GATE

2019

EMFT

ELECTRONICS ENGINEERING

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CONTENTS

CHAPTER		PAGE
1.	INTRODUCTION……………………………………………………….	1-30
2.	TIME VARYING FIELD…..…………………………………………	31-83
3.	STATIC MAGNETIC FIELD……..…………………………………..	84-133
4.	ELECTRO MAGNETIC FIELD………..…………………………….	134-220
5.	TRANSMISSION LINE…….…………………………………………	221-277
6.	WAVE GUIDE'S.…………………….…..……………………………	278-313
7.	ANTENNA ……………..…………..………………………………	314-353

CHAPTER - 1
INTRODUCTION

1.1 INTRODUCTION

1. Scalar

It refers to a quantity whose value may be repeated by a single real number (either +ve, -ve). x, y, z, we used in basic algebra to represents the scalar quantities e.g. mass, time, temperature, work etc.

2. Vector

It refers to the quantity has both magnitude and direction in space. Vector quantity can be defined in n-dimensional space in more advanced application e.g. force, velocity, displacement, acceleration.

Vector is represented by arrow whose direction is appropriately chosen and whose length is proportional to the magnitudes of vectors.

3. Field

If at each point of a region there is a corresponding value of some physical function that region is called field. Fields may be classified as scalar/ vector depending upon the type of function involved.

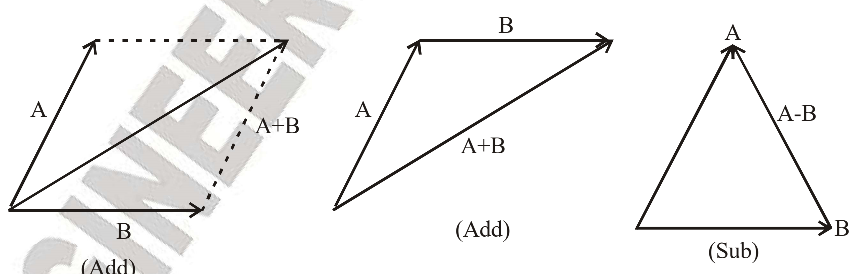
(i) Scalar Field

If the value of physical function at each point is a scalar quantity, then the field is scalar field.
Example of scalar fields is Temperature of atmosphere.

(ii) Vector Field

If the value of function at each point is a vector quantity then the field is vectors field.
Example

Wind velocity of atmosphere; Forced on a charge particle in electric Field effect.



3D vector is completely represented by its projection on the x, y, z, axis coordinate.

$$\vec{A} = A_x \hat{a}_x + A_y \hat{a}_y + A_z \hat{a}_z$$

GATE QUESTIONS

1. If the vector function:

$\vec{F} = \hat{a}_x(3y - k_1 z) + \hat{a}_y(k_2 x - 2z) - \hat{a}_z(k_3 y + z)$ is ir-rotational, then the values of the constants k_1, k_2 and k_3 respectively, are

[GATE - 2017]

(a) 0.3, –2.5, 0.5 (b) 0.0, 3.0, 2.0
(c) 0.3, 0.33, 0.5 (d) 4.0, 3.0, 2.0

2. The smaller angle (in degrees) between the planes $x + y + z = 1$ and $2x - y + 2z = 0$ is ___.

[GATE - 2017]

3. A three dimensional region R of finite volume is described by

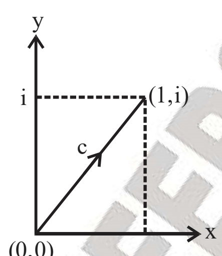
$x^2 + y^2 \leq z^3;\ 0 \leq z \leq 1,$

where x, y, z are real. The volume of R (up to two decimal places) is ____.

[GATE - 2017]

4. Consider the line integral $I = \int_c (x^2 + iy^2)dz$

where z is x + iy. The line c is shown in the figure below:



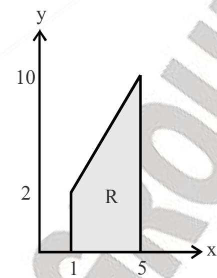
The value of I is

[GATE - 2017]

(a) $\frac{1}{2}i$ (b) $\frac{2}{3}i$

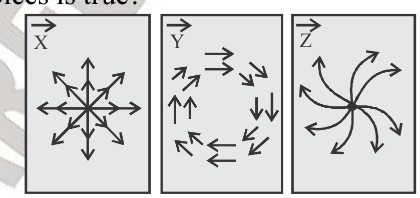
(c) $\frac{3}{4}i$ (d) $\frac{4}{5}i$

5. Let $I = c\iint_R xy^2 dxdy$, where R is the region shown in the figure and $c = 6 \times 10^{-4}$. The value of I equals ___. (Give the answer up to two decimal places)



[GATE - 2017]

6. The figures shows diagrammatic representations of vector fields $\vec{X}, \vec{Y}$, and $\vec{Z}$, respectively. Which one of the following choices is true?



