 2022)**
   Refer Page. No 305- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010
5. **Distinguish between lossless and distortion less transmission lines. (Apl/ may 2022)**
   Refer Page. No 282- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010
6. **Define the reflection coefficient and voltage standing wave ratio and draw the voltage and current waveforms when the transmission line is terminated by matched load, short circuit, open circuit and reactance terminations. (Nov/dec 2022)**
   Refer Page. No 297- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010
7. **Find the required value of Zo of the transmission line of length ßl=z/2 that will match 10 ohms load resistance to the generator. The generator internal resistance is 200 ohms. Find the VSWR and reflection coefficient on the line.(Nov/dec 2022)**
   Refer Page. No 291- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010
8. **Define input impedance of a transmission line. A lossless 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 (NOV/ DEC 2021)**
   Refer Page. No 295- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010
9. **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. (NOV/ DEC 2021)**
   Refer Page. No 291- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010
10. **Derive an expression for power and find the input impedance of dissipation less line when the load is short circuited, open circuited and for a matched line. (April/May 2019)**
    Refer Page. No 264- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010
11. **Derive the line constants of a zero-dissipation line. (April/May 2019)**
    Refer Page. No 261- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010
12. **Briefly explain on 1) Standing wave 2) Reflection loss. (April/May 2019) (May/June 2018)**
    Refer Page. No 291&265,302- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010
13. **A 30m long lossless transmission line with Zo = 50 ohms operating at 2 MHZ is terminated with a load ZL = 60+j40 ohms. If u= 0.6c on the line, find (i) Reflection co-efficient (ii) Standing wave ratio**

**(iii) Input impedance. (b) Draw the input impedance pattern of lossless line when short circuited and open circuited. (Nov /Dec 2017)**
**Refer notes**

14. **Derive the expression for the input impedance of the dissipation less line. (NOV/ DEC 2016) (APR/MAY 2015) (MAY/JUNE 2014) (NOV/DEC'13)**
Refer Page. No 295&- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010.
15. **Explain the parameters of open wire line and coaxial cable at RF.Mention the standard assumptions made for radio frequency line.(NOV/DEC'14) (NOV/DEC'15)**
Refer Page. No 278- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010.
16. **What are standing waves? Derive the expression for standing wave Ratio. (NOV/DEC 2016)**
Refer Page. No 291- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010
17. **Discuss on reflection loss and return loss. (APR/MAY 2015)**
Refer Page. No 302- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010
18. **A loss less line has a SWR of 4. The R0 is 150 ohms and the maximum voltage measured in the line is 135V. Find the power delivered to the load. (May 2016)**
Refer Notes
19. **Explain the concept of transmission line equations at radio frequency.**
**Refer Page. No 291- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010**
20. **A transmission line is terminated in ZL. Measurements indicate that the standing wave minima are 102cm apart and that the last minimum is 35cm from the load end of the line. The value of standing wave ratio is 2.4 and Ro = 250 ohm. Determine wavelength and load impedance**
Refer Notes
21. **The input impedances of a $\frac{\lambda}{8}$ long, 50 ohms transmission line are Z1 = 25+j100 ohms Z2 = 10-j50 ohms, Z3 = 100+j0 ohms and Z4 = 0+j50 ohms, when various load impedances are connected at the other end. In each case, determine the load impedance and the reflection coefficient at the input and load ends.**
Refer Notes

## UNIT III- IMPEDANCE MATCHING IN HIGH FREQUENCY LINES

Impedance matching: Quarter wave transformer, One Eighth wave line, Half wave line- Impedance matching by stubs - Single stub and double stub matching - Smith chart – Application of smith chart, Solutions of problems using Smith chart - Single and double stub matching using Smith chart.

### PART A

1. **Mention the advantages of double stub matching (APL/MAY 2023)**

   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

2. **A quarter wave transformer is used to match a 100Ω load to a 50Ω transmission line at 2 GHz. Find the characteristic impedance of a quarter wave transformer. (APL/MAY 2023)**

   Solution: The characteristic impedance of a quarter wave transformer,

   $R_0' = \sqrt{R_A R_0}$

   **=√(100×50) =22.36Ω**

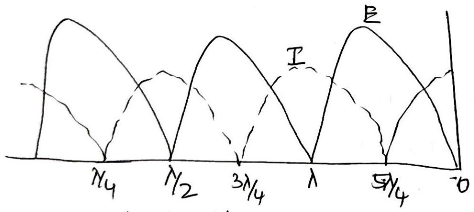
3. **Calculate the length of short circuit line to give an impedance of +j 20 ohms. The characteristic impedance of the line is 100 ohms.(NOV/DEC 2022)**

$$l_t = \frac{\lambda}{2\pi}\tan^{-1}\frac{\sqrt{Z_R Z_0}}{(Z_R - Z_0)} \qquad l_s = \frac{\lambda}{2\pi}\tan^{-1}\sqrt{\frac{Z_R}{Z_0}}$$

4. **A Certain line of Ro= 100 ohms is short at the termination. Find the impedance seen by the generator connected at a point λ/2. .(NOV/DEC 2022)**

$$Z_s = R_0\left(\frac{z_R + j\,R_0 \tan\beta s}{R_0 + j\,z_R \tan\beta s}\right)$$

5. **Represent the variation of impedance of short circuit transmission for a distance of one wavelength. (Apl/may 2022)**




Short ckt

$R_R = 0$.

For short ckt,
nodal pts shift by a distance of λ/4.

Voltage node occur ⇒ 0, λ, λ/2, ...
Current node occur ⇒ λ/4, 3λ/4, 5λ/4, ...

**6. Mention the applications of Smith Chart. (May 2015/ Nov 2018) (Apl/may 2022)**

**Smith chart can be used**

- as an admittance diagram to convert impedance into admittance
- to determine the sending end impedance.
- to determine the load impedance.

**7. What is the outer circle present on the smith chart? One complete revolution around a Smith chart represents how many wavelengths? (NOV/DEC 2021)**

Two scales on the Smith chart's outer periphery indicate movement in wavelengths either **toward the generator** (clockwise) or **toward the load** (counterclockwise). One complete rotation around the chart amounts to a half wavelength traversal.

**8. Mention the two applications of quarter wave transmission line. (NOV/DEC 2021)**

The application of quarter wave transmission line is impedance matching and impedance inversion in size relevant electronic structures, another application in RF/DC coupling in transistor amplifiers.

**9. How is impedance matching achieved with stubs? (April/May 2019)**

If maximum power has to transfer between the source and the load, the resistance of the load should be equal to that of the source and the reactance of the load should be equal to that of the source but opposite in sign (ie) if the source is inductive, the load should be capacitive and vice versa. When this condition is achieved, it is commonly referred to as impedance matching. Impedance matching is achieved by inserting a section of transmission line between the load and the source. It is also possible to connect sections of open or short circuited line called stub in shunt with the main line at some point or points to effect impedance matching.

**10. Distinguish between single stub and double stub matching. (May 2019)**

| SINGLE STUB MATCHING | DOUBLE STUB MATCHING |
|---|---|
| It is used for only one frequency | It is used for different frequencies |
| Location of stub have to be changed | Stub positions are arbitrary |
| Difficult method of impedance matching | Easy method of impedance matching |

**11. What is the application of quarter wave line matching section? (Nov/Dec 2018)**

The expression for input impedance of the quarter wave line is given by

$Z_s = R_o^2 / Z_R$

(1)It may be thought of as a transformer to match a load of $Z_R$ to a source of $Z_s$. It may be considered as an impedance inverter in that it can transform low impedance into high impedance and vice versa.

(2)It may be used to couple a transmission line to a resistive load such as an antenna.

(3)It can be used as an insulator to support an open-wire or the center conductor of a coaxial line Such lines are sometimes referred to as copper insulators.

**12. Why a quarter wave line called as impendence inverter?(MAY/JUNE'16)(NOV/DEC 2017)(NOV/DEC 2017)**

A quarter wave line may be considered as an impedance inverter in that it can transform a low impedance into a high impedance and vice versa.

**13. Explain impedance matching using stub.(MAY/JUNE 2018)(NOV/DEC 2017)**

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 antiresonant resistance equal to Ro.

**14. List the applications of smith chart .(APR/MAY 2015)(MAY/JUNE'18)**

The applications of the smith chart are,

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

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.

**15. Why Double stub matching is preferred over single stub matching.(MAY/JUNE'14)(APR/MAY 2017)**

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

**16. List the applications of quarter wave line. (NOV/DEC 2015)(APR/MAY 2017)**

An important application of the quarter wave matching section is to a couple a transmission line to a resistive load such as an antenna .The quarter – wave matching section then must be designed to have a characteristic impendence Ro so chosen that the antenna resistance Ra is transformed to a value equal to the characteristic impendence Ra of the transmission line. The characteristic impendence Ro of the matching section then should be

Ro' = √ Ra Ro

**17. What is a stub? Why it is used in between transmission lines?( MAY/JUNE 2016)**

A Stub is 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 antiresonant resistance equal to Ro.

**18. What is the use of eighth wave line? (NOV/DEC 2016)**

An eighth wave line is used to transform any resistance to an impendence with a magnitude equal to Roof the line or to obtain a magnitude match between a resistance of any value and a source of Ro Internal resistance.

**19. State the use of half wave line**

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

**20. Mention the significance of λ/4 line.**

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.

It can transform a low impedance into a high impedance and vice versa.

