UNIT I - TRANSMISSION LINE THEORY

1. What are the line parameters?

The parameters of a transmission line are:
Resistance (R)
Inductance (L)
Capacitance (C)
Conductance (G)

2. Define the line parameters.

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.

3. 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, and G are distributed through the entire length of the line, they are called as distributed elements. They are also called as primary constants.

4. Define Characteristic impedance

Characteristic impedance is the impedance measured at the sending end of the line. It is given by

$$Z_0 = Z/Y,$$

Where $Z = R + j\omega L$ is the series impedance $Y = G + j\omega C$ is the shunt admittance

5. 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.

6. 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).

7. 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.

8. What is wavelength of a line?

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

9. 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.

10. 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.

11. 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 α should be made independent of frequency.
b) By using equalizers at the line terminals which minimize the frequency distortion.
c) 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.

12. 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.

13. How to avoid the delay distortion that occurs in the line?

Coaxial cables are used to avoid delay distortion. In such cables internal inductance is low at high frequencies because of skin effect, the resistance is small because of large conductors and the capacitance is small because of air dielectric with a minimum of spacers.

14. What are Equalizers?

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.

15. What is a distortion less line? What is the condition for a distortion les 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 α should be made independent of frequency.
b) The phase constant β should be made dependent of frequency.
c) The velocity of propagation is independent of frequency.

16. 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, the frequency and phase distortion occurs in the line.

17. 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.

18. What is Loading of a transmission Line?

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

19. What are the types of loading?

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

20. 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.

21. 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.

22. 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.

23. 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=Reflected Voltage at load /Incident voltage at the load K=Vr/Vi

24. 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.

25. 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.

26. 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.

27. 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

.

28. 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.

29. What are the different types of transmission lines?

- Openwire line
- Cable
- Coaxial line

- Waveguide

30. What is called a line of small dissipation?

If resistance R is small, the line is considered one of small dissipation and this concept is useful when lines are employed as circuit elements or where resonant properties are involved.

UNIT II THE LINE AT RADIO FREQUENCIES

1. 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 $\sqrt{f}$ while inductance L increases with f. Hence $\omega L >> R$.
3. The leakage conductance G is zero

2. What is dissipation less line?

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

3. What is the nature and value of Z_0 for the dissipation less line?

For the dissipation less line, the Z_0 is purley resistive and given by, $Z_0=R_0 = \sqrt{L/C}$

4. State the values of α and β for the dissipation less line.

Answer:

$\alpha=0$ and $\beta=\omega \sqrt{LC}$

5. 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.

6. What is standing wave ratio?

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

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

7. What is the range of values of standing wave ratio?

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

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

Ans: S = 1+|K| / 1-|K|

9. 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.

10. 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 nonlinear, corrections must be applied to the readings obtained.

11. Give the input impedance of a dissipation less line.

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

$$Z_s = \frac{E_s}{I_s} = R_0 \frac{(1+k \angle \varphi - 2\beta s)}{(1- k \angle \varphi - 2\beta s)}$$

12. Give the maximum and minimum input impedance of the dissipationless line.

Maximum input impedance, $R_{max} = R_0 \frac{1+k}{1-k} = SR_o$

Minimum input impedance, $R_{min} = R_o \frac{1+k}{1-k} == R_o S$

13. Give the input impedance of open and short circuited lines.

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

$Z_{sc} = jR_o \tan 2\pi s\lambda$

14. 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.

15. What is the use of eighth wave line?

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.

16. Give the input impendence of eighth wave line terminated in a pure resistance Rr.

The input impendence of eighth wave line terminated in a pure resistance Rr. Is given by

$Zs = (Z_R+jRo/Ro+jZ_R)$
From the above equation it is seen that Zs = Ro.

17. Why is a quarter wave line called as impendence inverter?

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

18. What is the application of the quarter wave matching section?

An important application of the quarter wave matching sections 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

19. 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 se of the fact that the input impendence of a quarter –wave shorted line is very high ,Such lines are sometimes referred to as copper insulators.

20. 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.

21.Give some of the impendence –matching devices.

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

22. Explain impendence matching using stub.

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

23.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 opencircuited.

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.

24.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.

25.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 +_-cos-1|K|)/(2_)

26. 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_)

27. Give the formula to calculate the length of the short circuited stub.

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

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

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.

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

The input impendence equation of a dissipation less line is given by (Zs/Ro)=(1+|K|(-2_s)/(1-|K|(-2_s)

29.Give the equation for the radius of a circle diagram.

The equation for the radius of a circle diagram is R=(S2-1)/2S and

C = (S2+1)/2S

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

30.What is the use of a circle diagram?

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

31. 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 amittance .The S circle is again the vertical axis, and susceptance values may be read off at appropriate intersection of the βs circles with the vertical axis.

32. List the applications of the smith chart.

The applications of the smith chart are,

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

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

33. 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.

34. 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 _/4.This is called double stub matching.

35. 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 a smooth adjustment of length.

