

## TRANSMISSION LINES AND WAVEGUIDES TWO MARKS QUESTION & ANSWERS

### UNIT I-TRANSMISSION LINE THEORY

#### 1. 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 defined as the loop conductance per unit length of the wire. Its unit is mho/Km

#### 2. 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.

#### 3. Define Characteristic impedance

Characteristic impedance is the impedance measured at the sending end of the line. It is given by  $Z_0 = \sqrt{Z/Y}$ , where

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

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

#### 4. Define Propagation constant

Propagation constant is defined as the natural logarithm of the ratio of the sending end current or voltage to the receiving end current or voltage of the line. It gives the manner in the wave is propagated along a line and specifies the variation of voltage and current in the line as a function of distance. Propagation constant is a complex quantity and is expressed as  $\gamma = \alpha + j\beta$

The real part is called the attenuation constant whereas the imaginary part of propagation constant is called the phase constant

#### 5. 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 ( $Z_R = Z_0$ ), so the input impedance of the finite line is equal to the characteristic impedance ( $Z_S = Z_0$ ).

**6.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.

**7.What is wavelength of a line?**

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

**8.What are the types of line distortions?**

The distortions occurring in the transmission line are called waveform distortion or line distortion. Waveform distortion is of two types:

- a) Frequency distortion
- b) Phase or Delay Distortion.

**9.How frequency distortion occurs in a line?**

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.

**10.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  $\alpha$  should be made independent of frequency. b) By using equalizers at the line terminals which minimize the frequency distortion. Equalisers 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.

**11.What is delay distortion?**

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

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

In order to reduce frequency distortion occurring in the line,

- a) The phase constant  $\beta$  should be made dependent of frequency.
- b) The velocity of propagation is independent of frequency.
- c) 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 phase is equal for all the frequencies.

**13.What is a distortion less line? What is the condition for a distortion less line?**

A line, which has neither frequency distortion nor phase distortion is called a distortion less line.

The condition for a distortion less line is  $RC=LG$ . Also,

- a) The attenuation constant should be made independent of frequency.
- b) The phase constant should be made dependent of frequency.
- d) The velocity of propagation is independent of frequency.

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

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

**15.How the telephone line can be made a distortion less line?**

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

**16.What is Loading?**

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

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

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

**18.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 the line.

**19.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

**20.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

**21.Define reflection coefficient**

Reflection Coefficient can be defined as the ratio of the reflected voltage to the incident voltage at the receiving end of the line Reflection Coefficient

$K = \text{Reflected Voltage at load} / \text{Incident voltage at the load}$

$$K = V_r / V_i$$

**22. Define reflection loss**

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

### **23.What is Impedance matching?**

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

### **24. Define the term insertion loss**

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

### **25.When reflection occurs in a line?**

Reflection occurs because of the following cases:

- 1) when the load end is open circuited
- 2) when the load end is short-circuited
- 3) when the line is not terminated in its characteristic impedance

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

### **26.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.

## **UNIT II-HIGH FREQUENCY TRANSMISSION LINES**

### **27. State the assumptions for the analysis of the performance of the radio frequency line.**

- 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 square root of  $f$  while inductance  $L$  increases with  $f$  . Hence  $\omega L \gg R$ .
- 3.The leakage conductance  $G$  is zero

### **28.State the expressions for inductance $L$ of a open wire line and coaxial line.**

For open wire line ,

$$L=9.21*10^{-7}(\mu/\mu_r +4\ln d/a)=10^{-7}(\mu_r +9.21\log d/a) \text{ H/m}$$

For coaxial line,

$$L = 4.60*10^{-7}[\log b/a]\text{H/m}$$

### **29.State the expressions for the capacitance of a open wire line**

**For open wire line ,**

$$C=(12.07)/(\ln d/a)\mu\mu_f/\text{m}$$

**30.What is dissipationless line?**

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

**31.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,

$$Z_0=R_0 = ( L/c)^{1/2}$$

**32.State the values of a and b for the dissipation less line.**

Answer:

$$\alpha=0 \text{ and } \beta=w (LC)^{1/2}$$

**33.What are nodes and antinodes on a line?**

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

**34.What is standing wave ratio?**

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

**35.What is the range of values of standing wave ratio?**

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

**36.State the relation between standing wave ratio and reflection coefficient.**

Ans:  $S = 1+|K|$

.....

$$1- |K|$$

**37.What are standing waves?**

If the transmission is not terminated in its characteristic impedance ,then there will be two waves traveling along the line which gives rise to standing waves having fixed maxima and fixed minima.