**21. Define impedance matching.**

The input impedance of an electrical load or the output impedance of its corresponding Signal source to maximize the power transfer or minimize signal reflection from the Load.

$Z_S=Z_R$

**22. Give reason for an open line not frequently employed for impedance Matching.**

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

**23. Design a quarter wave transformer to match a load of 200ohms to a source resistance of 500 ohms. The operating frequency is 200 MHz.**

Solution: The characteristic impedance of a quarter wave transformer, $R_0^{'} = \sqrt{R_A R_0}$

$$R_0^{'} = \sqrt{200\text{x}500} = 316.227 \text{ ohms}$$

**24. Give some of the impedance matching devices.**

The quarter wave line or transformer, exponential line and the use of an open or closed stub line of suitable length are some of the impedance matching devices.

**25. What are the advantages of stub matching?**

The advantages of stub matching are the length and characteristic impedance of the line remain unaltered. From mechanical stand point, adjustable susceptances are added in shunt with the line so that impedance matching can be achieved.

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

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.

**27. Define Smith chart.**

Smith chart is a special polar diagram containing constant resistance circles, constant reactance circles, circles of constant standing wave ratio and radius lines representing line-angle loci; used in solving transmission line and waveguide problems.

**28. Give the formula to calculate the distance of the point from the load at which the stub is to be connected.**

The formula to calculate the distance of the point from the load at which the stub is to be connected is,

S1 = (ϕ +π-cos-1|K|)/(2β)

**29. Give the formula to calculate the length of the short circuited stub.**

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

L=λ/2π tan-1((s)½ /(s-1))

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.

**30. Mention the disadvantages of single stub matching.**

The difficulties of the smith chart are

Single stub impedance matching requires the stub to be located at a definite point on the line.

This requirement frequently calls for placement of the stub at an undesirable place from a mechanical view point.

For a coaxial line, it is not possible to determine the location of a voltage minimum without a slotted line section, so that placement of a stub at the exact required point is difficult.

In the case of the single stub it was mentioned that two adjustments were required, these being location and length of the stub.

**31. What is double stub matching?**

Another possible method of impedance matching is to use two stubs in which the locations of the stub are arbitrary,the two stub lengths furnishing the required adjustments. The spacing is frequently made λ/4.This is called double stub matching.

**32. Mention the significance of Quarter wave line**

A Quarter wave line is first and foremost an impedance invertor and only under a special case resistive loads can be utilized as an impedance transformer.

**33. What is the application of the quarter wave matching section?**

An important application of the quarter wave matching sectionis to a couple a transmission line to a resistive load such as an antenna .The quarter .wave matching section then must be designed to have a characteristic impendence Ro so chosen that the antenna resistance Ra is transformed to a value equal to the characteristic impendence Ra of the transmission line .The characteristic impendence Ro of the matching section then should beRo’ = ( Ra Ro) ½

**34. Give the equation for the radius of a circle diagram.**

The equation for the radius of a circle diagram is

$R=(S^2-1)/2S$ and

**35. Why a short circuited stub is preferred to an open circuited stub?**

A short circuited stub is preferred to an open circuited stub because of greater ease in construction and because of the inability to maintain high enough insulation resistance at the open circuited point to ensure that the stub is really open circuited. A short circuited 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.

**36. What are the drawbacks of impedance circle diagram?**

Though the circle diagram is very useful in calculating the line impedance and admittance it has the following drawbacks. 1. Constant S and $\beta s$ circles are not concentric, making interpolation difficult.2.Only a limited range of impedance values can be accommodated in a chart of reasonable size.

**37. What are the properties of Smith Chart?**

The properties of Smith chart are as follows: (a) Normalizing impedance. (b) Plotting of an impedance. (c) Determination of Standing wave ratio(d) Determination of reflection co-efficient K in magnitude and direction. e) Location of voltage maxima and voltage minima. f) Movement along the periphery of the chart. g) Matched load.

**38. Write down the basic difference between circle diagram and Smith chart.**

The basic difference between circle diagram and Smith chart is that in the circle diagram the impedance is represented in a rectangular form while in the Smith chart the impedance is represented in a circular form.

**39. Write down the application of circle diagram.**

The circle diagram may be used to find the input impedance of a line of any chosen length.

**40. Match a load with impedance $Z_A$=100 Ohms to be 50 Ohms using a quarter-wave transformer.**

$$R_0' = \sqrt{Z_A R_0}$$

=√(100x50)=70.7ohms

**41. Design a coaxial quarter wave transformer to match a 10 ohm load to a 80 ohm line at 3000 MHZ.**

$$R_0' = \sqrt{Z_A R_0} = \sqrt{10\text{x}80} = 28.28 \text{ ohms}$$

**42. Write down the expression to determine the length of the short circuited stub.**

$$L = \frac{\lambda}{2\pi} \tan^{-1} \frac{\sqrt{1-|K|^2}}{2|K|}$$

**43. Give the names of circles on smith chart.**

The names of circles on smith chart are (i) Constant – R circles and (ii) constant – X circles

**44. What are constant - S circles?**

The input impedance equation for a dissipation less line if expressed in terms of SWR S, results in the form of a circle. These circles are called as constant – S circles.

**45. Give the application of eighth-wave line.**

It is used to transfer any resistance to an impedance with a magnitude equal to $R_0$ of the line, or to obtain a magnitude match between a resistance of any value and $R_0$, the internal source resistance.

**46. What is the use of a circle diagram?**

The circle diagram may be used to find the input impendence of a line m of any chosen length.

**47. What are the drawback of a circle diagram?**

S & ß circles are not concentric.

*Only a limited range of impedance can be allocated

**48. How is the circle diagram useful to find the input impendence of short and open circuited lines?**

An open circuited line has s =α ,the correspondent circle appearing as the vertical axis .The input impendence is then pure reactance , with the value for various electrical lengths determined by the intersections of the corresponding βs circles with the vertical axis. A short circuited line may be solved by determining its admittance .The S circle is again the vertical axis, and suspectance values may be read off at appropriate intersection of the βs circle with the vertical axis.

**49. Distinguish between impedance circle diagram and smith chart and double stub matching. (NOV/DEC 2015)**

| IMPEDANCE CIRCLE DIAGRAM | SMITH CHART |
|---|---|
| Impedance is in rectangular form | Impedance is in rectangular form |
| Only a limited range of impedance are accommodated | Wide range of impedance are accommodated |

**50. Name few applications of half- wave line.**
(i) One to one transformer.
(ii) Used to connect a load to a source when the load and source cannot be made adjacent.

**51. When does standing wave occur in a transmission line?**
The standing wave occurs in a transmission line when the line is not terminated with its characteristic impedance. Due to this there is a reflection wave along the line.

**52. What is the input impendence of an eighth wave line terminated in a pure resistance RR?**
The input impendence of an eighth wave line terminated in a pure resistance RR is given by Zin = R0 [(RR + jR0 ) / (R0 + jRR)]

**53. What is an impedance matching in stub?**
An impedance matching in stub is the use of an open or short circuited line of suitable length as a reactance shunted across the transmission line at a designated distance from the load.

**54. State reasons for preferring a short– circuited stub over an open circuited stub.**
A short circuited stub is preferred to open circuited stub because of the following reason:
Easy in constructions
Lower loss of energy due to radiation
Effectively stopping all field propagation

**55. Why is double stub matching preferred over single stub matching?**
Double stub matching is preferred over single stub matching due to the disadvantages of single stub matching. Single stub matching is useful for a fixed frequency. As the frequency changes the location of single stub will also changed. So Double stub matching is preferred.
The single stub matching system is based on the measurement of voltage minimum. Hence for the coaxial line it is very difficult to get such voltage minimum, without using slotted line section.

## PART B &C

**1. With neat diagram, explain the single stub and double stub matching network. Also explain the design procedure. (Nov/Dec 2017) (May/June 2018) (Nov/Dec 2022) (Apl/ May 2023)**
Refer Page. No 331&333- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010

**2. A load of 40-70 is connected to a 100 Ω lossless transmission line of length 0.3 λ. Find the following parameters using smith chart (Apl/ May 2023)**
**(i) Reflection Coefficient at the source and load.**
**(ii) Standing wave ratio**
**(iii) Input impedance**
Refer notes

**3. An antenna with an impedance of 40+30j Ω is to be matched to a 100Ω lossless line with a shorted stub. Using smith chart find all possible solutions to determine**
**(i) The distance between the stub and antenna**
**(ii) The stub length (Apl/ May 2023)**
Refer notes

**4. A line of Ro = 300 ohms is connected to a load of 50 ohms resistance. For a frequency of 50 Hz, find the length, termination of single stub nearest to the load to produce an impedance match. (Use smith chart). (apl/ may 2022) (Nov/Dec 2022)**
Refer Notes

**5. Explain the procedure of double stub matching on a transmission line. (apl/may 2022)**
Refer Page. No 333- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010

**6. Describe quarter wave transmission line. Discuss the applications of quarter wave transmission line. (NOV/DEC 2021)**
Refer Page. No 305- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010

**7. 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 Ro is 300 ohms on the line (Use smith chart) (NOV/DEC 2021)**
Refer Page. No 305- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010

**8. Explain the operation of a quarter-wave transformer and mention its important applications.(ii) A single stub is to match a load 400 Ω line to a load of 200-j100 Ω. The wavelength is 3m. Determine the position & length of the short-circuited stub.(April/May 2019)**
Refer Page. No 305- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010

**9. A 75 ohm lossless transmission line is to be matched with a 100-j80 ohm load using single stub. Calculate the stub length and its distance from the load corresponding to the frequency of 30 MHZ using Smith chart. .(April/May 2019)**
Refer Notes

**10. Prove that the input impedance of a quarter wave line is Zin=R0 /ZR(MAY/JUNE 2016)(APR/MAY 2015)(NOV/DEC 2016)(MAY/JUNE 2018)**
Refer Page. No 305- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010.

