UNIT I
PART A

1. Define neper & bel

<u>Neper :-</u> It is defined as

N nepers = lr (V_1 / V_2) = lr (I_1 / I_2)
Also It is defined as the natural algorithm of I/P voltage or current to the O/P voltage or current.

<u>Bel :-</u> The bel is defined as the logarithm of a power ratio.

Number of bels = log P_1 / P_2

2. Define decibel.

<u>Decibel:</u> It is the 10 times of common logarithm of ratio of I/P power to O/P power.

i.e. D= 10 log (P_1 / P_2)

Where
P_1 = I/P Power
D = 8.686N

3. What is filter?

<u>Filter: -</u> It is the electronics device which is designed to separate and pass or suppress a group of signal through a mixer of signals. And it also passes freely a desired band of frequency. While almost suppressed other band of frequency.

4. What are the types of filter?

<u>Types of filter:-</u>
a. Active filters: They contains transistor, inductors and op-amp.
b. Passive filters: They contains resistor, capacitor.

5. What is symmetrical networks?

When Z_1 = Z_2 or the two series arms of a T network are equal, or Z_a = Z_0 and the shunt arms of a π network are equal the network works are said to be symmetrical.

6. Write the equivalent value of neper to decibel?

1 Neper = 8.686 db
Or
N = 0.115D

7. What are the parameter of filter?

   The Parameter of filter are :-

   i. Characteristics impedance(Z_0).
   ii. Passband.
   iii. Stopband.
   iv. Cut off Frequency.
   v. Attenuation.

8. How will you construct band pass filter by using LPF & HPF?

   We can construct bandpass filter by connecting LPF and HPF in series, in which the cut off frequency of the LPF is above the cut off frequency of the HPF, the overlap thus allowing only a band of frequencies to pass.

9. How will you construct band stop filter by using LPF & HPF?

   We can construct band stop filter by connecting LPF and HPF in parallel in which the cut-off frequency of the LPF is below that of the HPF.

10. What is cut off frequencies?

    The frequency which separates passband and stopband is known as cut off frequency. It is denoted by 'f_C'.

11. Define characteristics impedance.

    The characteristic impedance of symmetrical network is the impedance measured at the I/P terminal of the 1st channel in the chain of infinite network in cascade and it is represented by Z_o

12. What is propagation constant?

    Propagation constant is the complex sum of attenuation constant and phase shift constant. It is denoted by 'γ'.

    $\gamma = \alpha + j\beta$

    Where, α = attenuation constant

    β = phase shift constant

13. What is constant k low pass filter?

    If Z_1 and Z_2 of a reactance network are unlike reactance arms, then $Z_1Z_2 = K^2$
    Where K is a constant independent of frequency network or filter sections for which this relation hold are called constant k filters.

14. What are the types of constant k filter?

    Types of constant k filter are :-

    i. The constant k low-pass filter.
    ii. The constant k high-pass filter.

15. What is low pass filter?

The filter which allow to pass frequencies below the cutoff-frequency and attenuates all other frequencies is known as low pass filter.

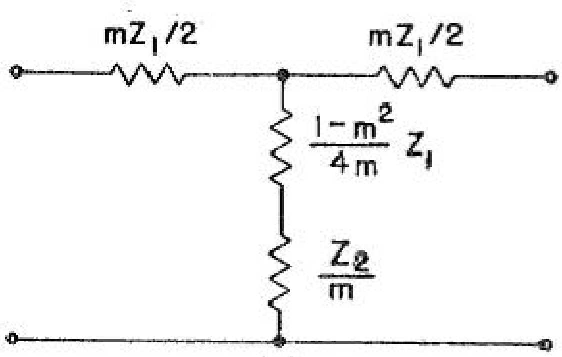
16. Write a short notes on m derived filter?

Constant –k section suffers from very slow attenuation rate and non-constant image impedance. Thus we replace Z_1 and Z_2 to Z_1 and Z_2 respectively.
Let's 'Z_i = mZ_1 and Z_2' to obtain the same Z_{iT} as in constant k-section

$Z_{iT} = \sqrt{\boldsymbol{Z1Z2} + \boldsymbol{Z1}^2/4}$

$=\sqrt{\boldsymbol{Z1Z2} + \boldsymbol{Z1}^2/4}$

$Z^I_2 = Z_2/M + (1-M^2)Z_1^2 / 4M$

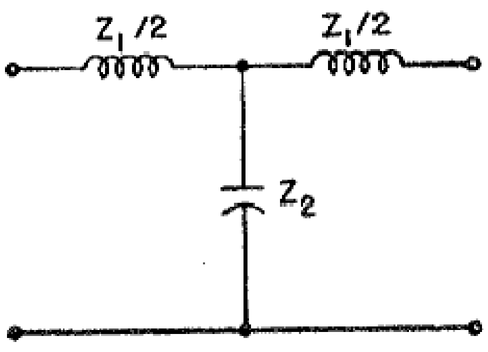


17. What are the disadvantage of constant k filter?

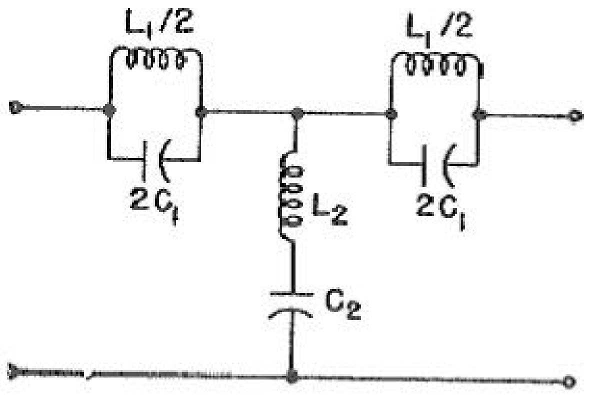
There are two disadvantages of constant k filter

i. Very slow attenuation rate.
ii. Non-constant image impedance.