**38.What is called standing wave ratio?**

The ratio of the maximum to minimum magnitudes of current or voltage on a line having standing wave is called the standing-wave ratio S.

**39.State the relation between standing wave ratio S and reflection co-efficient**

**k.**

The relation between standing wave ratio S and reflection co-efficient k is,

$$S = 1+|K|$$

.....

$$1- |K|$$

$$\text{Also } k = S-1$$

.....

**40. How will you make standing wave measurements on coaxial lines?**

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

**41. Give the input impedance of a dissipationless line.**

The input impedance of a dissipationless line is given by,

**42. Give the maximum and minimum input impedance of the dissipationless line.**

Maximum input impedance,

Minimum input impedance,

**43. Give the input impedance of open and short circuited lines.**

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

**44. Why the point of voltage minimum is measured rather than voltage maximum?**

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

**45. What is the use of eighth wave line?**

An eighth wave line is used to transform 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 a source of  $R_0$  internal resistance.

**46. Give the input impedance of eighth wave line terminated in a pure resistance**

$R_r$ . The input impedance of eighth wave line terminated in a pure resistance

$R_r$  is given by

$$Z_s = (Z_r + jR_0/R_0 + jZ_r)$$

From the above equation it is seen that

$$|Z_s| = R_0.$$

**47. Why is a quarter wave line called as impedance inverter?**

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

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

An important application of the quarter wave matching section is to 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 impedance  $R_0$  so chosen that the antenna resistance  $R_a$  is transformed to a value equal to the characteristic impedance  $R_0$  of the transmission line. The

characteristic impedance  $R_o$  of the matching section then should be  
 $R_o' = (R_a R_o)^{1/2}$

**49. What do you mean by copper insulators?**

An application of the short circuited quarter wave line is an insulator to support an open wire line or the center conductor of a coaxial line. This application makes use of the fact that the input impedance of a quarter wave shorted line is very high. Such lines are sometimes referred to as copper insulators.

**50. Bring out the significance of a half wavelength line.**

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

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

The quarter wave line or transformer and the tapered line are some of the impedance matching devices.

**52. Explain impedance matching using stub.**

In the method of impedance 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  $R_o$ .

**53. Give reasons for preferring a short-circuited stub when compared to an open circuited stub.**

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

**54. 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.

**55. 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,

$$S1 = (\phi + \pi - \cos^{-1}|K|) / (2\beta)$$

**56. Give the formula to calculate the distance  $d$  from the voltage minimum to the point stub be connection.**

The formula to calculate the distance  $d$  from the voltage minimum to the point of stub be connection is,

$$d = \cos^{-1}|K| / (2\beta)$$

## UNIT-III IMPEDANCE MATCHING IN HIGH FREQUENCY LINES

### 57. Give the formula to calculate the length of the short circuited stub.

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

$$L = \lambda/2\pi \tan^{-1}((s)^{1/2} / (s-1))$$

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.

### 58. What is the input impedance equation of a dissipation less line ?

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

$$(Z_s/R_o) = (1 + |K|(\phi - 2\beta s)) / (1 - |K|(\phi - 2\beta s))$$

### 59. Give the equation for the radius of a circle diagram.

The equation for the radius of a circle diagram is

$$R = (S^2 - 1) / 2S \text{ and}$$

$$C = (S^2 + 1) / 2S$$

Where C is the shift of the center of the circle on the positive Ra axis.

### 60. What is the use of a circle diagram?

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

### 61. How is the circle diagram useful to find the input impedance of short and open circuited lines?

An open circuited line has  $s = \alpha$  , the correspondent circle appearing as the vertical axis .The input impedance is then pure reactance , with the value for various electrical lengths determined by the intersections of the corresponding  $\beta s$  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 susceptance values may be read off at appropriate intersection of the  $\beta s$  circles with the vertical axis.

### 62. List the applications of the smith chart.

The applications of the smith chart are,

- (i) It is used to find the input impedance and input admittance of the line.
- (ii) The smith chart may also be used for lossy lines and the locus of points on a line then follows a spiral path towards the chart center, due to attenuation.
- (iii) In single stub matching

### 63. What are the difficulties in single stub matching?

The difficulties of the smith chart are

- (i) 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.
- (ii) 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.
- (iii) In the case of the single stub it was mentioned that two adjustments were required ,these being location and length of the stub.