36. 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 can not be made adjacent.

37. 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 coxial line it is very difficult to get such voltage minimum, without using slotted line section.

UNIT III GUIDED WAVES

1. 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

2. 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 Hz in the direction of propagation and no component of electric field Ez in the same direction.

3. 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 Ez in the direction of propagation and no component of magnetic field Hz in the same direction.

4. 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 Ez and Hz
.It is also referred to as the principal wave.

5. What is a dominant mode?

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

6. Give the dominant mode for TE and TM waves

Dominant mode: TE_{10} and TM_{10}

7. What is cut off frequency?

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

8. What is cut-off wavelength?

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

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

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

10. Mention the characteristics of TEM waves.

a) It is a special type of TM wave

b) It doesn't have either e or H component
c) Its velocity is independent of frequency
d) Its cut-off frequency is zero.

11. Define attenuation factor

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

12. Give the relation between the attenuation factor for TE waves and TM waves

$\alpha TE = \alpha TM (fc/f)2$

13. Define wave impedance

Wave impedance is defined as the ratio of electric to magnetic field strength Zxy= Ex/ Hy in the positive direction

Zxy= -Ex/ Hy in the negative direction

14. What is a parallel plate wave guide?

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

15. 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.

16. 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

UNIT IV-RECTANGULAR WAVEGUIDES

1. 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.

2. What is an evanescent mode?

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

3. 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)

4. 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)

5. 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} waves have the lowest cut off frequency compared to the TM11 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.

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

H_x, H_z and E_y.

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

H_x, H_y ,E_y. and E_z.

8. Define characteristic impedance in a waveguide.

The characteristic impedance Z_o 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_o (V,I) = V/I

9. 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

10. Explain why TM_{01} and TM_{10} 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_{01} and TM_{10} modes in a rectangular waveguide do not exist.

11. 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_{mn} and TM_{mn} modes

UNIT – V CIRCULAR WAVE GUIDES AND RESONATORS

1. 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

2. 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= 0.5

b) 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.

3. Mention the applications of circular waveguide.

Circular waveguides are used as attenuators and phase-shifters

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

TE01

5. What are the possible modes for TM waves in a circular waveguide?

The possible TM modes in a circular waveguide are: TM01, TM02, TM11, and TM12

6. Define dominant mode for a circular waveguide.

The dominant mode for a circular waveguide is defined as the lowest order mode having the lowest root value.

7. What are the possible modes for TE waves in a circular waveguide?

The possible TE modes in a circular waveguide are: TE01, TE02, TE11, and TE12

8. What are the root values for the TE modes?

The root values for the TE modes are: (ha)01 = 3.85 for TE01

(ha)02 = 7.02 for TE02 (ha)11 = 1.841 for TE11 (ha)12 = 5.53 for TE12

9. 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

10. What is the dominant mode for TM waves in a circular waveguide?

The dominant mode for TM waves in a circular waveguide is the TM01 because it has the lowest root value of 2.405.

11. What is the dominant mode in a circular waveguide?

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 because it 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.

12. Mention the dominant modes in rectangular and circular waveguides

For a rectangular waveguide, the dominant mode is TE01
For a circular waveguide, the dominant mode is TE11

13. 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.

14. What are the performance parameters of microwave resonator?

The performance parameters of microwave resonator are:
(i) Resonant frequency
(ii) Quality factor
(iii) Input impedance

15. 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.

16. 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 _ x Maximum energy stored / Energy dissipated per cycle = _ W/ P
Where W is the maximum stored energy

P is the average power loss

17. 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.

18. 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.

19. 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.

20. 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

21. 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.

22. 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

23. 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. The electromagnetic energy is confined within this metallic enclosure and they acts as resonant circuits.

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

25. Why rectangular or circular cavities can be used as microwave resonators?
Rectangular or circular cavities can be used as microwave resonators because they have natural resonant frequency and behave like a LCR circuit.

26. How the cavity resonator can be represented by a LCR circuit?
The electromagnetic energy is stored in the entire volume of the cavity in the form of electric and magnetic fields. The presence of electric field gives rise to a capacitance value and the presence of magnetic field gives rise to a inductance value and the finite conductivity in the walls gives rise to loss along the walls giving rise to a resistance value. Thus the cavity resonator can be represented by a equivalent LCR circuit and have a natural resonant frequency

27. Name the three basic configurations of coaxial resonators.
The basic configurations of coaxial resonators are:
d) Quarter wave coaxial cavity
e) Half wave coaxial cavity
f) Capacitance end coaxial cavity

28. What is the dominant mode for rectangular resonator?
The dominant mode of a rectangular resonator depends on the dimensions of the cavity. For $b<a<d$, the dominant mode is TE_{101}

29. What is the dominant mode for circular resonator?

The dominant mode of a circular resonator depends on the dimensions of the cavity. Ford< 2a, the dominant mode is TM010

30. When a medium is said to be free- space.

A free-space medium is one in which there are no conduction currents and no charges.