11. **Design a quarter wave transformer to match a load a 200Ω to a source resistance of 500 Ω, operating frequency is 200 MHz.(MAY/JUNE 2018)**
Refer Page. No 305- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010.
12. **Find the sending end impedance of a line with negligible losses when characteristic impedance is 55 Ω and load impedance is (115+j75) Ω length of the line is 1.183 wavelength by using smith chart.(MAY/JUNE 2018)**
Refer Page. No235- Umesh Sinha "Transmission Lines and Networks",TechIndia Publications,8$^{th}$ Edition.

13. **Explain the significance of smith chart and its application in a transmission line in a transmission line lines.(MAY/JUNE 2018)**
Refer Page. No221- Umesh Sinha "Transmission Lines and Networks",TechIndia Publications,8$^{th}$ Edition.

**14. Explain the procedure for obtaining Smith chart using R and X circles. (Nov/Dec 2018)**
Refer Page. No 324- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010

**15. A 50 Ω lossless transmission line is connected to a load composed of a 75 Ω resistor in series with a capacitor of unknown capacitance. If at 10 MHz the voltage standing wave ratio on the line was measured as 3, determine the capacitance C.(Nov /Dec 2018)**
Refer notes
**16. A transmission line has $Z_{in}$ = 1.0, $Z_L$=0.2-j0.2 Ω (i) What is z at =$\lambda$/4=0.25 $\lambda$? What is the VSWR on the line? (iii)How far from the load is at the first voltage minimum? Use Smith chart. (Nov/Dec 2018)**
Refer notes
**17. Explain the technique of single stub matching and discuss operation of quarter wave transformer. (Nov/Dec 2018)**
Refer Page. No 331&305- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010
**18. Design a double-stub stunt tuner to match a load impedance $Z_L$=60-j80 Ω to a 50 Ω line. The stubs are to be short-circuited stubs and are spaced λ/8 apart. Find the length of the two stubs using Smith chart. (NOV/DEC 2017)**
Refer Page. No235- Umesh Sinha "Transmission Lines and Networks", TechIndia Publications,8$^{th}$ Edition.
**19. Explain the significance of smith chart and its application in a transmission line.**
Refer Page. No 327- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010

**20. A 30m long lossless transmission line with characteristic impedance of 50 ohm is terminated by a load impedance ZL = 60 + j40 ohm. The operating wavelength is 90m. Find the reflection coefficient, SWR and input impedance using Smith Chart.**

Refer Notes

## UNIT IV WAVEGUIDES

Waves between parallel planes of perfect conductors- Transverse Electric waves and Transverse Magnetic waves, Characteristics of TE and TM waves, Transverse Electromagnetic waves, TM and TE waves in rectangular waveguides, TM and TE waves in Circular waveguides

## PART-A

1. **Why TEM waves are not possible in rectangular waveguide (Apl/May 2023)**

   Suppose a TEM wave is assumed to exist within a hollow guide of any shape. Then lines of H must lie entirely in the transverse plane. Also in a nonmagnetic material, ∇. H = 0 which Suppose requires that the lines of H be closed loops. Therefore, if a TEM exists inside the guide, the lines of H will be closed loops in plane perpendicular to the axis. Now by Maxwell's first equation the magnetomotive force around each of these closed loops must equal the axial current ($J_C$ or $J_D$). In the case of a guide with an inner conductor, example, a coaxial transmission line, this axial current through the H loops is the conduction current in the inner conductor. However, for a hollow waveguide having no inner conductor, this axial current must be a displacement current But an axial displacement current requires an axial component of E, something not present in a TEM wave. Therefore the TEM wave cannot exist in a single conductor waveguide.

2. **A rectangular waveguide of cross section 5 cm X 2 cm is used to propagate $TM_{11}$ mode at 10 GHZ. Determine the cut-off wavelength. (Nov 2015) (Apl/May 2023)**

   Cut-off frequency, $f_c = \dfrac{1}{2\sqrt{\mu\varepsilon}}\sqrt{\left(\dfrac{m}{a}\right)^2 + \left(\dfrac{n}{b}\right)^2}$

   Here, a = 0.05m and b = 0.02m, m = 1 and n = 1, f = 10 GHZ

   If air is the dielectric within the rectangular waveguide, $\dfrac{1}{\sqrt{\mu\varepsilon}} = \dfrac{1}{\sqrt{\mu_0\varepsilon_0}} = 3\text{x}10^8\,\text{m/sec}$

   Therefore, $f_c = \dfrac{1}{2\sqrt{\mu_0\varepsilon_0}}\sqrt{\left(\dfrac{m}{a}\right)^2 + \left(\dfrac{n}{b}\right)^2} = \dfrac{C\sqrt{\left(\dfrac{m}{a}\right)^2 + \left(\dfrac{n}{b}\right)^2}}{2}$

   $\dfrac{C}{f_c} = \dfrac{2}{\sqrt{\left(\dfrac{1}{0.05}\right)^2 + \left(\dfrac{1}{0.02}\right)^2}} = 0.037m$ ,Cut-off wavelength, $\lambda_C = 0.037\text{m}$

3. **What is the dominant mode for the rectangular waveguide?(MAY/JUNE 2016)(nov/dec 2022)**

   The lowest mode for TE wave is TE10 (m=1 , n=0) whereas the lowest mode for TM wave is TM11 m=1 , n=1). The TE10 wave have the lowest cut off frequency compared to the TM11 mode. Hence the TE10 (m=1, n=0) is the dominant mode of a rectangular waveguide. Because the TE10 mode has the lowest attenuation of all modes in a rectangular waveguide and its electric field is definitely polarized in one direction everywhere.

4. **A parallel plane guide having distance between them as 4 cm is filled with dielectric material with dielectric constant of 2. Find the cut off frequency, for TM11 mode. )(nov/dec 2022)**

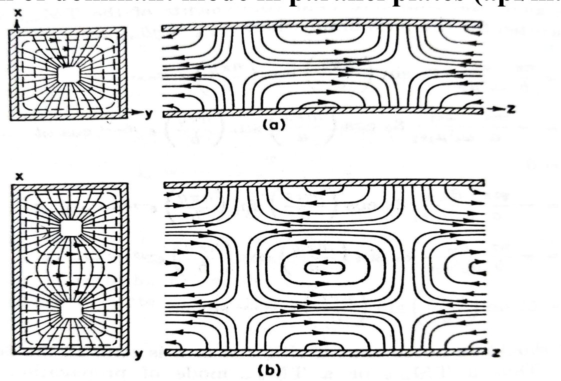
$$f_c = \frac{m}{2a}\frac{1}{\sqrt{\mu\varepsilon}}$$

**5. Define cut off frequency and cut off wavelength of modes of propagation in rectangular waveguides (apl/may 2022)**

Cut-off frequency, $f_c = \frac{1}{2\sqrt{\mu\varepsilon}}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$

cut off wavelength= $\lambda_C = \frac{C}{f_c}$

**6. Represent the field distribution of dominant mode in parallel plates (apl/may 2022)**



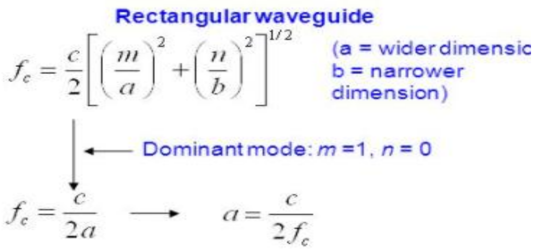

Configuration of $TM_{1,1}$ fields; (b) configuration of $TM_{2,1}$ fields.

7. **Define phase velocity and group velocity. (NOV/DEC 2021)**

The rate at which the wave changes its phase as the wave propagates inside the region between planes is defined as phase velocity $v_p$ and is given by ,$v_p = \frac{\omega}{\beta}$ ; $\beta = \varpi\sqrt{\mu\varepsilon}\sqrt{1-\left(\frac{f_c}{f}\right)^2}$

The actual velocity with which the wave propagates inside the region between the planes is defined as group velocity $v_g$, given by $v_g = \frac{d\omega}{d\beta}$

**8. 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. (NOV/DEC 2021)**




**9. Justify, why TM01 and TM10 modes in a rectangular waveguide do not exist. (April/May 2019).**

TM01 and TM10 do not exist in a rectangular wave guide. Because no fields are present if neither ‘m’ or ‘n’ be zero. (i.e., Ez = Ey= Hx= Hy= 0).

**10. How a cavity resonator is formed? What are its different types? (April/May 2019) (MAY/JUNE 2016)**

A cavity resonator is one in which waves exist in a hollow space inside the device.

The Cavity resonator is short segment of waveguide which acts as high Q resonant circuit

Types: Regulated Cavity Resonator. Un Regulated Cavity Resonator. Co-axial Cavity Resonator. Capacitive Cavity Resonator. Inductive Cavity Resonator. Waveguide Cavity Resonator. Reentrant Cavity Resonator.

**11. Write the applications of cavity resonators.(NOV/DEC 2015) (NOV/DEC 2013) (NOV/DEC 2010)(MAY/JUNE2018)**

- Used in klystron amplifier, Light house tube, and cavity magnetron.
- Used in duplexers in the RADAR system as resonant cavity in TR and ATR tubes.

