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DEPARTMENT OF ECE

EC8651– TRANSMISSION LINES AND RF SYSTEMS

QUESTION BANK

(FOR II B.E ECE)

EC8651 - TRANSMISSION LINES AND RF SYSTEMS

UNIT I - TRANSMISSION LINE THEORY

1. **Define – Characteristic Impedance** **[M/J – 06], [N/D – 06]**

Characteristic impedance is defined as the impedance of a transmission line measured at the sending end. It is given by

$$Z_0 = \sqrt{Z/Y}$$

where Z = R + jωL is the series impedance Y = G + jωC is the shunt admittance

2. **State the line parameters of a transmission line.**

The line parameters of a transmission line are resistance, inductance, capacitance and conductance.

- Resistance (R) is defined as the loop resistance per unit length of the transmission line. Its unit is ohms/km.
- Inductance (L) is defined as the loop inductance per unit length of the transmission line. Its unit is Henries/km.
- Capacitance (C) is defined as the shunt capacitance per unit length between the two transmission lines. Its unit is Farad/km.
- Conductance (G) is defined as the shunt conductance per unit length between the two transmission lines. Its unit is mhos/km.

3. **What are the secondary constants of a line?**

The secondary constants of a line are

i. Characteristic impedance, $Z_0 = \sqrt{Z/Y}$

ii. Propagation constant, $\gamma = \alpha + j\beta$

4.Why the line parameters are called distributed elements?

- The line parameters R, L, C and G are distributed over the entire length of the transmission line. Hence they are called distributed parameters. They are also called primary constants.

4. **What is an infinite line?** **[M/J – 12], [A/M – 04]**

An infinite line is a line where length is infinite. For an infinite line, the input impedance is equal to its characteristic impedance. A finite line, which is terminated by characteristic impedance is also called infinite line.

5. **Define – Propagation Constant** **[N/D – 07], [M/J – 09]**

Propagation constant is defined as the natural logarithm of the ratio of the sending end current or voltage to the receiving end current or voltage of a line. It gives the manner in which the wave is propagated along the line. It specifies the variation of voltage and current in the line as a function of its length.

6. **How does frequency distortion occur in a line?** **[M/J – 07]**

When signals having many frequency components are transmitted along a line, different frequency components have different attenuations. Hence the receiving end waveform will not be identical with the input waveform at the sending end. This type of distortion is called frequency distortion.

7. **What is an equalizer in transmission line?** **[A/M – 05]**

An equalizer is a network whose frequency and phase characteristics are adjusted to the inverse the line. This results in a uniform frequency response over the desired frequency band. Hence the attenuation is equal for all the frequencies.

8. **What is delay distortion?** **[A/M – 11], [M/J – 06], [M/J – 07]**
When a signal having many frequency components is transmitted along a line, all the components will not have same transmission time, some components of the signal get delayed more than the others. So the receiving end signal and sending end signal will not be identical. This type of distortion is called delay distortion.
9. **What is a distortion less line?** **[A/M – 10]**
A transmission line, which has neither frequency distortion nor phase distortion is called a distortion less line.
10. **What is the condition for a distortion less line?** **[M/J – 09]**
The condition for a distortion less line is RC = LG.
where, R - Resistance
C - Capacitance L
- Inductance G -
Conductance
11. **What is a finite line and state its significance?**
A finite line is a line in which the length of the line is finite. Its input impedance is equal to its characteristic impedance. ($Z_s = Z_0$)
12. **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.
13. **What is meant by line distortion?**
If the output waveform and the corresponding input waveform of a transmission line are not identical, it is called line distortion.
14. **What are the different types of line distortions?**
The different types of line distortions are
    i. Frequency distortion
    ii. Phase or delay distortion
15. **How is the frequency distortion avoided in a transmission line?**
The frequency distortions can be avoided using the following methods:
    i. The attenuation constant α should be made independent of frequency
    ii. By placing equalizers at the line terminal
16. **How is distortion avoided in a telephone line?**
Distortion is avoided in a telephone line by decreasing R/G ratio or by increasing L/C ratio.
17. **What is loading?** **[N/D – 04]**
Loading is the process of increasing the inductance value of the line by placing lumped inductors at specific intervals along the line. This avoids distortion.
18. **What are the different types of loading?**
The different types of loading are
    i. Continuous loading
    ii. Patch loading
    iii. Lumped loading
19. **What is continuous loading?**
Continuous loading is the process of increasing the inductance of a line by placing an iron core or a magnetic tape over the conductor of the line.
20. **What is patch loading?**
Patch loading is the process of using sections of continuously loaded cables separated by sections of unloaded cables. This increases the inductance value of the line.
21. **What is lumped loading?**
Lumped loading is the process of increasing the inductance of a line by placing lumped inductors at specific intervals along the line.
22. **What is the purpose of impedance matching?**

If the load impedance is not equal to the source impedance, then all the power that is transmitted from the source will not reach the load end and hence some power is wasted. For proper maximum power transfer, the impedance in the sending and receiving ends are matched.