18. Draw the diagram of symmetrical T-network of LPF?



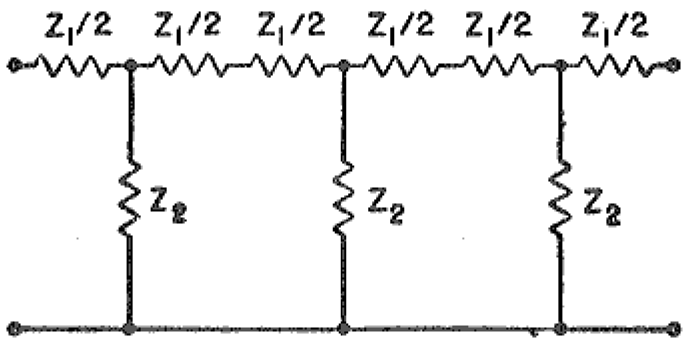
19. Draw the circuit diagram of band elimination filter of m derived filter?



20. What is crystal filter?

A crystal filter is a special form of quartz crystal used in electronics systems, in particular communications devices. It provides a very precisely defined centre frequency and very steep bandpass characteristics, that is a very high Q factor—far higher than can be obtained with conventional lumped circuits.

21. Design a ladder network formed by symmetrical T-network?



22. Write a relationship between propagation constant in terms of Zo.

tan $\gamma = Z_0 / Z_1/2 + Z_2$

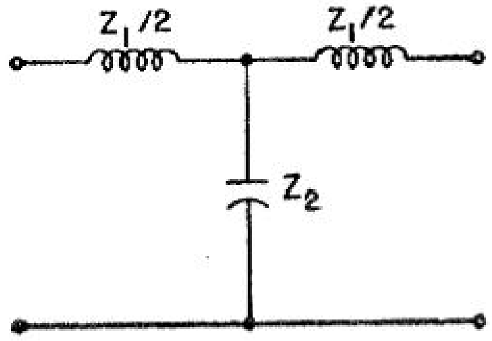
cos $\gamma = 1 + Z_1 / 2Z_2$

sin $\gamma = Z_0 / Z_2$

23. Define composite filter.

The m-derived section is designed following the design of the prototype T section. The use of a prototype and one or more m-derived section in series results in a composite filter.

24. Draw the general configuration of constant k LPF?



25. Draw the variation of attenuation α & β with frequency in constant k LPF & HPF?

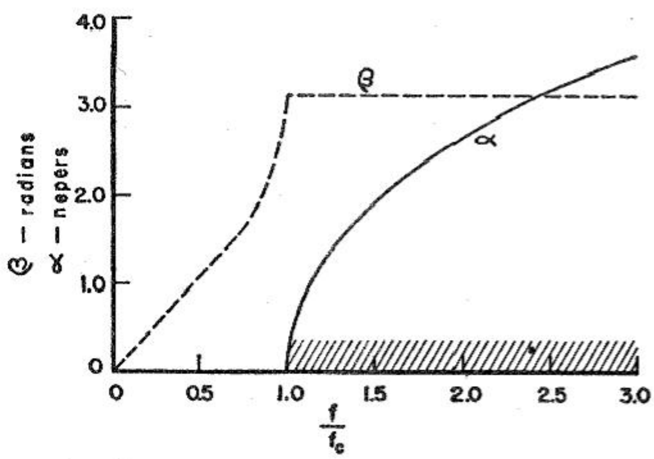


Fig. 4-9. Variation of α and β with frequency for the low-pass section.

UNIT II
PART A

1. What is transmission line?

The electrical lines which are used to transmit the electrical waves along them are called transmission lines. The transmission lines are assumed to consist of a pair of wires are uniform throughout their whole length. The transmission line parameters like resistance, inductance and capacitance are not physically separable unlike circuit elements of a lumped circuit. The transmission parameters are distributed all along the length of the transmission line.

2. What are the types of transmission lines?

The various types of transmission lines are,

1. Open-wire line: These lines are the parallel conductors open to air hence called wires lines. The conductors are separated by air as the dielectric and mounted on the posts or the towers.
2. Cables: These are underground lines. The underground electrical transmission cable consist of two or three large conductors which are insulated with oil impregnated paper or other solid dielectric and placed inside protective lead sheath. i)Telephone cable ii) Electrical transmission cable
3. Co-axial line: As the name suggests, there are two conductors which are co-axially placed. One conductor is hollow and other is placed co-axially inside the first conductor. The dielectric may be solid or gaseous.
4. Wave guides: These types of transmission lines are used to transmit the electrical wave at microwave frequencies. i) Rectangular Waveguide ii) Circular waveguide.

3. What are the parameters of transmission lines?

Thus the four important transmission line parameters are

1. Resistance R→ Ω
2. Inductance L → H
3. Capacitance C →F
4. Conductance G → mho

These line parameters are constants and are called primary constants of the transmission line. These constants are assumed to be independent of frequency for the transmission line. These primary constants can be obtained by the measurements on a sample of the transmission line.

4. Define Propagation constant.

Propagation constant per unit length may be defines as the natural logarithmic of ratio of the sending end current or voltage to the receiving end current or voltage.

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

It is a complex quantity

$\gamma = \alpha + j\beta$

Where α is attenuation constant
β is phase shift

$$\gamma = \sqrt{ZY} = \sqrt{(R + j\omega L)(G + j\omega C)}$$

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

The short line means a practical line of finite length. Short word does not indicate the information related to the actual length of the line. As it is a practical line with finite length, it is also called finite line. A finite line which is terminated in its characteristic impedance behaves as an infinite line. This means that it's I/P impedance will be Z_0 and there will be no reflection.

6. Give the properties of infinite lines.
   1. No waves will ever reach receiving and hence there is no reflection.
   2. The Z_0 at the sending end decides the current flowing when voltage is applied Z_R has no effect on the sending end current.

7. What are the types of line distortions?
   Line distortions is usually of two types
   1. Frequency distortion
   2. Delay distortion

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

Thus in high frequency radio broadcasting such frequency distortion is eliminated by use of equalizers. The frequency and phase characteristics of such equalizers are inverse to those of the line. Thus nullifying the distortion, making the overall frequency response, uniform in nature.

9. What is a distortion less line? What is the condition for a distortion less line?

A line in which there is no phase or frequency distortion and also it is correctly terminated,, is called a distortionless line.