Used in measurement of microwave signals.

**12. State the significance of dominant mode of propagation. (NOV/DEC 2014)(MAY/JUNE 2018)**

Dominant mode is useful in finding the lowest cut-off frequency for any waveguide.

**13. What is dominant mode?(MAY/JUNE 2016)(NOV/DEC 2017)**

Dominant mode is defined as the node in which the wave has lowest cut off frequency

**14. Write the expression for cutoff wavelength of the wave which is propagated in between two parallel planes.(NOV/DEC 2017)**

$\lambda_c$= v/fcf$_c$=m/2a[sqrt(μ€)]$\lambda_c$=2va[sqrt(μ€)]/mFor free space, $\lambda_c$=2a/m.

**15. What is the dominant mode in a circular waveguide? (MAY/JUNE 2016)**

The dominant mode for TM waves in a circular waveguide is the TM01 because it has the root value of 2.405. The dominant mode for TE waves in a circular waveguide is the TE11 becauseit has the root value of 1.841 .Since the root value of TE11 is lower than TM01, TE11 is the dominant or the lowest order mode for a circular waveguide.

**16. How the resonator is constructed at low frequencies? (MAY/JUNE 2016)**

At low frequencies upto VHF (300 MHz) , the resonator is made up of the reactive elements or the lumped elements like the capacitance and the inductance.

**17. What are guided waves? Give examples.**

The electromagnetic waves that are guided along or over conducting or dielectric surface are called guided waves. Examples: The waves along ordinary Parallel wire co-axial transmission lines.

**18. Define TEM wave.**

The transverse electromagnetic waves are waves in which both electric and magnetic fields are transverse entirely but have no components of $E_z$ and $H_z$. It is referred to as principal wave.

**19. Define skin depth.**

In a medium which has conductivity the wave is attenuated as it progress owing to the losses which occur. In a good conductor at radio frequencies the rate of attenuation is very great and the wave may penetrate only a short distance before being reduced to a negligibly small percentage of its original strength. Such circumstance is called depth of penetration or skin depth defined as δ, the depth the wave has been attenuated to 1/e or approximately 37% of its original value.

**20. Write down the expression for the wave impedance for TM,TE and TEM wave.**

Wave impedance for TM wave, $Z_{TM} = \eta\sqrt{1-\left(\frac{f_c}{f}\right)^2}$ ; For TE wave, $Z_{TE} = \dfrac{\eta}{\sqrt{1-\left(\frac{f_c}{f}\right)^2}}$

Wave impedance for TEM wave, $Z_{TEM} = \eta_o = \sqrt{\frac{\mu_o}{\varepsilon_o}}$ = 120π ohms

**21. Two conducting planes have a distance of separation of 6 cm in air. At a frequency of 6 GHZ with $TM_2$ mode being excited, find the cut-off wavelength.**

**Solution:**

$$\lambda_c = \frac{2a}{m} = \frac{2 x 0.06}{2} = 0.06\ m$$

22. **Mention the characteristics of TEM waves.**
(a)TEM waves are special type of TM wave. (b) It does not have either $E_z$ or $H_z$ component.
(c) Its velocity is independent of frequency. (d) Its cut-off frequency is zero.

23. **The electric field in free space is given by $\vec{E} = 50\cos(10^8 t + \beta x)\vec{a}_y$ , v/m. find the direction of wave propagation and phase constant.**
Solution: Direction of wave propagation = negative x direction
Phase constant $\beta = \omega\sqrt{\mu\varepsilon}$ ; since the electric field is in free space, $\mu = \mu_o and \varepsilon = \varepsilon_o$

= $\omega\sqrt{\mu_o\varepsilon_o}$ ; We know that $\frac{1}{\sqrt{\mu_o\varepsilon_o}}$ = 3 X $10^8$ m/sec From the given electric field vector, $\omega = 10^8$ ;

=> $\beta = \frac{10^8}{3x10^8} = 0.33 rad$

24. **Compare TE and TM mode**
**TM wave:** Transverse magnetic wave is a wave in which magnetic field strength H is entirely transverse. It has an electric field strength $E_z$ in the direction of propagation and no component of magnetic field strength $H_z$ in the same direction.**TE wave:** Transverse electric wave is a wave in which electric field strength E is entirely transverse. It has a magnetic field strength $H_z$ in the direction of propagation and no component of electric field strength $E_z$ in the same direction.
25. **What is meant by dominant mode? What is the dominant mode for parallel plate waveguides?**
Dominant mode is the mode which has the lowest cut-off frequency. For parallel plate waveguides, it is $TE_{10}$.

26. **What is degenerate mode in rectangular waveguide?**
Some of the higher order modes, having the same cut-off frequency, are called degenerate modes. It is seen that in a rectangular waveguide possible $TE_{nm}$ and $TM_{mn}$ modes (both m≠ 0 and n ≠0 ) are always degenerate.

27. **A wave is propagated in a parallel plane waveguide. The frequency is 6 GHz and the plane separation is 3 cm. Determine the group and phase velocities for the dominant mode. (Nov 2013)** Solution: f = 6 GHz, a = 3cm, Dominant mode = $TE_1$

Cut-off frequency = $\frac{m}{2a\sqrt{\mu\varepsilon}}$ =(1x3x$10^8$)/(2x0.03) =5GHz

$v_p = \frac{\omega}{\beta}$ ; $\beta = \varpi\sqrt{\mu\varepsilon}\sqrt{1-\left(\frac{f_c}{f}\right)^2}$

28. **Identify when an evanescent mode occurs?**
When the operating frequency is lower than the cut-off frequency the propagation constant becomes real ie γ = α . Since the phase shift constant is zero, the wave cannot be propagated and an evanescent mode is identified to occur.
29. **Why rectangular waveguides are preferred over circular waveguide?**
Rectangular waveguides are preferred over circular waveguides because of the following reasons.
Rectangular waveguide is smaller in size than a circular waveguide of the same operating frequency. It does not maintain its polarization through the circular waveguide.
The frequency difference between the lowest frequency on dominant mode and the next mode of a rectangular waveguide is bigger than in a circular waveguide.

30. **What is meant by the dominant mode of a waveguide?**

The cut-off frequency $f_c = \frac{1}{2\sqrt{\mu\varepsilon}}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$ shows that the physical size of the waveguide will determine the propagation of the modes of specific orders determined by m and n. The minimum cut-off frequency is obtained for a guide having dimension a > b, for m = 1,n = 0 Since for $TM_{mn}$ modes, m $\neq 0$ or n $\neq 0$, the lowest order mode possible is $TE_{10}$ and $TM_{11}$ mode, called the dominant mode in a rectangular waveguide for a >b

**31. Explain the impossibility of TEM wave in waveguide.**

Suppose a TEM wave is assumed to exist within a hollow guide of any shape. Then lines of H must lie entirely in the transverse plane. Also in a nonmagnetic material, $\nabla . H = 0$ which requires that the lines of H be closed loops. Therefore, if a TEM exists inside the guide, the lines of H will be closed loops in plane perpendicular to the axis. Now by Maxwell's first equation the magnetomotive force around each of these closed loops must equal the axial current ($J_C$ or $J_D$). In the case of a guide with an inner conductor, example, a coaxial transmission line, this axial current through the H loops is the conduction current in the inner conductor. However, for a hollow waveguide having no inner conductor, this axial current must be a displacement current. But an axial displacement current requires an axial component of E, something not present in a TEM wave. Therefore the TEM wave cannot exist in a single conductor waveguide.

**32. A circular waveguide operated at 11 GHZ has the internal diameter of 4.5 cm. for a $TE_{01}$ mode propagation, calculate free space wavelength and cut-off wavelength. ($(ha)_{01}$= 2.405)**

**Solution:** $\lambda_o = \frac{C}{f} = \frac{3\text{x}10^8}{11\text{x}10^9}$ **= 0.02 m**

$\lambda_C = \frac{C}{f_c}$ **;** $f_c = \frac{h_{nm}}{2\pi\sqrt{\mu\varepsilon}}$ **= 5.1 GHZ ;** $\lambda_C = \frac{3\text{x}10^8}{5.1\text{x}10^9}$ **= 0.0588 m**

**33. Why is $TM_{01}$ mode preferred to the $TE_{01}$ mode in a circular waveguide?**

$TM_{01}$ mode is preferred to the$TE_{01}$ mode, since it requires a smaller diameter for the same cut-off wavelength.

**34. What is the dominant TE and TM mode in rectangular waveguide?**

$TE_{10}$ and $TM_{11}$ mode, are called the dominant mode in a rectangular waveguide for a >b

**35. Justify, why $TM_{01}$ and $TM_{10}$ modes in a rectangular waveguide do not exist. (May 2019).**

$TM_{01}$ and $TM_{10}$ do not exist in a rectangular wave guide. Because no fields are present if neither 'm' or 'n' be zero. (i.e., $E_z = E_y = H_x = H_y = 0$).