23. **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 characteristic impedance
24. **What are the conditions for a perfect line?**
For a perfect line, the resistance and the leakage conductance values are neglected. The condition for a perfect line is R = G = 0.
25. **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 is also called flat line.

PART-B

1. Derive the conditions for minimum attenuation in the distortion less transmission line.**(Nov/Dec 2016)**
2. Explain in detail about the reflection on a line not terminated in its characteristic impedance Zo.**(Nov/Dec 2016).**
3. Derive the transmission line equation and hence obtain the expression for voltage and Current on a transmission line.**(April/May 2016)**
4. Prove that an infinite line equal to finite line terminated in its characteristic impedance.**(April /May 2016)**
5. A communication link has R = 10.4 ohm/km, L = 3.67 mH/km, G = 0.08 μmho/km and C = 0.0083μF/km. Determine the characteristic impedance, propagationconstant, phase constant, velocity of propagation, sending end current and receiving end current for given frequency f = 1kHz, sending end voltage is 1 volts and transmission line length is 100km.**(Nov/Dec 2016)**
6. Derive the expressions for input impedance of open&short circuited lines.**(Nov/Dec 2015)**
7. A telephone cable 64 km long has a resistance of 13 ohms/km and a capacitance of 0.008 micro farad/km. Calculate attenuation constant, velocity and wavelength of the line at 1000 HZ. (Nov/Dec 2015) 8. A 2 meter long transmission line with characteristic impedance of 60+j40 ohm is operating at rad= ω10 /sec 6 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.**(Nov/Dec 2015)**

UNIT II - HIGH FREQUENCY TRANSMISSION LINES

1. **What is dissipation less line?** **[A/M – 11]**
A transmission line is called dissipation less line if the resistance of the line is negligible compare to other parameters of the line.
2. **What are the assumptions for the analysis of radio frequency line?**
The following assumptions are made for the analysis of radio frequency line
    i. Due to the skin effect, the currents are assumed to flow on the surface of the conductor
    ii. The leakage conductance (G) is zero
    iii. The resistance R increases with $\sqrt{f}$ while inductance L increases with f. Hence L>>R.
3. **What is the nature and value of Z_0 for the dissipation less line?**
For the dissipation less line, the Z_0 is purely resistive and it is given by $\omega Z_0 = R_0 = \sqrt{L/C}$
4. **What are nodes and antinodes on a line?**

Nodes are the points over the line where magnitude of voltage or current is zero. Antinodes are the points over the line magnitude of voltage or current is maximum.

5. **Define – Standing Wave Ratio** **[N/D – 11], [M/J – 07]**

Standing wave ratio is the ratio of the maximum to minimum magnitude of voltages or currents over a line.

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

6. **What is the relationship between standing wave ratio and reflection coefficient? [M/J– 2012]**

The relationship between standing wave ratio and reflection coefficient is given by

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

7. **Define – Reflection Coefficient** **[N/D – 07]**

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

Reflection coefficient, K = Reflected voltage at load/Incident voltage at the load K = V_r/V_i

8. **Define – Reflection Loss** **[M/J – 06, A/M – 08]**

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

9. **Define – Insertion Loss** **[N/D – 06, M/J – 07]**

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 an insertion.