[GATE - 2017]

(a) $\nabla.\vec{X} = 0, \nabla \times \vec{Y} \neq 0, \nabla \times \vec{Z} = 0$

(b) $\nabla.\vec{X} \neq 0, \nabla \times \vec{Y} = 0, \nabla \times \vec{Z} \neq 0$

(c) $\nabla.\vec{X} \neq 0, \nabla \times \vec{Y} \neq 0, \nabla \times \vec{Z} \neq 0$

(d) $\nabla.\vec{X} = 0, \nabla \times \vec{Y} = 0, \nabla \times \vec{Z} = 0$

7. Let x and y be integers satisfying the following equations :

$2x^2 + y^2 = 34$

$x + 2y = 11$

The value of (x +y) is _____.

[GATE - 2017]

8. Consider a function f(x, y, z) given by

$F(x,y,z) = (x^2 + y^2 - 2z^2)(y^2 + z^2)$

The partial derivative of this function with respect to x at the point x = 2, y = 1 and z = 3 _____.

[GATE - 2017]

CHAPTER - 3
STATIC MAGNETIC FIELD

3.1 BIOT SAVART'S LAW

It is an ampere law for current Element.

$I\overrightarrow{dL}$ = a small zero length D.C current carrying wire as the basic cause of magnetic field. It is called as current element.

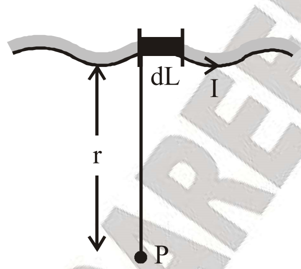
$$\vec{H} = \frac{I\overrightarrow{dL} \times \hat{a}_r}{4\pi r^2} A/m$$

Above is the equation of magnetic field

H (direction) = I (flow direction) × Radial Direction for current

$$\vec{B} = \mu\vec{H}$$

$$\vec{B} = \frac{\mu\, I\overrightarrow{dL} \times \hat{a}_r}{4\pi r^2} wb/m^2$$



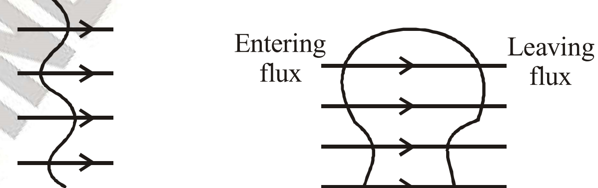
Magnetic force is weakest force.

3.1.1 Basic Current Element

$$I\overrightarrow{dL} = J_s\overrightarrow{ds} = J_v\overrightarrow{dv}$$

1. Magnetic field lines are always closed in nature.

2. They are always around the current.



Open surface | Closed surface

$\int \vec{B}.\overrightarrow{ds} = \sum \psi_m$ = vector | $\oint \vec{B}.\overrightarrow{ds} = 0$

3. Magnetic field line do not Start/End at point i.e. they lane no source & no sink.

GATE QUESTIONS

1. A soft-iron toroid is concentric with a long straight conductor carrying a direct current I. If the relative permeability μ_r of soft-iron is 100, the ratio of the magnetic flux densities at two adjacent points located just inside and just outside the toroid is _______.

[GATE - 2016]

2. Faraday's law of electromagnetic induction is mathematically described by which one of the following equations?

[GATE - 2016]

(a) $\nabla \bullet \vec{B} = 0$ (b) $\nabla \bullet \vec{D} = \rho_v$

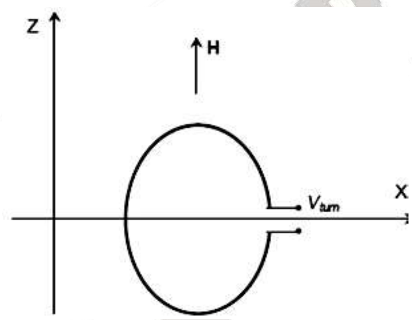
(c) $\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$ (d) $\nabla \times \vec{H} = \sigma \vec{E} + \frac{\partial \vec{D}}{\partial t}$

3. A uniform and constant magnetic field B = $\hat{z}$ B exists in the $\hat{z}$ direction in vacuum. A particle of mass m with a small charge q is introduced into this region with an initial velocity $v = \hat{x}v_x + \hat{z}v_z$. Given that B, m, q, v_x and v_z are all non-zero, which one of the following describes the eventual trajectory of the particle?

[GATE - 2016]

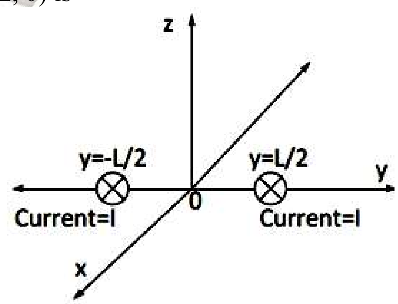
(a) Helical motion in the zˆ direction
(b) Circular motion in the xy plane
(c) Linear motion in the zˆ direction
(d) Linear motion in the xˆ direction

4. A circular turns of radius 1m revolves at 60 rpm about its diameter aligned with the x – axis as show in the figure. The value of μ_0 is $4\pi \times 10^{-7}$ in SI unit. If a uniform magnetic field intensity $\vec{H} = 10^7 \hat{z} A/m$ is applied, then the peak value of the induced voltage, V_{turn} (in Volts), is _________.