**36. Write the expression for cut-off wavelength of the wave which is propagated in between parallel planes.**

$$\lambda_C = \frac{2a}{m}$$

**37. An air-filled rectangular waveguide of inner dimensions 2.286 cm X 1.016 cm in the dominant $TE_{10}$ modes. Calculate the cut-off frequency and phase velocity of a wave in the guide at a frequency of 7 GHz.**

Cut-off frequency, $f_c = \frac{1}{2\sqrt{\mu\varepsilon}}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$

Here, a = 2.286 cm and b = 1.016 cm, m = 1 and n = 0, f = 7 GHz

If air is the dielectric within the rectangular waveguide, $\frac{1}{\sqrt{\mu\varepsilon}} = \frac{1}{\sqrt{\mu_0\varepsilon_0}} = 3x10^8\, m/\sec$

Therefore, $f_c = \frac{1}{2\sqrt{\mu_0 \varepsilon_0}} \sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2} = \frac{C\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}}{2} = 1.98\, GHz$

$V_p = \frac{\omega}{\beta}$ ; $\beta = \varpi\sqrt{\mu\varepsilon}\sqrt{1-\left(\frac{f_c}{f}\right)^2}$ $V_p = \frac{C}{\sqrt{1-\left(\frac{f_c}{f}\right)^2}} = 3.127x10^8\, m/\sec$

**38. Calculate the cut-off frequency of rectangular waveguide whose inner dimensions are a=2.5cm and b=1.5cm operating at $TE_{10}$ mode. (May 2017)**

Cut-off frequency, $f_c = \frac{1}{2\sqrt{\mu\varepsilon}} \sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$

Here, a = 2.5cm and b = 1.5cm, m = 1 and n = 0, f = 6 GHZ

**39. Why is circular or rectangular form used as waveguide?**

Waveguides usually take the form of rectangular or circular cylinders because of its simpler forms in use and less expensive to manufacture.

**40. What is the dominant mode for the TE waves in the rectangular waveguide?** The lowest mode for TE wave is TE10 (m=1 , n=0)

**41. What is the dominant mode for the TM waves in the rectangular waveguide?** The lowest mode for TM wave is TM11(m=1 , n=1)

**42. Which are the non-zero field components for the for the TE10 mode in a rectangular wave guide?**

$H_x$, $H_z$ and $E_y$.

**43. Which are the non-zero field components for the for the TM11 mode in a rectangular waveguide?**

$H_x$, $H_y$, $E_y$ and $E_z$.

**44. Define characteristic impedance in a waveguide**

The characteristic impedance Zo can be defined in terms of the voltage-current ratio or in terms of power transmitted for a given voltage or a given current.Zo (V,I) = V/I

**45. Why TEM mode is not possible in a rectangular waveguide?**

Since TEM wave do not have axial component of either E or H, it cannot propagate within a single conductor waveguide

**46. Explain why TM01 and TM10 modes in a rectangular waveguide do not exist. (NOV/DEC 2016)**

For TM modes in rectangular waveguides, neither m or n can be zero because all the field equations vanish ( i.e., Hx, Hy ,Ey. and Ez.=0). If m=0,n=1 or m=1,n=0 no fields arepresent. Hence TM01 and TM10 modes in a rectangular waveguide do not exist.

**47. What are degenerate modes in a rectangular waveguide?**

Some of the higher order modes, having the same cut off frequency, are called degenerate modes. In rectangular waveguide,$TE_{mn}$ and $TM_{mn}$ modes (both m =0 and n =0) are always degenerate.

**48. What is a circular waveguide?**

A circular waveguide is a hollow metallic tube with circular cross-section for propagating the electromagnetic waves by continuous reflections from the surfaces or walls of the guide.

**49. Why circular waveguides are not preferred over rectangular waveguides?**

The circular waveguides are avoided because of the following reasons:a)The frequency difference between the lowest frequency on the dominant mode and the next mode is smaller than in a rectangular waveguide, with b/a= 0.5b)The circular symmetry of the waveguide may reflect on the possibility of the wave not maintaining its polarization throughout the length of the guide. c) For the same operating frequency, circular waveguide is bigger in size than a rectangular waveguide.

**50. What are the root values for the TM modes?**

The root values for the TM modes are: (ha)01 = 2.405 for TM01

(ha)02 = 5.53 for TM02
(ha)11 = 3.85 for TM11 (ha)12 = 7.02 for TM12ular waveguides are used as attenuators and phase- shifters.

**51. Which mode in a circular waveguide has attenuation effect decreasing with increase in Frequency?**
TE01

**52. What is the dominant mode for TE waves in a circular waveguide?**
The dominant mode for TE waves in a circular waveguide is the TE11 because it has the lowest root value of 1.841

**53. Mention the dominant modes in rectangular and circular waveguides**
For a rectangular waveguide, the dominant mode is TE01 For a circular waveguide, the domina

**54. Why is TM01 mode preferred to the TE01 mode in a circular waveguide?**
TM01 mode is preferred to the TE01 mode in a circular waveguide, since it requires a smaller diameter for the same cut off wavelength. dominant mode is TE11.

**55. What are the performance parameters of microwave resonator?**
The performance parameters of microwave resonator are:
Resonant frequency
Quality factor

**56. What is resonant frequency of microwave resonator?**
Resonant frequency of microwave resonator is the frequency at which the energy in the resonator attains maximum value. i.e., twice the electric energy or magnetic energy

**57. What are cavity resonators?**
Cavity resonators are formed by placing the perfectly conducting sheets on the rectangular or circular waveguide on the two end sections and hence all the sides are surrounded by the Conducting walls thus forming a cavity

**58. What are the types of cavity resonators?**
There are two types of cavity resonators. They are: a) Rectangular cavity resonator b) Circular cavity resonator

**59. Define quality factor of a resonator.**
The quality factor Q is a measure of frequency selectivity of the resonator. It is defined as Q = 2 π x Maximum energy stored / Energy dissipated per cycle = ω W/ P Where W is the maximum stored energy P is the average power loss

## PART B &C

**1. Discuss the propagation of Transverse Electric waves between parallel plates. (Nov/Dec 2021) (Apl/May 2022) (Apl/ May 2023)**
Refer Page. No 471 John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010.

**2. Discuss the propagation of TM waves in a rectangular waveguide with relevant expressions and diagrams for the field components. (Nov/Dec 2010) (Nov/Dec 2012). (Nov/Dec 2022) (Apl/ May 2023)**
Refer Page. No 505- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010

**3. An air filled rectangular Waveguide with dimensions 3 cm× 5 cm allows 10 GHz signal to propagate through it. Calculate the cut off frequency, cut-off wavelength, guide wavelength and the characteristics, impedance of the wave for the $TE_{10}$ mode of propagation (Apl/ May 2023)**
Refer notes

**4. For a frequency of 10GHz and planes separation of 5cm in air, find cut-off frequency, cut-off wavelength, phase velocity and group velocity of the wave (April/May 2019)( APL/MAY 2022)**
Refer Notes

**5. Determine possible modes of propagation for a rectangular waveguide of dimensions 7 cm × 3.1 cm at a frequency of 12 GHz. (NOV/DEC 2021)**
**Refer Notes**

6. **Derive an expression for the transmission of TE waves between parallel perfectly conducting planes for the field components. (April/May 2019)**
   Refer Page. No 479- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010
7. **Write Bessel's differential equation and Bessel function and TM and TE waves in circular waveguides. (Nov/Dec 2018)**
   Refer Page. No 513- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010
8. **A $TE_{10}$ wave at 10 GHz propagates in a brass $\sigma_c$=1.57x$10^7$mhos/m rectangular waveguide with inner dimensions a=1.5 cm and b=0.6 cm, which is filled with $\varepsilon_r$ = 2.25 and $\mu_r$ = 1, loss tangent = 4x$10^{-4}$. Determine (i)the phase constant, (ii)the guide wavelength, (iii)the phase velocity, (iv)the wave impedance, (v) the attenuation constant due to loss in the dielectric, and (vi) the attenuation constant due to loss in the guide walls(Nov/Dec 2018)**
   Refer Notes
9. **Discuss the transmission of TM waves between parallel perfectly conducting planes with necessary expressions.(NOV/DEC 2013)(MAY/JUNE 2018)**
   Refer Page. No 474- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010**.**

10. **An air filled circular waveguide having an inner radius of 1cm is excited in dominant mode at 10GHz.Find**
    i. **The cut-off frequency of the dominant mode at 10 GHz.(b)The guide wavelength and (c)Wave impedance. Also find the bandwidth for operation in the dominant mode only.(MAY/JUNE 2018)**

    Refer Page. No 5.50- Dr.P.Dananjayan, "Transmission Lines and Waveguides",Lakshmi Publications.
11. **Explain the wave behavior in a guiding structures. (MAY/JUNE 2018)**
    Refer Page. No 527- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010.
12. **Explain why TEM waves does not exist in waveguides. (MAY/JUNE 2018)** Refer Page. No 516- John D Ryder, "Networks, lines - and fields", 2nd Edition, Prentice Hall India, 2010.
13. **When dominant mode is transmitted through a circular waveguide, the wavelength measured is to be 13.33cm. The frequency of the microwave signal is 3.75GHz. Calculate a) Cut-off frequency b) Inner radius of guide c) Phase velocity d) Group velocity e) Phase constant f) Wave impedance g) Bandwidth for operation in dominant mode only. (May/June 2017)**
    Refer notes

14. **Discuss the propagation of TE waves in a rectangular waveguide with relevant expressions and diagrams for the field components. (MAY/JUNE 2014) (MAY/JUNE 2016) (NOV/DEC 2013)(NOV/DEC 2017).**
    Refer Page. No 525- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010**.**
15. **Explain the circular cavity resonator and its applications. (NOV/DEC 2016)**
    Refer Page. No 519- John D Ryder, "Networks, lines -and fields", 2nd Edition,Prentice Hall India, 2010
16. **Derive the expression for the field components of TE waves in a circular waveguide.(MAY/JUNE 2016) (MAY/JUNE 2013)**
    Refer Page. No 505- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010**.**
17. **Discuss briefly the attenuation of TE and TM waves between parallel planes.(NOV/DEC 2013)(MAY/JUNE 2014)**
    Refer Page. No 493&494 - John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010**.**
18. **A rectangular waveguide with a 5cm×2cm cross is used to propagate TM11 mode at 10GHz. Determine the cut off wavelength. (NOV/DEC 2010)**
    Refer Notes

## UNIT V RF SYSTEM DESIGN CONCEPTS

Active RF components: Semiconductor basics in RF, bipolar junction transistors, RF field effect transistors, High electron mobility transistors, Fundamentals of MMIC, Basic concepts of RF design, Filters, couplers, power dividers, Amplifier power relations, Low noise amplifiers, Power amplifiers.