Insertion Loss = $\frac{\text{Current flowing in the load without insertion of the network}}{\text{Current flowing in the load with insertion of the network}}$

PART –B

1. What is frequency warping in Bilinear transformation?**(April / May 2016)**
2. Find the sending end line impedance for a HF line having characteristic impedance of 50 Ω. The line is of length (1.185λ) and is terminated in a load of (110 + j80) Ω. **(Nov/Dec 2016).**
3. Derive the line constants for a line of zero dissipation**.(April /May 2016)**
4. Discuss in detail about the variation of input impedance along open and short circuit lines with relevant graphs. **(April /May 2016**).
5. 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**. (April /May 2016).**
6. Describe an experimental set up for the determination of VSWR of an RF transmission. . **(Nov/Dec 2016).**
7. Briefly explain on a) Standing wave b) Reflection loss. **(Nov/Dec 2016).**
8. Derive the expression that permit easy measurements of power flow on a line of negligible losses. **(Nov/Dec 2015)**

UNIT III – IMPEDANCE MATCHING IN HIGH FREQUENCY LINES

1. **What is the use of an eighth wave line?** **[N/D – 06]**

An eighth wave is used to obtain a magnitude match between a resistance of any value with source of internal resistance R_0.

2. **Why is a quarter wave line called an impedance inverter?** **[N/D – 03]**
A quarter wave line called an impedance inverter because the line can transform a low impendence in to a high impedance and vice versa.
3. **What is the significance of a half wavelength line?** **[M/J – 07]**
The significance of a half wavelength line is to connect load to a source where the load source cannot be made adjacent.
4. **List the applications of the smith chart.** **[M/J – 12]**
The applications of the smith chart are:
   i. It is used to find the input impendence and input admittance of the line
   ii. The smith chart also used for lossy transmission lines
   iii. To implement single stub matching
5. **Why is double stub matching preferred over single stub matching?**
[M/J – 12], [A/M – 05]
Double stub matching is preferred over single stub matching due to the disadvantages of single stub matching.
   i. 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.
   ii. 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.
6. **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.
7. **What is the input impendence of an eighth wave line terminated in a pure resistance R_R?**
The input impendence of an eighth wave line terminated in a pure resistance R_R is given by $Z_{in} = R_0 [(R_R + jR_0) / (R_0 + jR_R)]$
8. **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.
9. **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:
   i. Easy in constructions
   ii. Lower loss of energy due to radiation
   iii. Effectively stopping all field propagation
10. **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 the length of the stub.
11. **What is called double stub matching?**
Double stub matching is the method of impedance matching which has two stubs and the locations of the stub are arbitrary.
12. **Why an open line is not frequently employed for impedance matching?**
An open line is rarely used for impedance matching because of radiation losses from the open end due to capacitance effects and the difficulty of a smooth adjustment of length.

PART-B

1. Find the sending end impedance of a line with negligible losses when characteristic impedance

is 55Ω, the load impedance is 115 + j75Ω and the length if the line is 1.183λ by using smith chart. **(Nov/Dec 2016).**

2. Explain the significance of smith chart and its application in a transmission line. **(Nov/Dec 2016).**

3. Explain the procedure of double stub matching on a transmission line**.(Nov/Dec 2015)**

4. Determine the length and location of a single short circuited stub to produce an impedance match on a transmission line with Ro of 600Ω & terminated in1800 Ω. **(Nov/Dec 2016).**

5. Explain the operation of quarter wave transformer and mention its important applications. **(Nov/Dec 2016).**

6. Prove that the input impedance of a quarter wave line is Zin = R02/ZR**.(April/May 2016).**

7. Design a quarter wave transformer to match a load of 200 ohms to a source resistance of 500 ohms, operating frequency is 200 MHz**.(April /May 2016)**

8. A load (50 – j100) ohms is connected across a 50 ohms line. Design a short circuited stub to provide matching between the two at a signal frequency of 30 MHz using smith chart. **(April /May 2016)**

UNIT IV - WAVE GUIDES

1. **What is called dominant mode?** **[M/J – 12],[M/J – 09]**
   The mode which has lowest cut off frequency or highest cut of wavelength is called dominant mode.
2. **What is called cutoff frequency?** **[N/D – 07]**
   The frequency at which the wave motion ceases is called cutoff frequency of the waveguide.
3. **Distinguish between TE and TM waves.** **[N/D – 12]**

TE	TM
Electric field strength E is entirely transverse.	Magnetic field strength is entirely transverse.
It has z component of magnetic field (H_z).	It has z component of electric field (E_z).
It has no z component of electric field (E_z).	It has no z component of magnetic field (H_z).