RC = LG i.e. R/G = L/C

This is the required condition for distortionless line. For such a line received signal is exact replica of the signal at the sending end, though it is delayed by constant propagation time and its amplitude reduces.

10. What is the drawback of using ordinary telephone cables?

For an ordinary telephone cable

$$\alpha = \sqrt{\frac{\omega RC}{2}} \quad \text{And} \quad \beta = \sqrt{\frac{\omega RC}{2}}$$

$$v = \frac{\omega}{\beta} = \frac{\omega}{\sqrt{\frac{\omega RC}{2}}} = \sqrt{\frac{2\omega}{RC}}$$

Both α and velocity v are the functions of frequency ω. Hence for high frequencies, there is large attenuation. And the velocity v is also at high frequencies. Hence waves travel very fast than lower frequencies, when frequency is high. Thus in the telephone cable both phase and frequency distortions are dominant.

11. What is loading?

It is necessary to increase L/C ratio to achieve distortionless condition in a transmission line. This can be done by increasing the inductance of a transmission line. Increasing inductance by inserting inductances in series with line is termed as loading and such lines are called loaded lines.

12. Define reflection coefficient.

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

$$K = \frac{V_R}{V_S}$$

$$= \frac{Z_R - Z_O}{Z_R + Z_O}$$

Where Z_R = load impedance
Z_0 = characteristics impedance

13. What is a smooth line?

Finite line terminated in Z_o without having any reflection is called smooth line. The waves travel smoothly along the line and energy is absorbed in the load Z_o without any reflection.

14. List the parameters of a transmission line

Thus the four important transmission line parameters are

1. Resistance R→ Ω
2. Inductance L → H
3. Capacitance C →F
4. Conductance G → mho

These line parameters are constants and are called primary constants of the transmission line. These constants are assumed to be independent of frequency for the transmission line. These primary constants can be obtained by the measurements on a sample of the transmission line.

15.State the conditions for a distortion less line.

RC = LG i.e. R/G = L/C

This is the required condition for distortionless line. For such a line received signal is exact replica of the signal at the sending end, though it is delayed by constant propagation time and its amplitude reduces.

16. What are the disadvantages of parallel open wire line?

1. Exposed to atmosphere so affected by atmospheric conditions.
2. Need towers and posts to install.
3. Initial cost is high.
4. Short circuit chances due to flying objects.

17. What is the principle of reflection phenomenon?

Energy is transferred along the waves through electric field and magnetic field. When the line is terminated in Z_o, electric field energy W_e and magnetic field energy W_m are equal. But when line is not terminated in Z_o redistribution of these energies takes place. This redistribution is the main cause of reflection.

18. Define wave length.

The distance between the two points along the line at which currents or voltages differ in phase by 2π radians is called 1 wavelength of a line. It is given as,

$$\lambda = \frac{2\pi}{\beta}$$

19. Define velocity.

The wave travels distance of λ in one cycle. For which the time required is 1/f sec. Hence the velocity of propagation v can be written as,

v = distance travelled/ time taken $= \frac{\lambda}{\frac{1}{f}} = f\lambda$

$v = \frac{2\pi f}{\beta} = \frac{\omega}{\beta}$

It is measured in km/sec if β is in rad/km and in m/sec if β is in rad/m and so on

20. Why is waveform distorted in transmission line?

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

21. A transmission line with a characteristic resistance of 50 ohm is connected to a 100-ohm resistance load. Calculate the voltage reflection coefficient at the load.

$Z_O = 50 \angle 0° \Omega$ and $Z_R = 100 \angle 0° \Omega$

$= \frac{Z_R - Z_O}{Z_R + Z_O}$

$= 100-50 / 100+50$

$= 50 \angle 0° / 150 \angle 0°$

$= 0.333 \angle 0°$

22. Mention the characteristics of an infinite line.

In addition to the characteristics impendence, the infinite line has the following two important properties.

1. As the line has an infinite length, no waves will ever reach the receiving end and hence there is no possibility of the reflection at the receiving end. Thus there can not be any reflected waves, returning to the sending end. The complete power applied at the sending end is absorbed by the line.
2. As the reflected waves are absent, the characteristic impendence Z_O at the sending end will decide the current flowing, when a voltage is applied to the sending end. The current will not be affected by the terminating impedance Z_R at the receiving end. This condition is fulfilled by the long lines in practice.

23. What are the practical considerations of underground cable?

Hence for the unloaded underground cables, at audio frequencies, it can be assumed that

1. $\omega C \gg G$ hence G can be neglected.
2. $\omega L \gg R$ hence ω L can be neglected.

24. Discuss briefly about loading in Telephone cable.

Distortionless line with distributed parameters is used to avoid the frequency and delay distortion experienced on telephone cables. It is necessary to increase the L/C to achieve distotionless condition L/C = R/G. Heaviside suggested that the inductance be increased and Pupin suggested that this increase in the inductance by lumped inductors spaced at intervals along the line. This use of inductance is called loading the line. The distributed loading is obtained by winding the cable with a high permeability steel tape such as permalloy in some submarine cables.

25. What is return loss?

The ratio of power at the receiving end due to incident wave and power due to reflected wave by the load is called return loss.

UNIT III

PART A

1. State the assumptions for the analysis of the performance of the radio frequency line.

When a line, either open wire or of coaxial type is used at radio frequencies the following assumptions are made.

- The current is considered as following on the surface of the conductor in a skin of very small depth.
- $L\boldsymbol{\omega} \gg R$ because of skin effect.
- G may be considered as zero.

2. 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 points along the lines where magnitude of voltage or current is maximum are called antinodes or loops.

3. What is standing wave?

When a line is not terminated correctly into its characteristic impedance R_O then the part of energy transmitted returns back to the source as reflected wave. Then the distribution of voltage along the length of the line is not uniform, but minimum along the length of the line is not uniform; but minimum or maximum at different lengths. The points of minimum and maximum voltage or current are called nodes and antinodes respective. A line reflected back from the load consisting nodes and antinodes is called standing wave.