### PART-A

1. **State the importance of Low noise amplifier in RF systems (Apl/ May 2023)**
   **A low-noise amplifier** (LNA) is commonly found in all receivers. Its role is to boost the received signal a sufficient level above the noise floor so that it can be used for additional processing. The noise figure of the LNA therefore directly limits the sensitivity of the receiver.
2. **Distinguish between oscillator and Mixer (Apl/ May 2023)**
   Oscillators and mixers are used in heterodyne bat detectors.
   Oscillators generate a signal of a certain frequency.
   Mixers can multiply two signals (bat signal with a local oscillator signal) to produce an audible difference tone

3. **Define cutoff frequency of microwave transistor (nov/ dec 2022)**
   The cutoff frequency fT is an important figure of merit for transistors, and is defined as the frequency at which β goes to unity.
4. **Define the condition for stability in circuit design. (NOV/DEC 2021) (nov/ dec 2022)**

$$K = \frac{1-|S_{11}|^2 - |S_{22}|^2 + |S_{11}S_{22} - S_{12}*S_{21}|}{2|S_{12}S_{21}|} > 1 \quad and \quad |S_{11}S_{22} - S_{12}S_{21}| < 0$$

5. **Differentiate between PN junction and Schottky contact (Apl/May 2022)**
   Schottky diode offers fast switching action and has a low forward voltage drop. As we are aware that in a PN junction diode, p-type and n-type are joined together to form a PN junction. Whereas, in a Schottky diode metals like platinum or aluminum are used instead of P type semiconductors.
6. **Define intermodulation distortion (Apl/May 2022)**
   Intermodulation Distortion (IMD): When two signals mix in non-linear circuits or devices, new frequency components are created that are not in the original signal. The resulting signal error is called intermodulation distortion, or IMD.

7. **Mention the requirements and applications of low noise amplifiers. (NOV/DEC 2021)**
   For low noise, a high amplification is required for the amplifier in the first stage. Therefore, junction field-effect transistors (JFETs) and high-electron-mobility transistors (HEMTs) are often used. They are driven in a high-current regime, which is not energy-efficient, but reduces the relative amount of shot noise. It also requires input and output impedance matching circuits for narrow-band circuits to enhance the gain LNAs are used in communications receivers such as in cellular telephones, GPS receivers, wireless LANs (WiFi), and satellite communications.

8. **How do we implement RF system designs?**
   The implementation of RF system designs can be accomplished in a number of different semiconductor technologies. While standard silicon is preferred at low frequency, due to its widespread use in integrated circuits, materials based on SiGe, GaAs, InP are used for high to extremely high operating frequencies.

9. **Define Fermi energy level.**
   Fermi energy level indicates the energy level that has a 50% probability of being occupied by an electron.
10. **Define diffusion current.**
    The physical contact of a p – type with an n – type semiconductor leads to the pn – junction. Because of the difference in the carrier concentrations between the two types of semiconductors, a current flow will be

initiated across the interface. This current is commonly known as diffusion current and is composed of electrons and holes.

**11. Define PIN diode.**

**PIN diode** is a diode with a wide, undoped intrinsic semiconductor region between a p-type and an n-type semiconductor region. The p-type and n-type regions are typically heavily doped because they are used for ohmic contacts.

**7. What is a Schottky diode?**

The **Schottky diode** also known as **Schottky barrier diode** or **hot-carrier diode**, is a semiconductor diode formed by the junction of a semiconductor with a metal. It has a low forward voltage drop and a very fast switching action. It has a different reverse-saturation current mechanism: it is determined by the thermionic emission of the majority carriers across the potential barrier. For instance, the Schottky diode has a typical reverse – saturation current density on the order of $10^{-6}$ A/cm$^2$ compared with $10^{-11}$ A/cm$^2$ of a conventional Si-based pn-junction diode.

**8. What are the applications of PIN diode?**

PIN diodes find applications as high – frequency switches and variable resistors (attenuators) in the range from 10 kilo ohm to less than 1 ohm for RF signals up to 50 GHz.

**9. Define varactor diode and list down its uses.**

Varactor diode is a ***diode*** whose internal capacitance varies with the variation of the reverse voltage. It is used for storing the charge. The varactor diode always works in reverse bias, and it is a voltage-dependent semiconductor device.

Varactors are used as voltage-controlled capacitors. They are commonly used in voltage controlled oscillators, parametric amplifiers, and frequency multipliers.

**10. What is an IMPATT diode? Write down its applications.**

An **IMPATT diode** (**IMP**act ionization **A**valanche **T**ransit-**T**ime diode) is a form of high-power semiconductor diode used in high-frequency microwave electronics devices. They have negative resistance and are used as oscillators and amplifiers at microwave frequencies. They operate at frequencies of about 3 and 100 GHz, or higher. The main advantage is their high-power capability; single IMPATT diodes can produce continuous microwave outputs of up to 3 kilowatts, and pulsed outputs of much higher power. These diodes are used in a variety of applications from low-power radar systems to proximity alarms.

**11. Define transition frequency.**

The transition frequency also known as cut-off frequency of a microwave BJT is an important figure of merit since it determines the operating frequency at which the common emitter, short circuit current gain decreases to unity.

**12. What is Gunn Effect?**

Above some critical voltage corresponding to an electric field of 2000-4000 v/cm the current in every specimen became a fluctuating function of time. The frequency of oscillation was determined mainly by the specimen and not by the external circuit. The length of the specimen is inversely proportional to the frequency of oscillation. Some of materials like GaAs, InP, CdTe exhibit a negative differential mobility when biased above a threshold value of the electric field.

**13. Define TRAPATT diode.**

The TRAPATT or TRApped, Plasma Avalanche Triggered Transit diode belongs to the same basic family as the IMPATT diode but it provides a number of advantages in some applications. The TRAPATT diode is normally used as a microwave oscillator. It has the advantage of a greater level of efficiency when compared to an IMPATT microwave diode. Typically the DC to RF signal conversion efficiency may be in the region of 20% to 60% which is particularly high.

**14. Define BARITT diode.**

The **BARITT diode** (barrier injection transit-time) is a high frequency semiconductor component of microelectronics. The BARITT diode uses injection and transit-time properties of minority carriers to produce a negative resistance at microwave frequencies. About the biased forward boundary layer, the minority carriers are injected. There is no avalanche breakdown instead. Consequently, both the phase shift and the output power is substantially lower than in a IMPATT diode.

**15. What are RF Field effect transistors?**

Unlike BJTs, field effect transistors (FETs) are unipolar devices, meaning that only one carrier type, either holes (p – channel ) or electrons (n – channel) , contributes to the current flow through the channel. Moreover, the FET is a voltage – controlled device. A variable electric field controls the current flow from the source to the drain by changing the applied voltage on the gate electrode.

**16. Define SOAR.**

The safe operating area (SOAR) is defined as a set of biasing points where the transistor can be operated without risk of unrecoverable damage to the device.

**17. What are the basic characteristics of mixers?**

Mixers are commonly used to multiply signals of different frequencies in an effort to achieve frequency translation. The motivation for this translation stems from the fact that filtering out a particular RF signal channel centered among densely populated, narrowly spaced neighboring channels would require extremely high – Q filters.

**18. What is the use of HEMT?**

High electron mobility transistors are well suited for high performance mixer circuits due to their low noise, high frequency range and superior large-signal behavior.

**19. List down the classification of FETs.**

FETs are classified according to how the gate is connected to the conducting channel. Specifically, the following four types are used:

**Metal Insulator Semiconductor FET**: the gate is separated from the channel through an insulation layer. The MOSFET belongs to this class.

**Junction FET:** This type relies on a reverse-biased pn-junction that isolates the gate from the channel.

**Metal Semiconductor FET** (MESFET): If the reverse –biased pn-junction is replaced by a Schottky contact, the channel can be controlled just as in the JFET case.

**Hetero FET**: As the name implies, heterostructures utilize abrupt transitions between layers of different semiconductor materials. Examples are GaAlAs to GaAs or GaInAs to GaAlAs interfaces. The **high electron mobility transistor** (HEMT) belongs to this class.

**20. Name the parameters to be considered for the design of a suitable mixer.**

Conversion loss or gain between the RF and IF signal powers.
Noise figure
Isolation between LO and RF signal ports
Nonlinearity

**21. Define conversion loss of a mixer.**

The conversion loss (CL) of a mixer is defined in dB as the ratio of supplied input power to the obtained IF power.

$$CL[dB] = 10\log\left(\frac{P_{RF}}{P_{IF}}\right)$$

**22. List the characteristics of amplifiers.**

The parameters of amplifier includes (i) Gain and gain flatness (in dB) (ii) Operating frequency and bandwidth (in Hz) (iii) Output power (in dBm) (iv) Power supply requirements (in V and A) (v) Input and output reflection coefficients (VSWR) and (vi) Noise figure (in dB).