4. **What are called guided waves?**
   The electromagnetic waves that are guided along or over conducting or dielectric surface are called guided waves. Examples of guided waves are parallel wires and transmission lines.
5. **What is TE wave or H wave?**
   Transverse electric (TE) wave is a wave in which the 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 E_z in the direction of wave propagation.
6. **What is TM wave or E wave?**
   Transverse magnetic (TM) wave is a wave in which the magnetic field strength H is entirely transverse. It has a electric field strength E_z in the direction of wave propagation and no component of magnetic field H_z in the direction of wave propagation.
7. **What are the dominant modes for TE and TM waves in parallel plane waveguides?**
   The Dominant modes in parallel plane waveguides for TE and TM waves are TE_{10} and TM_{10} respectively.
8. **What is called cutoff wavelength?**
   The frequency at which the wave motion ceases is called cutoff frequency of the waveguide.
9. **Write down the expression for cutoff frequency when the wave is propagated between two parallel planes.**

The cutoff frequency when the wave is propagated between two parallel plates, is given by

$$f_c = {}^{m}/_{(2a(\sqrt{\mu\varepsilon}))}$$

$$f_c = {}^{mv}/_{(2a)}$$

where, m – mode μ – permeability a – distance of seperation ε – permitivity v – velocity of propagation

10. Write the expression for cutoff wavelength of the wave which is propagated in between two parallel planes.

The cutoff wavelength of the wave which is propagated in between two parallel planes is given by,

$$\lambda_c = 2a / m$$

where, m – mode

a – distance of seperation

11. Write the expression for guide wavelength when the wave is transmitted between two parallel planes.

The expression for guide wave length when the wave is transmitted in between two parallel planes is given by

$$\lambda_g = {}^{2\pi}/_{[\omega^2\mu\varepsilon - ({}^{m\pi}/_{a}2)]}$$

where, m – mode μ – permeability

a – distance of seperation ε – permitivity

ω – angular frequency

12. Find the frequency of minimum attenuation for TM mode.

The attenuation α_{TM} reaches a minimum value at the frequency equal to √3 times the cutoff frequency.

$$f = \sqrt{3} f_c$$

13. State the relation between the attenuation factor for TE waves and TM waves for parallel plane waveguide.

The relation between the attenuation factor for TE waves and TM waves for parallel plate waveguide is given by,

$$\alpha_{TE} = \alpha_{TM} \left({}^{f_c}/_{f}\right)^2$$

14. What is a TEM wave or principal wave? [A/M – 08]

The Transverse Electromagnetic (TEM) 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 also called the principal wave.

15. What are the characteristics of TEM waves? [N/D – 06], [M/J – 09]

The characteristics of TEM waves are:

i. The amplitude of field component is constant
ii. The velocity of propagation and the wave impedance are independent of frequency of the wave
iii. TEM waves cannot exist in a single conductor hollow waveguide
iv. The cut – off frequency of TEM wave is zero
v. The ratio of amplitudes of E to H is intrinsic impedance.

vi. It doesn't have either E_z or H_z component.

16. **Define – Phase Velocity and Group Velocity** **[M/J – 07]**

Phase velocity (v_p) is defined as the velocity of propagation of equiphase surfaces along a guide. It is given by,

$$v_p = \omega/\beta$$

Group velocity (v_g) is defined as the velocity with which the energy propagates along a guide. It is given by,

$$v_g = d\omega/d\beta$$

17. **State the relation between phase velocity and group velocity.** **[N/D – 11]**

The relation between phase velocity and group velocity is given by,

$$v_p\, v_g = c^2$$

18. **Define – Attenuation Factor**

Attenuation factor is defined as the ratio of power loss per unit length to twice the transmitted power.

Attenuation factor = (Power lost per unit length) / (2 x power transmitted)

19. **Define – Wave Impedance**

Wave impedance is defined as the ratio of electric field strength to magnetic field strength, which is given by

$$Z_{xy} = \frac{E_x}{H_y}$$, in the positive direction and

$$Z_{xy} = -\frac{E_x}{H_y}$$, in the negative direction.

20. **State the applications of waveguides.**

The wave guides are employed for transmission of energy at very high frequencies where the attenuation caused by wave guide is smaller. The waveguides are used in microwave transmission. The circular waveguides are used as attenuators and phase shifters.

21. **Define – Wave Impedance** **[N/D – 07]**

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

22. **What is the dominant mode for the TE waves in the rectangular waveguide? [N/D – 12]**

The dominant mode for the TE waves in the rectangular waveguide is TE_{10} mode.

23. **What is the dominant mode for the TM waves in the rectangular waveguide?[N/D – 12]**

The dominant mode for the TM waves in the rectangular waveguide is TM_{11} mode.