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

The range of values of standing wave ration is theoretically 1 to ∞

5. What is called standing wave ratio?

The ratio of maximum to minimum magnitudes of voltage or current on a line having standing waves is called the standing wave ratio(SWR).

SWR = $V_{max} / V_{min} = I_{max} / I_{min}$

6. Give the input impedance of dissipationless line.

$Z_{in} = R_O [Z_R + j R_O \tan \boldsymbol{\beta} s / R_O + j Z_R \tan \boldsymbol{\beta} s]$

Another convenient form of the I/P impedance is as follows. As Z_{in} is the I/P/impedance measured at

The sending end hence it is also termed as Z_S.

$\therefore Z_{in} = Z_S = R_O [1+ | K | \angle \boldsymbol{\phi} - \mathbf{2\beta s} / 1- | K | \angle \boldsymbol{\phi} - \mathbf{2\beta s}]$

The I/P impedance will be maximum at a distance

$Z_{S(max)} = R_O [1+|K| / 1- |K|] = S R_O$

Where S is standing wave ratio, thus $Z_{S(max)}$ becomes resistive.
Hence I/P impedance will be minimum if
$Z_{S(min)} = R_O / S$
Where S is standing wave ratio. Thus $Z_{S(max)}$ becomes resistive.

7. What is the application of the quarter wave matching section?
   a. One of the important applications is the impedance transformation in coupling a transmission line to a resistive load such as an antenna.
   b. The quarter wave line may be used to provide mechanical support to the open wire line or centre conductor of coaxial cable.

8. Explain impedance matching using stub.

Another mean of accomplishing impedance matching is the use of an open or short circuited line of suitable length, called stub at a designated distance from the load. This is called stub matching. There are two types of stub matching. They are
i) Single stub matching
ii) Double stub matching

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

$$L = \frac{\lambda}{2\Pi} \tan^{-1}\left[\frac{\sqrt{S}}{S-1}\right]$$

10. List the applications of the smith chart.
    1. Plotting an impedance
    2. Measurement of VSWR
    3. Measurement of reflection coefficient K [magnitude and phase]
    4. Measurement of I/P impendence of the line
    5. Impendence to admittance conversion

11. Write a note on 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"

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.

Smith Chart is based on two sets of orthogonal circles. The tangents drawn at the points of intersection of two circles would be mutually perpendicular one set of circles represent the rate of the resistive component(R) of the line impedance to the characteristic impedance (Z_o) of the line, which for a lossless line is purely resistive. The second set of circles represent the ratio of the reactive component(X) of the line impedance to the characteristic impedance (Z_o) of the line.

12. What are the difficulties in single stub matching?

The main disadvantage is that this technique is suitable for fixed frequency only. So as frequency changes, the location of the stub will have to be changed. Another disadvantages is that, for adjusting the stub for final position, along the line, the stub has to be moved or repositioned. This is possible for open wire conductor transmission line. But in case of co-axial cable it is difficult to locate V_{min} point without a slotted section.

13. Give reason for an open line not frequently employed for impedance matching.

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

14. Why Double stub matching is preferred over single stub matching?

The main disadvantage of single stub matching is that this technique is suitable for fixed frequency changes the location of the stub will have to be changed. Another disadvantage is that, for adjusting the stub for final position along the line, the stub has to be moved or repositioned.

To overcome the disadvantages a double stub impedance matching technique is used. In this technique two different short circuited stubs of length l_1 and l_2 are used for impedance matching.

15. A 50 ohm line is terminated in load Z_R (90+j60). Determine VSWR due to this load.

$$K = \frac{ZR - ZO}{ZR+ZO}$$

= 90+j60-50 / 90+j60+50 = 40+j60 / 140+j60

= 72.111$\angle\mathbf{56.3}°$ / 152.315$\angle\mathbf{23.2}°$ = 0.473$\angle\mathbf{33.1}°$

Therefore VSWR = 1+|K| / 1- |K| = 1+0.473 / 1- 0.473 = 2.795

16. Derive the expression for the voltage at a point S away from the receiving end interms of reflection coefficient.

Consider a transmission line of length l and terminated in Z_R as shown in the Fig. 2.1.

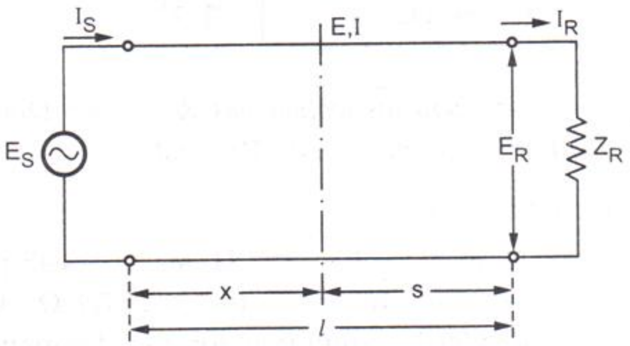


Fig. 2.1

In previous chapter we have obtained the expression for voltage E and current I at a distance x from sending end in terms of receiving end voltage E_R and receiving end current I_R.

The voltage E at a distance x from the sending end is given by,

$$E = E_R \cdot \cosh\gamma(l-x) + I_R \cdot Z_0 \sinh\gamma(l-x) \quad \text{... (1)}$$

Putting $(l-x) = s$, equation (1) reduces to,

$$E = E_R \cosh\gamma s + I_R \cdot Z_0 \sinh\gamma s \quad \text{... (2)}$$

But at very high frequencies,

$$Z_0 = R_0 \quad \text{and} \quad \gamma = j\beta$$

Hence equation (2) can be rewritten as,

$$E = E_R \cosh(j\beta s) + I_R R_0 \sinh(j\beta s)$$

$$\therefore \quad E = E_R \left[\frac{e^{j\beta s} + e^{-j\beta s}}{2}\right] + j I_R R_0 \left[\frac{e^{j\beta s} - e^{-j\beta s}}{2}\right]$$

$$\therefore \quad E = E_R \cos(\beta s) + j I_R \cdot R_0 \sin(\beta s) \quad \text{... (3)}$$

Above equation represents a voltage in terms of receiving end voltage and current, at a point distance 's' away from receiving end. 16

17. A line with characteristic impedance of 692∟-12º is terminated with 200 ohm resister. Determine K.

$Z_O = 692\angle -12°\Omega$ = 678.878-j143.87
$Z_R = 200\Omega$

The reflection coefficient is given by

$$K = \frac{ZR - ZO}{ZR + ZO}$$

= 200-(678.878-j143.87) / 200+(678.878-j143.87)

= 467.878+j143.87 / 878.878 – j143.87

K = 498.1$\angle\mathbf{163.21}$ / 890.57 $\angle -\mathbf{9.29}$

K = 0.559$\angle$ $\mathbf{172.5}^{\circ}$

18. Write a note on quarter wave line.

A quarter wave line may be used as a transformer for impedance matching of load Z_R with I/P impedance $Z_{in} = Z_R$.