**23. What is transducer power gain?**

Transducer power gain $G_T$ which quantifies the gain of the amplifier placed between source and load that is power delivered to the load to available power from the source

**24. Define available power gain.**

The available power gain is defined as the ratio of the power available from the network to the power available from the source.

**25. Define operating power gain.**

The power gain (operating power gain) is defined as the ratio of the power delivered to the load to power supplied to the amplifier.

**26. What are the factors affecting amplifier performance.**

The factors affecting amplifier performance are Inter modular distortion, harmonics, feedback, and heating effects.

**27. Define noise figure of a two port network. (Dec 2018)**

Noise figure F of a two port network is defined as the ratio of the input Signal to Noise Ratio to the output Signal to Noise Ratio.

**28. What are stabilization methods?**

The stabilization methods are

Stabilization of input port through series resistance or shunt conductance

Stabilization of output port through series resistance or shunt conductance

**29. Define unconditional stability?**

Unconditional stability refers to the situation where the amplifier remains stable for any Passive source and load at the selected frequency and bias condition.

**30. What is the need of Rollett factor, K? Write its expressions. (May 2018)**

Rollett's **stability factor** is a one way to get an indication of whether a problem is there or not. **K-factor** that is greater than one than the amplifier is unconditionally **stable**. If **K** is less than 1, problem is there. The best amplifiers usually have **K-factor** as low as 1.5 in the band.

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

**31.** $\Delta = S_{11}S_{22} - S_{12}S_{21}$

**32. Write the necessary and sufficient conditions for an amplifier to be unconditionally stable (May 2019)**

Unconditional stability refers to the situation where the amplifier remains stable for any passive source and load at the selected frequency and bias conditions. For $|S_{11}| \prec 1$ and $|S_{22}| \prec 1$, it is stated that the stability circles have to reside completely outside the magnitudes of source reflection co-efficient = 1 & the load reflection co-efficient = 1.

**33. State the non linearities available in a RF circuit.**

a. Harmonic distortion (2) Gain compression (3) Cross modulation and (4) Intermodulation

**34. Define harmonic distortion.**

If a sinusoid is applied to a non-linear system, the output generally exhibits frequency components that are integral multiples of the input frequency. These higher order frequency terms available at the output are termed as harmonics.

**35. Define 1 dB compression point.**

1 dB compression point is defined as the input signal level that causes the small signal gain to drop by 1 dB. If plotted on a log-log scale as a function of the input level, the output level falls below its ideal value by 1 dB at the 1 dB compression point.

**36. List out the types of low noise amplifiers.**

Single ended LNA, Differential LNA

**37. Define intermodulation**

When two signals with different frequencies are applied to a non-linear system, the output in general exhibits some components that are not harmonics of the input frequencies called intermodulation**.**

**38. Define SFDR.**

Spurious free dynamic range (SFDR) is defined as the signal to noise ratio corresponding to the input amplitude at which an undesired product (IM3) just equals the noise power, and thus it is the maximum dynamic range that an amplifier can exhibit.

**39. What is the function of a voltage controlled oscillator?**

The output frequency of an oscillator can be varied by the input voltage, then the oscillator is labelled as voltage controlled oscillator. VCOs are utilized in down conversion RF receivers.

**40. State the types of mixers.**

Single – ended mixer, single - balanced mixer, double -balanced mixer, integrated active mixers and image reject mixer.

**41. What are the differences between transferred electron devices and avalanche transit time devices**

TED's are bulk devices having no junction or gates. TED's are fabricated from

a. compound semiconductors such as GaAs, Inp(Indium phosphate) or CdTe (Cadmium telluride) as against Ge and Si of transistors. Ted's operate with hot electrons whose energy is very much greater than the thermal energy. Avalanche transit time devices are p-n junction diode with highly doped p and n regions. They could produce a negative resistance at microwave frequencies by using a carrier impact ionization avalanche breakdown and carriers drift in the high field intensity region using reverse biased condition

**42. What are the advantages and disadvantages of parametric amplifiers**

a. Noise figure is less, in the range 1-2 dB
b. Bandwidth of the parametric amplifier is small due to the presence of tuned circuits .Bandwidth can be increased by stagger tuning
c. The gain is limited(20-80 dB ) by the stabilities of pump source and time varying capacitance

**43. Name two materials that are used in schottky barrier diode**

i. Schottky diodes are metal semiconductor barrier diodes .the diodes is constructed

b. on a thin silicon ($n^+$ type )substrate by growing epitaxially on n-type active layer of about 2micron thickness. A thin $SiO_2$ layer is grown thermally over this active layer. Metal semiconductor junction is formed by depositing metal over $SiO_2$

**44. Mention two basic differences between IMPATT and TRAPATT**

| | **IMPATT** | **TRAPATT** |
|---|---|---|
| **Operating frequency** | **0.5-100GHz** | **1-10GHz** |
| **Harmonics** | **Less** | **Strong** |
| **Noise figure** | **High 30Db** | **High 60dB** |
| **Basic semiconductors** | **Si,Ge,GaAs or InP** | **Si** |

**45. Give any two differences between microwave transistors and transferred electron devices**

TED's are bulk devices having no junction, or gates as compared to microwave

a. transistors which operate with either junction or gates. TED's are fabricated from
b. compound semiconductors such as GaAs, Inp(Indium phosphate) or CdTe (Cadmium
c. telluride) as against Ge and Si of transistors.

i. TED's operate with hot electrons whose energy is very much greater than the

d. thermal energy. Transistors operate with warm electrons is not much greater than their
**e.** thermal energy (0.026 eV at room temperature).

**46. What is the necessary condition for an IMPATT diode to produce oscillations?**

a. The maximum negative resistance occurs at drift transit angle $\theta = \omega t_d = n$.

i. The fundamental frequency of microwave oscillation is,

ii.

$$\theta = \omega\tau = \frac{\omega L}{v_d}$$

$$f = \frac{1}{2\tau} = \frac{v_d}{2L}$$

b. For a given load and bias stable oscillations are obtained when $Rd=R_L$

**47. What are the different modes of oscillation for the Gunn diodes?**

Two principal modes of operation that result in microwave oscillations in Gunn diodes are Gunn mode or transit-time mode(TT) and limited space charge(LSA) modes and others modes are Quenched domain mode and delayed mode

**48. Explain about quenched domain mode.**

i. If the resonant circuit is tuned to a value slightly above that of TT mode, the

b. dipole domain will be quenched before it arrives at the anode by the negative swing of
c. the oscillation voltage but the Gunn diode will operate mostly like Gunn mode.

**49. What is transferred electron effect**

i. TED's are bulk devices having no junction or gates. TED's are fabricated from

b. compound semiconductors such as GaAs, Inp(Indium phosphate) or CdTe (Cadmium
c. telluride) as against Ge and Si of transistors. Ted's operate with hot electrons whose
d. energy is very much greater than the thermal energy

**50. What are the characteristics of ideal substrate materials**

High dielectric constant
Low dissipation factor or loss tangent
High purity and constant thickness

High thermal conductivity
High resitivity and dielectric strength

**51. What is meant lumped element MIC's**

a. Lumped elements in MIC's means the capacitors and inductors microwave integrated circuit

**52. State the various stages in epitaxial layer growth**

(i) IVapour phase epitaxy
(ii) Molecular beam Epitaxy
(iii) Liquid layer epitaxy

**53. Define Voltage controlled Oscillators.**

A Voltage controlled oscillator is an oscillator with an output signal whose output can be varied over a range, which is controlled by the input DC voltage. It is an oscillator whose output frequency is directly related to the voltage at its input.

## PART B&C

1. **Explain the power amplifiers used at RF frequencies. (NOV/DEC 2021) (APL/MAY 2022) (Apl/ May 2023)**
   Refer Page. No 620- Reinhold Ludwig &Gene Bogdanov, "RF Circuit Design", 2nd Edition
2. **Discuss in brief construction and functionality of high electron mobility transistor. (Apl/ May 2023)**
   Refer Page. No 342- Reinhold Ludwig &Gene Bogdanov, "RF Circuit Design", 2nd Edition
3. **Explain in detail the types of mixers in RF circuits. (Apl/ May 2023)**
   Refer Page. No 622- Reinhold Ludwig &Gene Bogdanov, "RF Circuit Design", 2nd Edition
4. **Explain the concept of Voltage controlled Oscillators with neat diagram. (Apl/ May 2023)**
   Refer Page. No 604- Reinhold Ludwig &Gene Bogdanov, "RF Circuit Design", 2nd Edition
5. **Derive stability conditions for a microwave amplifier. (NOV/DEC 2022)**
   Refer Page. No 492- Reinhold Ludwig &Gene Bogdanov, "RF Circuit Design", 2nd Edition
6. **Explain the frequency domain considerations and design of mixer. (NOV/DEC 2022)**
   Refer Page. No 612- Reinhold Ludwig &Gene Bogdanov, "RF Circuit Design", 2nd Edition