**64. 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  $\lambda/4$ . This is called double stub matching.

**65. 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.

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

The expression for the input impedance of the line is given by  $Z_s = Z_r$  Thus the line repeats its terminating impedance .Hence it is operated as one to one transformer .Its application is to connect load to a source where they can not be made adjacent.

**67. Why Double stub matching is preferred over single 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.

**UNIT IV- PASSIVE FILTERS**

**1. What is filter?**

Electronic filters are electronic circuits which performs signal processing functions. Specifically to remove unwanted frequency components from the signal, to enhance wanted once or both.

**2. What are passive filters?**

Passive implementation of linear filters are based on combination of resistor, capacitor, inductor. These types are collectively known as passive filters, because they do not depend upon an external power supply and/or they do not contain active components such as transistor.

**3. What are active filters?**

active filters are implemented using a combination of passive and active components, and required an outside power source. Operational amplifier are frequently used in active filters designs.

**4. What are the characteristics of ideal filters?**

Ideal filter would have zero attenuation in pass band and infinite attenuation in the stop band.

**5. What is a symmetrical network?**

When the electrical properties of the networks are not effected even after interchanging input and output terminals the network is called as symmetrical network.

A network is said to be symmetrical if two series arms of a T network or shunt arms of a  $\Pi$  network are equal.

#### **6. Define characteristic impedance of a symmetrical network?**

Characteristic impedance of a symmetrical of a symmetrical network is the impedance measured at the input terminals of the first network in a chain of infinite networks in cascade and is denoted as  $Z_0$ .

#### **7. What is constant k filters.**

A filter in which the series arm impedance  $Z_1$  and arm shunt arm impedance  $Z_2$  satisfy the relationship between  $Z_1.Z_2=R_k$ . Is called constant k filter, where  $R_k$  is a real constant independent of frequency.

#### **8. What is importance of terminating half section?**

1. Terminating half section are normally added to any filter to provide uniform terminated and matching characteristics.
2. They provide a point of high attenuation at a frequency 1.25 times that of cut off. Thus improving the attenuation the attenuation characteristic of the filter.

#### **9. What is one Neper equal to?**

1 Neper = 8.686 db.

#### **10. Why constant k filters are also known as proto type filters?**

Constant k filters are also known as proto type filters because other complicated networks can be derived from it.

#### **11. Define Neper.**

The natural logarithmic of the ratio of input current or voltage to the output current or voltage is expressed in neper.

$$N = \ln \left[ \frac{v_1}{v_2} \right] = \ln \left[ \frac{I_1}{I_2} \right].$$

#### **12. Give relationship between decibel and neper.**

One neper = 8.686 db.

One db = 0.115 nepers.

**13. What are the advantages of m-derived filters?**

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

**15. What is the significant of propagation constant in symmetrical network?**

The current ratio or voltage ratio is expressed as  $v_1/v_2$  (or)  $i_1/i_2$ .

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

Where  $\alpha$  is the attenuation constant

$\beta$  is the phase constant.

**16. Define cut off frequency of a filter?**

The frequency at which the network changes from a pass band to stop band is called cut off frequency.

$$Z_1/Z_2 = 0 \text{ or } z = 0$$

$$Z_1/Z_2 = -1 \text{ Or } Z_1 = -Z_2.$$

**17. What are the features of crystal filter?**

The piezoelectric quartz crystal having a very high Q, therefore it is possible to make very narrow band filters and filters in which attenuation rises very rapidly at cut off.

**UNIT V-GUIDED WAVES**

**What are guided waves? Give examples**

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

**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 same direction

**. What is TH 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 propagation and no component of magnetic field  $H_z$  in the same direction

**What is a TEM wave or principal wave?**

TEM wave is a special type of TM wave in which an electric field  $E$  along the direction of propagation is also zero. The 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 referred to as the principal wave.

**What is a dominant mode?**

The modes that have the lowest cut off frequency is called the dominant mode.

**Give the dominant mode for TE and TM waves**

Dominant mode: TE<sub>10</sub> and TM<sub>10</sub>

**What is cut off frequency?**

The frequency at which the wave motion ceases is called cut-off frequency of the waveguide.

**What is cut-off wavelength?**

It is the wavelength below which there is wave propagation and above which there is no wave propagation.