For matching impedance Z_R and Z_{in}, the line with characteristic impedance R_o may be selected such that condition given in equation gets satisfied.

$$R_o = |\sqrt{Z_R . Z_{in}}|$$

A quarter wave line can transform a low impedance into a high impedance and vice versa, thus it can be considered as an impedance inverter. Hence an open circuited $\boldsymbol{\lambda/4}$ line gives zero I/P impedance while a short circuited $\boldsymbol{\lambda/4}$ line gives infinite I/P impedance. Thus a short circuit quarter wave line behaves as an open circuit at the other end while an open circuit quarter wave lines behaves as a short circuit at the other end.

19. A certain transmission line, working at ratio frequencies, has following constants L=9μH/m, C-16pf/m. the line is terminated in a resistive load of 1000Ω. Find the reflection coefficient and standing wave ratio.

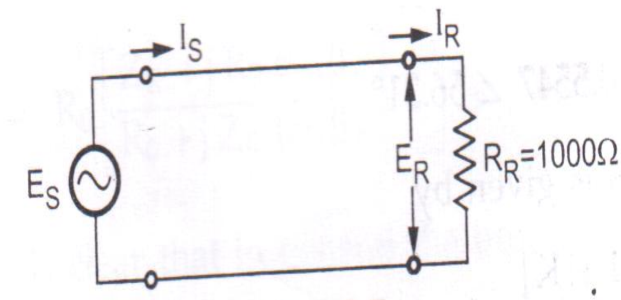


Fig. 2.7

The characteristic impedance of line is given by,

$$Z_0 = R_0 = \sqrt{\frac{L}{C}}$$

$$= \sqrt{\frac{9*10\text{-}6}{16*10\text{-}12}} \quad = \mathbf{750\Omega}$$

Hence reflection coefficient is given by

$$K = \frac{ZR - ZO}{ZR + ZO} = \frac{1000-750}{1000+750} = 0.1428$$

The standing wave ratio S is given by,

$$K = \frac{1+|K|}{1-|K|} = \frac{1+0.1428}{1-0.1428} = 1.3333$$

20. What is dissipation less line.

The velocity of propagation is given by

$v = \omega/\beta = \omega/\omega\sqrt{LC} = 1/\sqrt{LC}$ m/sec

The velocity of propagation for open wire disipationless line, separated by air, is same as the velocity of light in space.

The distance corresponding to the phase shift of 2π radians is called wavelength(λ). For the dissipationless line wave length is given by

$\lambda = 2\pi/\beta = 2\pi/\omega\sqrt{LC}$ m

21. Calculate the standing wave ratio and reflection co efficient on a line having Zo=300Ω and terminated in ZR=300 + j 400.

The reflection coefficient is given by

$$K = \frac{ZR - ZO}{ZR + ZO}$$

= 300-(300+j400) / 300+(300+j400)

= j 400/ 600 + j400

K = 400$\angle 90°$ / 721.11 $\angle 33.69°$

K = 0.5547$\angle 56.31°$

The standing wave ratio S is given by

S = 1+|K| / 1-|K| = 1+0.5547/ 1-0.5547 = 3.4913

22. What is resonant lines.

When transmission line is open circuited at its end, the current is always zero and voltage is maximum at the open end. This repeats at every $\boldsymbol{\lambda/4}$ distance from open end. From this it is clear that the I/P impedance varies all along the length of a line. The nature of the I/P impedance is also varying such as low resistance, high resistance, inductive reactance or capacitive reactance. These characteristics are similar to those of resonant circuit. Hence mismatched lines are called resonant lines.

23. Write the properties of smith chart.

1. The smith chart may be used for impedance as well as for admittances.
2. The smith chart consists constant r_i-circles and constant x_i-circles superpositioned on one chart. The values of r_i and x_i are normalized and they are given by

   $r_i = R/R_o$ and $x_i = j\frac{XR}{Ro}$ where $Z_R = R_R + jx_R$

   The constant r_i – circles have their centers on the horizontal axis i.e. u-axis and constant x_i – circles have their centers on the vertical axis i.e v-axis.
3. The smith chart is based on the assumption that,

   $|K| \angle\boldsymbol{\phi} - 2\boldsymbol{\beta s} = u+jv$

   The maximum magnitude of u+jv is the maximum value of |K| i.e. unity. Thus, in the chart, it is possible to locate all possible values of impedance inside the outer circle of unit radius.

4. The outer rim of the chart is scaled into either degrees or wavelengths with an arrow. This arrow indicates the direction of travel along the line. The outer circle is called $\boldsymbol{\beta s}$ scale of the chart which indicates the electrical length of the line.
5. If the smith chart is used for impedances, the inductive reactance are above r_i – axis or u-axis while the capacitive reactance are below u-axis.

24. What is a application of half wave line.

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

25. What is zero dissipation line?

If R is neglected completely as compared with $\boldsymbol{\omega L}$, then such a line is termed as zero dissipation line. This concept is useful when the line is used for transmission of power at a high frequency and the losses are neglected completely.

UNIT IV
PART A

1. What are guided waves? Give examples.

The electromagnetic waves that are guided along or over conducting or dielectric surfaces are called guided waves.

Examples: Parallel wires and transmission lines.