7. **Explain the working of FET at RF frequencies. (NOV/DEC 2021) (APL/MAY 2022)**
   Refer Page. No 330- Reinhold Ludwig &Gene Bogdanov, "RF Circuit Design", 2nd Edition
8. **Write short notes on (a) Schottky diode (b) PIN diode (c) Varactor diode**
   Refer Page. No 299,307- Reinhold Ludwig &Gene Bogdanov, "RF Circuit Design", 2nd Edition
9. **Write short notes on (a) IMPATT diode (b) TRAPATT diode (c) BARRITT diode**
   Refer Page. No 310,313- Reinhold Ludwig &Gene Bogdanov, "RF Circuit Design", 2nd Edition
10. **Explain in detail about tunnel and Gunn diodes.**
    Refer Page. No 310,313- Reinhold Ludwig &Gene Bogdanov, "RF Circuit Design", 2nd Edition
11. **Discuss in brief construction and functionality of bipolar junction transistor.**
    Refer Page. No 314- Reinhold Ludwig &Gene Bogdanov, "RF Circuit Design", 2nd Edition
12. **Explain the construction and functionality of RF Field effect transistors.**
    Refer Page. No 330- Reinhold Ludwig &Gene Bogdanov, "RF Circuit Design", 2nd Edition
13. **With reference to RF transistor amplifier, discuss the considerations for stability and gain.**
    Refer Page. No 492,504- Reinhold Ludwig &Gene Bogdanov, "RF Circuit Design", 2nd Edition
14. **Investigate the stability regions of a transistor whose S-parameters are recorded as follows: $S_{12}=0.2\angle -10^\circ$; $S_{11}=0.7\angle -70^\circ$; $S_{21}=5.5\angle 85^\circ$; $S_{22}=0.7\angle -45^\circ$; at 750 MHz.**
15. **State and formulate the transducer power gain, available power gain and operating power gain of a microwave amplifier in terms of S parameters and different reflection coefficient.**
    Refer Page. No487, 488,489,- Reinhold Ludwig &Gene Bogdanov, "RF Circuit Design", 2nd Edition
16. **Explain the stability considerations of RF Transistor amplifier.**
    Refer Page. No 492- Reinhold Ludwig &Gene Bogdanov, "RF Circuit Design", 2nd Edition
17. **Explain the operation of high power amplifier with neat diagram**
    Refer Page. No 492- Reinhold Ludwig &Gene Bogdanov, "RF Circuit Design", 2nd Edition

**B.E./B.Tech. Degree Examination,**
**APRIL/MAY 2023**
**Sixth Semester**
**EC8651 – Transmission Lines and RF Systems**
**(Regulations 2017)**
**PART-A**

1. **Define characteristic impedance**
The characteristic impedance or surge impedance (usually written Z0) of a uniform transmission line is the ratio of the amplitudes of voltage and current of a single wave propagating along the line; that is, a wave travelling in one direction in the absence of reflections in the other direction. Alternatively, and equivalently, it can be defined as the input impedance of a transmission line when its length is infinite.
General expression for the characteristic impedance of a transmission line is:

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

2. **What is distortion less line? Give the condition for distortion-lees transmission line.**
A distortion less line is one which has neither frequency nor delay distortion. The attenuation constant and velocity of propagation cannot be functions of frequency. The condition for a distortion less line is, LG = RC

3. **Give the relationship between standing wave ratio and reflection coefficient**

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

4. **Find the input impedance of an open circuited line.**

The input impedance of a line of length $l$ is

$$Z_s = Z_0 \left( \frac{Z_R \cosh \gamma l + Z_0 \sinh \gamma l}{Z_0 \cosh \gamma l + Z_R \sinh \gamma l} \right).$$

For open circuit case, $Z_R = \infty$.

$$Z_{oc} = Z_0 \frac{\cosh \gamma l}{\sinh \gamma l}$$

$$= Z_0 \coth \gamma l.$$

5. **Mention the advantages of double stub matching**
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

6. **A quarter wave transformer is used to match a 100Ω load to a 50Ω transmission line at 2 GHz. Find the characteristic impedance of a quarter wave transformer.**
Solution: The characteristic impedance of a quarter wave transformer, $R_0^{'} = \sqrt{R_A R_0}$

**=√(100×50) =22.36Ω**

7. **Why TEM waves are not possible in rectangular waveguide**
   Suppose a TEM wave is assumed to exist within a hollow guide of any shape. Then lines of H must lie entirely in the transverse plane. Also in a nonmagnetic material, ∇. H = 0 which requires that the lines of H be closed loops. Therefore, if a TEM exists inside the guide, the lines of H will be closed loops in plane perpendicular to the axis. Now by Maxwell's first equation the magnetomotive force around each of these closed loops must equal the axial current ($J_C$ or $J_D$). In the case of a guide with an inner conductor, example, a coaxial transmission line, this axial current through the H loops is the conduction current in the inner conductor. However, for a hollow waveguide having no inner conductor, this axial current must be a displacement current. But an axial displacement current requires an axial component of E, something not present in a TEM wave. Therefore the TEM wave cannot exist in a single conductor waveguide.

8. **Consider an air-filled rectangular waveguide with a cross section of 5cm ×3cm. Find the cutoff frequency of $TE_{11}$ mode**

   Cut-off frequency, $$f_c = \frac{1}{2\sqrt{\mu\varepsilon}}\sqrt{\left(\frac{m}{a}\right)^2+\left(\frac{n}{b}\right)^2}$$

   Here, a = 0.05m and b = 0.02m, m = 1 and n = 1, f = 10 GHZ

   If air is the dielectric within the rectangular waveguide, $\frac{1}{\sqrt{\mu\varepsilon}} = \frac{1}{\sqrt{\mu_0\varepsilon_0}} = 3\text{x}10^8\ \text{m/sec}$

   Therefore, $$f_c = \frac{1}{2\sqrt{\mu_0\varepsilon_0}}\sqrt{\left(\frac{m}{a}\right)^2+\left(\frac{n}{b}\right)^2} = \frac{C\sqrt{\left(\frac{m}{a}\right)^2+\left(\frac{n}{b}\right)^2}}{2}$$

   $$\frac{C}{f_c} = \frac{2}{\sqrt{\left(\frac{1}{0.05}\right)^2+\left(\frac{1}{0.02}\right)^2}} = 0.037m$$

   ,Cut-off wavelength, $\lambda_C = 0.037\text{m}$

9. **State the importance of Low noise amplifier in RF systems**
   **A low-noise amplifier** (LNA) is commonly found in all receivers. Its role is to boost the received signal a sufficient level above the noise floor so that it can be used for additional processing. The noise figure of the LNA therefore directly limits the sensitivity of the receiver.

10. **Distinguish between oscillator and Mixer**
    Oscillators and mixers are used in heterodyne bat detectors.
    Oscillators generate a signal of a certain frequency.
    Mixers can multiply two signals (bat signal with a local oscillator signal) to produce an audible difference tone

PART B-15×13=65 mark

11. (a) Obtain the general transmission line equation for the voltage and current at any point on a transmission line.
Refer Page No:236- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010

Or

b) (i) What is a loading? Specify the types of loading in transmission lines
Refer Page No:249- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010

(ii)Briefly explain about reflection factor and reflection loss.
Refer Page No:265- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010

12. (a) (i) Examine the voltage and currents at any point on the dissipation less line
Refer Page. No 291- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010

(ii) Obtain the variation of input impedance along open and short-circuited lines with relevant graphs
Refer Page. No 297- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010

Or

(b) Explain in detail about the wavelength and VSWR measurement of the transmission line
Refer Page. No 287- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010

13. (a) A load of 40-70 is connected to a 100 Ω lossless transmission line of length 0.3 λ. Find the following parameters using smith chart
(i) Reflection Coefficient at the source and load.
(ii) Standing wave ratio
(iii) Input impedance
Refer notes

Or

(b) Describe the single stub and double stub impedance matching procedure with appropriate transmission line parameters.
Refer Page. No 331&333- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010

14. (a) Derive the Field components for Transverse Electric (TE) Mode of propagation in a parallel Plane wave guide
Refer Page. No 471 John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010**.**

Or

(b) In a rectangular wave guide find the transverse field components for Transverse Magnetic (TM) Model of propagation
Refer Page. No 505- John D Ryder, "Networks, lines -and fields", 2nd Edition, Prentice Hall India, 2010

15. (a) Write short notes on the following
(i) Power amplifiers and power gain relations.
Refer Page. No 620- Reinhold Ludwig &Gene Bogdanov, "RF Circuit Design", 2nd Edition

(ii) High Electron Mobility Transistor

Refer Page. No 342- Reinhold Ludwig &Gene Bogdanov, "RF Circuit Design", 2nd Edition

Or

(b) (i) Examine the Linearity, conversion gain, and isolation parameter of an RF mixer
Refer Page. No 622- Reinhold Ludwig &Gene Bogdanov, "RF Circuit Design", 2nd Edition

(ii) Explain the basic RF design concepts of Voltage controlled oscillator
Refer Page. No 604- Reinhold Ludwig &Gene Bogdanov, "RF Circuit Design", 2nd Edition

PART C- 15 marks)

16. (a) An antenna with an impedance of 40+30j Ω is to be matched to a 100Ω lossless line with a shorted stub. Using smith chart find all possible solutions to determine

(iii) The distance between the stub and antenna
(iv) The stub length
Refer notes

Or

(b) An air filled rectangular Waveguide with dimensions 3 cm× 5 cm allows 10 GHz signal to propagate through it. Calculate the cut off frequency, cut-off wavelength, guide wavelength and the characteristics, impedance of the wave for the $TE_{10}$ mode of propagation
Refer notes.