24. **What are the degenerate modes in a rectangular waveguide?** **[N/D – 06]**

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

25. **What is a waveguide?**

A hollow conducting metallic tube of uniform cross section which is used for propagating electromagnetic wave is called wave guide.

26. **Why are rectangular waveguides preferred to circular waveguides?**

Rectangular wave-guides are preferred to circular waveguides because of the following reasons:

i. Rectangular waveguide is smaller in size than a circular waveguide of the same operating frequency.
ii. The frequency difference between the lowest frequency on dominant mode and the next mode of a rectangular wave guide is bigger than in a circular wave guide.

27. **Why is waveguide taken either in circular or in rectangular form?**

Waveguides usually take the forms of circular or rectangular because of its simplicity and less expensive to manufacture.

28. What is an evanescent mode?

When the operating frequency is lower than the cut-off frequency, the propagation constant becomes real. So the wave cannot be propagated for that frequency. This non- propagating mode is known as evanescent mode.

29. Which are the non-zero field components for the TM_{11} mode in a rectangular waveguide?

The non-zero field components for the TM_{11} mode in a rectangular waveguide are Hx, Hy, Ey and Ez.

30. Which are the non-zero field components for the TE_{10} mode in a rectangular waveguide?

The non-zero field components for the TE_{10} mode in a rectangular waveguide are H_x, H_z and Ey.

31. What are the cutoff wave length and cutoff frequency of the TE_{10} mode in a rectangular waveguide?

The cutoff wave length and cutoff frequency of the TE_{10} mode in a rectangular waveguide are given by,

Cut off wave length, $\lambda_c = 2a$ and

Cutoff frequency, $f_c = c/(2a)$

32. Why do TM_{01} and TM_{10} modes not exist in a rectangular waveguide?

For TM modes in rectangular waveguides, neither 'm' nor '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 are present. Hence TM_{01} and TM_{10} modes in a rectangular waveguide do not exist.

33. State the applications of circular waveguide.

Circular waveguides are used as attenuators and phase shifters.

34. Which mode in circular waveguide has attenuation effect decreasing with increase in frequency?

TE_{01} mode in circular wave guide has attenuation effect decreasing with increase in frequency.

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

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

36. What are the performance parameters of a microwave resonator? **[A/M – 12]**

The performance parameters of a microwave resonator are:

i. Resonant frequency
ii. Quality factor
iii. Input impedance

37. Define – Quality Factor of Microwave Resonator **[A/M – 09], [N/D – 11]**

Quality factor of microwave resonator is defined as the measure of frequency selectivity of the resonator. It is given by,

$$Q = {}^{f_0}/_{BW}$$

where f_0 – Resonant frequency BW – Bandwidth

38. What is resonant frequency of a microwave resonator?

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

39. List the basic configurations of coaxial resonator.

The basic configurations of coaxial resonator are:

i. Quarter wave coaxial cavity
ii. Half wave coaxial cavity
iii. Capacitive and coaxial cavity

PART-B

1. Derive the components of electric and magnetic field strength between a pair of parallel perfectly conducting planes of infinite extend in the „Y" and „Z" directions. The planes are separated in X direction by "a**".(May 2015)**

2. Derive the expressions for the field components of TM and TE waves between parallel plates, propagating in Z direction.(**Nov 2014) (Nov/Dec 2016)**

3. Two perfectly conducting planes are separated by 7.5 cm and filled with a dielectric material of dielectric constant εr = 2.5. For a frequency of 4000 MHZ with TM2 mode excited, find the following: (a) cut-off frequency (b) cut-off wavelength (c) phase velocity (d) group velocity (e) phase constant (f) wave impedance (g) guide wavelength and (h) Is it possible to propagate TM1 mode?**(Apr/May 2016)**

4. Discuss the characteristics of TE and TM waves and also derive the cut-off frequency and phase velocity from the propagation constant**.(May 2015)**

5. Derive the expressions for the field components of TM and TE waves in rectangular waveguides.**(Nov 2014)(Apr/May 2016)**

6. Derive the wave impedance for TM and TE waves between parallel planes**.(May 2015)**

7. Write a brief note on circular cavity resonator and its application. **(Nov/Dec 2016)**

8. A TE11 wave is propagating through a circular waveguide. The diameter of the guide is 10 cm and the guide is air-filled. Given X11 = 1.842. (1) Find the cut-off frequency (2) Find guide wavelength in the guide for a frequency of 3 GHz. (3) Determine the wave impedance in the guide**. (Nov/Dec 2016)**