2. What is cut off frequency?

The frequency (f_c) at which the wave motion ceases, is called the cut-off frequency of the wave guide.
Below the cut-off frequency the wave propagation cannot occur and the phase shift is zero. Above the cut-off frequency, the wave propagation does occur and the attenuation of the wave is zero.

$$f_c = \frac{m}{2a} v$$

Where velocity $v = 1/\sqrt{\mu\varepsilon}$

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

The cut off frequency, $f_c = m/2a\sqrt{\mu\varepsilon} = \frac{mv}{2a}$

4. Give the expressions for the guide wavelength when the wave is transmitted in between two parallel plates.

The guide wavelength $\lambda_g = \dfrac{2\pi}{\sqrt{\omega 2\ \mu\varepsilon - \left(\frac{m\pi}{a}\right) 2}}$

5. Mention the characteristics of TEM waves.
   - Is a special type of TM wave.
   - It does not have either E_z or H_z component.
   - Its velocity is independent of frequency.
   - Its cut-off frequency is zero.

6. Define attenuation factor.

Attenuation factor $\alpha = \frac{Power\ lost\ /\ unit\ length}{2\ X\ Power\ transmitted}$

7. What is dominant mode? Give examples.

The lowest order mode is called dominant mode.
Examples: TE_{10} and TM_{11}.

8. What is TE 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 strength E_z in the same direction.

9. What is TM wave?

Transverse magnetic (TM) wave is wave in which the 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.

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

$$\alpha_{TE} = (f\,c/\ f)^2\ \alpha_{Tm}$$

11. Why are rectangular wave-guides preferred over circular wave-guides?

Rectangular waveguides are preferred over circular waveguides because of the following reasons.

1. Rectangular waveguide is smaller in size than a circular waveguide of the same operating frequency.
2. It does not maintain its polarization through the circular waveguide.
3. The difference between the lowest frequency on a dominant mode and the next mode of a rectangular waveguide is higher than that in a circular waveguide.

12. Mention the applications of wave guides.

- The waveguides are employed for transmission of energy at very high frequencies where the attenuation caused by a waveguide is smaller.
- Waveguides are used in microwave transmission. Circular waveguides are

used as attenuators and phase shifters.

13. 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.

[OR]

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 referred to as principal wave.

14. What is TM wave or E wave?

Transverse magnetic (TM) wave is wave in which the 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.

15. What is the boundary conditions of TEmn wave in rectangular wave guide?

Thus the boundary conditions for the TEmn wave are given as,

$E_y = 0$ at $x = 0$, for all values of y from 0 to b,
$E_y = 0$ at $x = a$, for all values of y from 0 to b,
$E_x = 0$ at $y = 0$, for all values of x from 0 to a, and
$E_x = 0$ at $y = b$, for all values of x from 0 to a.

16. Distinguish TE wave and TM wave?

TE	TM
Electric field strength E is entire transverse.	Magnetic field strength H is entirely transverse.
It has z component of magnetic field H_z	It has z component of electric field E_z (Direction of propagation)
It has no z component of electric field E_z ($E_z = 0$)	It has no component of magnetic field H_z ($H_z = 0$)

17. Give the dominant mode for TE and TM waves

Dominant Mode: TE_{10} and TM_{11}.

18. Mention the characteristics of TEM waves.

- It is a special type of TM wave.
- It does not have either E_z or H_z component.
- Its velocity is independent of frequency.
- Its cut-off frequency is zero.

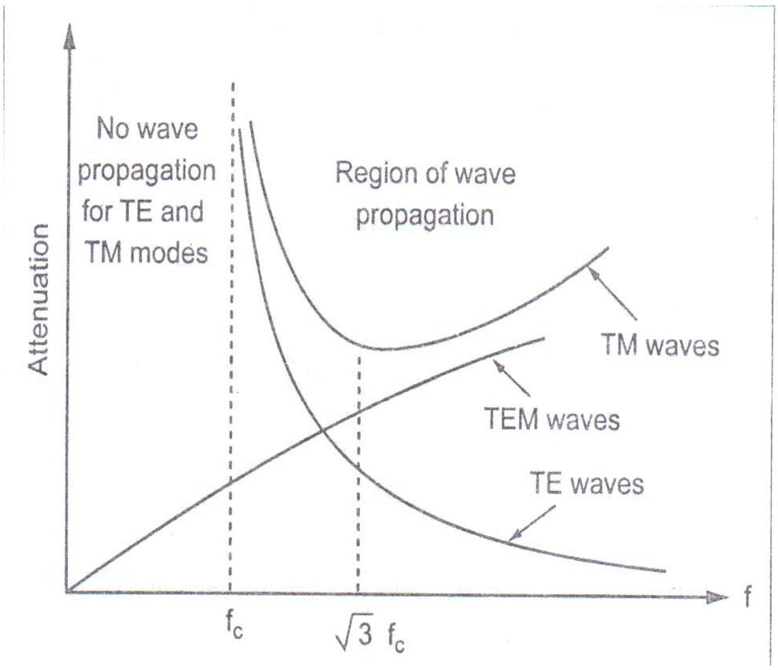
19. What is attenuation constant in range of propagation?

20. Define characteristic impedance in a waveguide.

For transmission lines the integrated characteristic impedance Z_o can be defined as in terms of the voltage-current ratio or in terms of power transmitted for given voltage or a given current.

i.e., $Z_0(V,I) = V/ I$
$Z_0(W,I) = 2 W/ I I^*$
$Z_0(W,V) = V V^*/ 2 W$
Where V and I are peak phasors. W is the power transmitted.
* indicates complex conjugate.

21. Draw the neat sketch showing the variation in the value of attenuation with frequency for TE,TM,TEM mode between parallel plates.



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

The attenuation $\propto_{TM}$ reaches a minimum value at a frequency equal to $\sqrt{3}$ times the cut-off frequency.

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

23. Define group velocity and phase velocity

The velocity with which the energy propagates along a guide is called group velocity. It is denoted by

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

If the frequency spread of the group is small enough $d\omega / d\beta$ may be considered to be constant throughout the group. It is always less than the free space velocity c.