**Write down the expression for cut off frequency when the wave is propagated in between two parallel plates.**

The cut-off frequency,  $f_c = m / (2a \sqrt{\mu\epsilon})^{1/2}$

**Mention the characteristics of TEM waves.**

- It is a special type of TM wave
- It doesn't have either E or H component
- Its velocity is independent of frequency
- Its cut-off frequency is zero.

**Define attenuation factor**

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

**Give the relation between the attenuation factor for TE waves and TM waves**

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

**Define wave impedance**

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

$Z_{xy} = E_x / H_y$  in the positive direction

$Z_{xy} = -E_x / H_y$  in the negative direction

**What is a parallel plate wave guide?**

Parallel plate wave guide consists of two conducting sheets separated by a dielectric material.

**Why are rectangular wave-guides preferred over circular wave-guides?**

Rectangular wave-guides preferred over circular wave guides because of the following reasons.

- a) Rectangular wave guide is smaller in size than a circular wave guide of the same operating frequency
- b) It does not maintain its polarization through the circular wave guide
- c) 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.

**.Mention the applications of wave guides**

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

**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.

**What is an evanescent mode?**

When the operating frequency is lower than the cut-off frequency, the propagation constant becomes real i.e ,  $\gamma = \alpha$  . The wave cannot be propagated. This non-propagating mode is known as evanescent mode.

**.What is the dominant mode for the TE waves in the rectangular waveguide?**

The lowest mode for TE wave is  $TE_{10}$  (m=1 , n=0)

**What is the dominant mode for the TM waves in the rectangular waveguide?**

The lowest mode for TM wave is  $TM_{11}$ (m=1 , n=1)

**What is the dominant mode for the rectangular waveguide?**

The lowest mode for TE wave is  $TE_{10}$  (m=1 , n=0) whereas the lowest mode for TM wave is  $TM_{11}$ (m=1 , n=1). The  $TE_{10}$  wave have the lowest cut off frequency compared to the  $TM_{11}$  mode. Hence the  $TE_{10}$  (m=1 , n=0) is the dominant mode of a rectangular waveguide. Because the  $TE_{10}$  mode has the lowest attenuation of all modes in a rectangular waveguide and its electric field is definitely polarized in one direction everywhere.

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

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

**Define characteristic impedance in a waveguide**

The characteristic impedance  $Z_0$  can be defined in terms of the voltage-current ratio or in terms of power transmitted for a given voltage or a given current.

$$Z_0 (V,I) = V/I$$

**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

**Explain why TM<sub>01</sub> and TM<sub>10</sub> modes in a rectangular waveguide do not exist.**

For TM modes in rectangular waveguides, neither m or n can be zero because all the field equations vanish ( i.e.,  $H_x$ ,  $H_y$ ,  $E_y$  and  $E_z=0$ ). If  $m=0, n=1$  or  $m=1, n=0$  no fields are present. Hence TM<sub>01</sub> and TM<sub>10</sub> modes in a rectangular waveguide do not exist.

**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 a rectangular waveguide, TE<sub>mn</sub> and TM<sub>mn</sub> modes ( both  $m \neq 0$  and  $n \neq 0$ ) are always degenerate.

109. What are the performance parameters of microwave resonator?

The performance parameters of microwave resonator are:

- (i) Resonant frequency
- (ii) Quality factor
- (iii) Input impedance

**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.

**Define quality factor of a resonator.**

The quality factor Q is a measure of frequency selectivity of the resonator. It is defined as  $Q = 2 \pi \times \text{Maximum energy stored} / \text{Energy dissipated per cycle} = \omega W / P$  Where W is the maximum stored energy P is the average power loss

**What is a resonator?**

Resonator is a tuned circuit which resonates at a particular frequency at which the energy stored in the electric field is equal to the energy stored in the magnetic field.

**How the resonator is constructed at low frequencies?**

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.

**What are the disadvantages if the resonator is made using lumped elements at**

high frequencies?

1) The inductance and the capacitance values are too small as the frequency is increased beyond the VHF range and hence difficult to realize .

**What are the methods used for constructing a resonator?**

The resonators are built by

- a) using lumped elements like L and C
- b) using distributed elements like sections of coaxial lines
- c) using rectangular or circular waveguide

**What is a transmission line resonator or coaxial resonator?**

Transmission line resonator can be built using distributed elements like sections of coaxial lines. The coaxial lines are either opened or shunted at the end sections thus confining the electromagnetic energy within the section and acts as the resonant circuit having a natural resonant frequency.

**Why transmission line resonator is not usually used as microwave resonator?**

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