Phase velocity is defined as the velocity of propagation of equiphase surfaces along a guide. It is denoted by

$$v_p = \omega / \beta$$

It is always greater than the free space velocity c.

24. For a frequency of 6000 MHz and plane separation of 7 cm, find critical wavelength.

Mode is TE_1 mode.
f = 6000 MHz
d = 7 cm = 7×10^{-2} m

Medium is air

Therefore $\mu_1 = \mu_0 = 4 \times \pi \times 10^{-7}$ and $\varepsilon_1 = \varepsilon_0 = 8.8542 \times 10^{-12}$

Critical frequency $f_c = m/2a \sqrt{1/\mu_1 \varepsilon_1}$

$$= 1/2 \times 7 \times 10^{-2} \sqrt{1/4 \times \pi \times 10^{-7} \times 8.8542 \times 10^{-12}}$$
$$= 2141.39 \text{ MHz}$$

25. What is attenuation for TEM wave.

The field strengths of electric and magnetic fields between parallel perfectly conducting planes for TEM wave.

$$\alpha = R_s / \eta a$$

Attenuation of TEM waves increases directly as the square root of frequency.

UNIT V
PART A

1. What are waveguide?

   A hollow conducting metallic tube of uniform cross section is used for propagating electromagnetic waves. Waves, that are guided along the surfaces (walls) of the tube is called waveguide.

2. What consists of wave guide?

   A waveguide consists of a hollow metallic tube of any arbitrary but uniform cross section. But the most commonly used waveguides are of either rectangular or circular cross-sections. These simple structures are less expensive to manufacture than other structures and have same electrical properties compares with others.

3. Draw the field distribution in TM wave in rectangular wave guide.

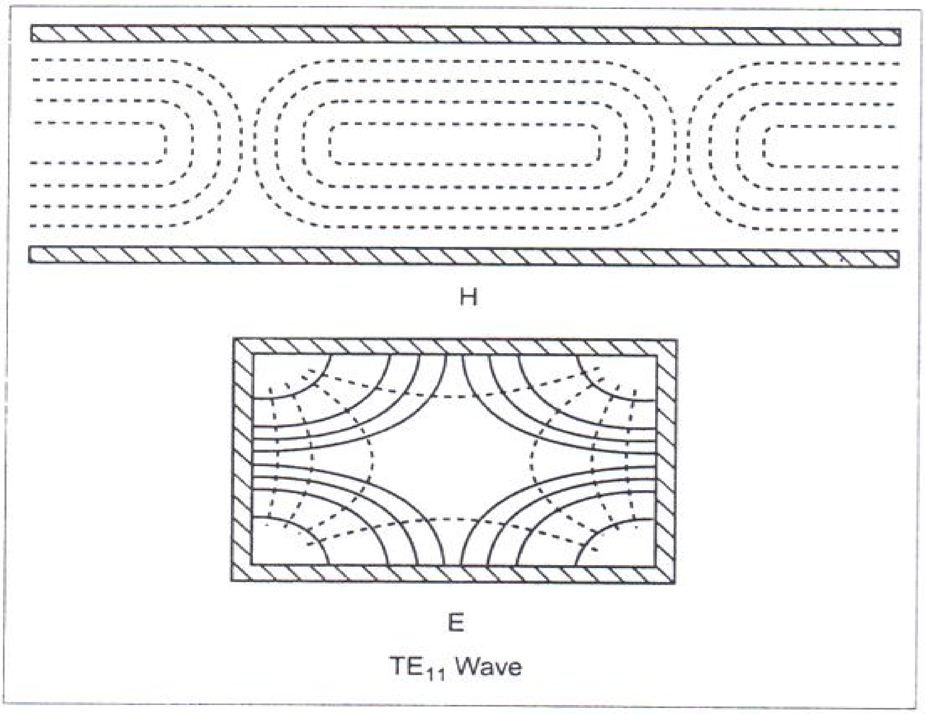


Fig. 4.2. Electric field and magnetic field configurations for the dominant mode in a rectangular wave guide

4. Write the boundary condition for the rectangular waveguide in rectangular co ordinate system (TM wave).

   Thus the boundary conditions for the rectangular waveguide in rectangular co ordinate system TM wave are given as,

   $E_Z = 0$ at $x = 0$, for all values of y from 0 to b,
   $E_Z = 0$ at $x = a$, for all values of y from 0 to b,
   $E_Z = 0$ at $y = 0$, for all values of x from 0 to a, and
   $E_Z = 0$ at $y = b$, for all values of x from 0 to a.

5. What is boundary condition of TEmn wave in rectangular wave guide?

Thus the boundary conditions for the TE wave rectangular waveguide are given as,

$E_Y = 0$ at $x = 0$, for all values of y from 0 to b,
$E_Y = 0$ at $x = a$, for all values of y from 0 to b,
$E_X = 0$ at $y = 0$, for all values of x from 0 to a, and
$E_X = 0$ at $y = b$, for all values of x from 0 to a.

6. What is meant by dominant mode of the wave?

The mode of the TX_{mn} wave for which the value of λ_{mn} is highest is known as the dominant mode of the wave.

Here m,n → integers (0 to ∞); X → E or m field

7. State the reason of impossibilities of TEM wave in wave guide.

Since Transverse electromagnetic (TEM) wave do not have axial component of either E or H, it cannot propagate within a single conductor waveguide.
Consider a TEM wave to exist within a hollow guide. In non-magnetic materials

$$\nabla \cdot H = 0$$

Which requires that the lines of H be closed loops in a plane perpendicular to the axis. According to Maxwell's first equation, the magnetomotive force around a closed loop is equal to the axial current. For a co-axial line the axial current is conduction current whereas for a hollow waveguide, the axial current is displacement current. But an axial displacement current requires an axial component of E which is not present in TEM wave. Therefore the TEM wave cannot exist in a waveguide.

8. Write the assumptions to be taken for analysis of rectangular wave guide in TE & TM modes?

9. What are the boundary conditions for the TE wave?

Thus the boundary conditions for the TEmn wave are given as,

$E_y = 0$ at $x = 0$, for all values of y from 0 to b,
$E_y = 0$ at $x = a$, for all values of y from 0 to b,
$E_x = 0$ at $y = 0$, for all values of x from 0 to a, and
$E_x = 0$ at $y = b$, for all values of x from 0 to a.

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

H_x, H_z and E_y

11. Which are non zero field components for the TM11 mode in a rectangular wave guide?

    H_x, H_y, E_y and E_z.

12. How the modes of the transverse electric and magnetic waves are represented?

13. What is the cut off wavelength & cut off frequency of the TE10 mode in a rectangular wave guide?

    Cut-off wavelength = $\lambda_c = 2a$

    Cut-off frequency, $f_c = c / 2a$

14. What is the cut off wavelength & cut off frequency of the TM11 mode in a rectangular wave guide?

    Cut-off wavelength, $\lambda_c = 2 / \sqrt{(1/a)^2 + (1/b)^2}$

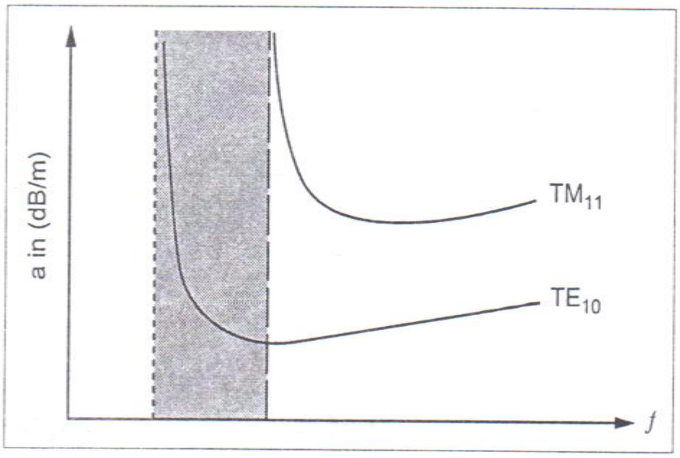
    Cut-off frequency, $f_c = 1/2\sqrt{\mu\epsilon}\,\sqrt{(1/a)^2 + (1/b)^2}$

    $= v/2\sqrt{(1/a)^2 + (1/b)^2}$

15. What are the root values for the TM modes?

16. Explain why TM01 & TM10 modes in a rectangular waveguides do not exist.
    For TM modes in rectangular waveguides, neither m or n can be zero because all the field equations vanish (i.e., $E_z = E_y = H_x = H_y = 0$), if m = 0, n=1 or m=1, n=0 no fields are present. Hence TM_{01} TM_{10} Modes in a rectangular waveguide do not exist.

17. Draw the neat sketch showing the variation of attenuation with frequency for TE & TM waves in a wave guide.



Attenuation due to wall losses in a rectangular copper waveguide for the TE_{10} and the TM_{11} modes.

18. Why the TE10 wave is called as dominant wave in rectangular wave guide?

    In TE_{mn} waves, either 'm' or 'n' equal to zero without causing all the field to vanish. The lowest order TE wave in rectangular guides is TE_{10} wave which has the lowest cut-off frequency. So, it is called dominant wave.

19. Write the note on excitation of waveguides.
20. Draw the field patterns for the dominant mode of TE_{mm} wave in the circular waveguide.

Fig.5.4 shows the TE waves in a circular waveguide.

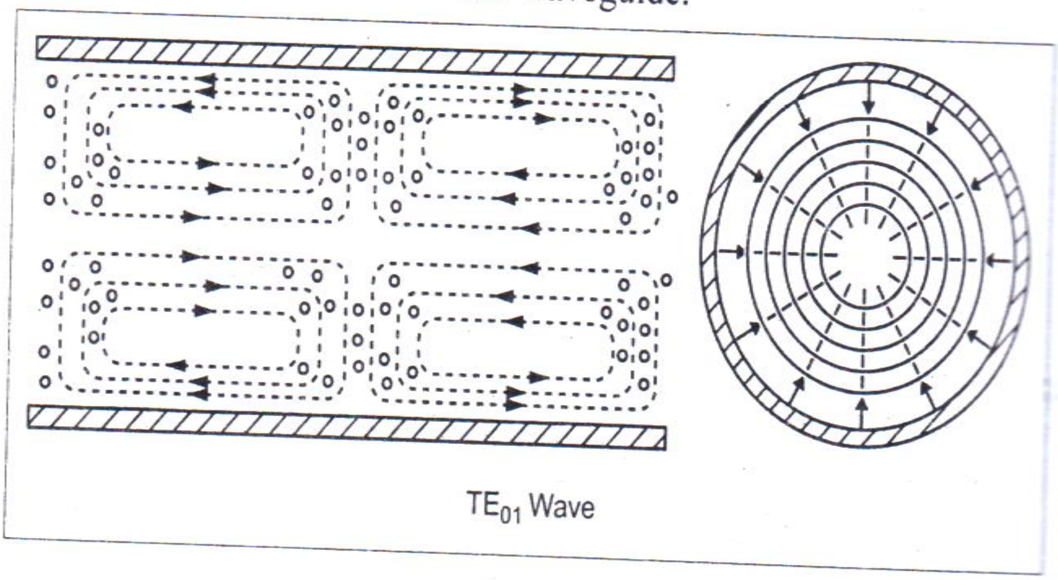


Fig. 5.4. TM waves in circular waveguide

21. Which is the most dominant mode in rectangular waveguide? Why?

    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). This wave has the lowest cut-off frequency. Hence the TE_{10} mode 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.

22. What is the Bessel's function?

The analysis of the field components within the hollow, perfectly conducting cylinder with uniform circular cross-section is carried out using the cylindrical co-ordinate system. The resulting differential equation is called Bessel's equation. The solution of such equation is called Bessel function.

23. Write a short notes on guide termination.
24. What is the cut off frequency of TEM wave?

Cut-Off frequency of TEM wave, $f_c = 0$

25. What is cavity resonator?

A shielded enclosure confines EM fields inside and furnish large area for current flow and eliminating radiation and high resistance effects. These enclosures have natural resonant frequencies and a very high 'Q' are called as cavity resonators.