[GATE - 2015]

5. A steady current I is flowing in the – x direction through each of two infinitely long wires at $y = \pm \frac{L}{2}$ as shown in the figure. The permeability of the medium is μ_0. The $\vec{B}$ - field at (0, L, 0) is



[GATE - 2015]

(a) $-\frac{4\mu_0 I}{3\pi L}\hat{Z}$ (b) $+\frac{4\mu_0 I}{3\pi L}\hat{Z}$

(c) 0 (d) $-\frac{3\mu_0 I}{4\pi L}\hat{Z}$

6. A region shown below contains a perfect conducting half – space and air. The surface current $\vec{K_s}$ on the surface of the perfect conductor is $\vec{K_s} = \hat{x}2$ amperes per meter. The

CHAPTER - 4
ELECTRO MAGNETIC FIELD

4.1 UNIFORM PLANE WAVE

Equation of Electromagnetic Wave

$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$ (Derived from faraday law of electromagnetic induction)

$\nabla \times \vec{H} = \sigma \vec{E} + \frac{\partial \vec{D}}{\partial t}$ (Ampere circuital law)

These two maxwell equations are responsible for generation of em waves. Time variation of one will induce the orthogonal wave of second field & vice-versa. This process keeps on repeating during the propagation of energy & energy is a form of disturbance and that disturbance is represented or carried over in the form of electromagnetic wave. Time varying field is must for the generation of em waves.

4.1.1 Generation Of Em-Wave

If there is an electric flux then their energy is transforming between electric and magnetic energy. Energy is in the alternating form.

$\text{Electric field} = \frac{1}{2} \in E^2;$

$\text{Magnetic field} = \frac{1}{2} \mu H^2$

1. Condition of EM-Wave

(i) If the DC is present then no wave is propagated

(ii) When time varying electric field and magnetic field is present.

(iii) This flow of energy takes place sometimes in the form of electrical energy and sometimes in the form of magnetic energy. This is a continuous process for alternating fields and hence electromagnetic waves propagate through this medium with a fix amount of energy.

(iv) When energy present and disturbance and created that disturbance travel through the distance and the wave travel .Wave direction is generated for the propagation.

$$\nabla \times \vec{E} = -\frac{\partial B}{\partial t} \quad \ldots(i)$$

$$\nabla \times \vec{H} = \sigma \vec{E} + \frac{\partial \vec{D}}{\partial t} \quad \ldots(ii)$$

Taking curl of equation (i) in both sides

$$\nabla \times (\nabla \times \vec{E}) = \nabla \times \left(\frac{-\partial B}{\partial t} \right)$$

$$(\nabla \cdot \vec{E})\nabla - (\nabla^2 E) = \frac{-\partial}{\partial t} \left(\nabla \times \mu H \right)$$

(v) Assuming medium to be homogeneous the only way ‘μ’ can be taken out is

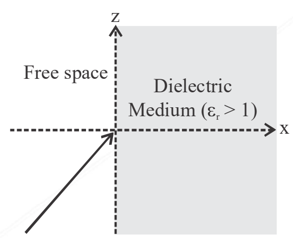
$$(\nabla \cdot \vec{E})\nabla - (\nabla^2 \vec{E}) = -\mu \frac{\partial}{\partial t} (\nabla \times \vec{H})$$

GATE QUESTIONS

1. A uniform plane wave traveling in free space and having the electric field

$$\vec{E} = \left(\sqrt{2}\hat{a}_x - \hat{a}_z\right)\cos\left[6\sqrt{3}\pi \times 10^8 t - 2\pi\left(x + \sqrt{2}z\right)\right] V/m$$

is incident on a dielectric medium (relative permittivity > 1, relative permeability = 1) as shown in the figure and there is no reflected wave.



The relative permittivity (correct to two decimal places) of the dielectric medium is ______

[GATE - 2018]

2. The distance (in meters) a wave has to propagate in a medium having a skin depth of 0.1 m so that the amplitude of the wave attenuates by 20 dB, is

[GATE - 2018]

(a) 0.12 (b) 0.23
(c) 0.46 (d) 2.3

3. If a right-handed circularly polarized wave is incident normally on a plane perfect conductor, then the reflected wave will be

[GATE - 2016]

(a) Right-handed circularly polarized
(b) Left-handed circularly polarized
(c) Elliptically polarized with a tilt angle of 45°
(d) horizontally polarized

4. The electric field of a uniform plane wave travelling along the negative z direction is given by the following equation:

$$\vec{E}_w^i = (\hat{a}_x + j\hat{a}_y) E_0 e^{jkz}$$

This wave is incident upon a receiving antenna placed at the origin and whose radiated electric field towards the incident wave is given by the following equation:

$$\vec{E}_a = (\hat{a}_x + 2\hat{a}_y) E_I \frac{1}{r} e^{-jkr}$$

The polarization of the incident wave, the polarization of the antenna and losses due to the polarization mismatch are, respectively,

[GATE - 2016]

(a) Linear,Circular (clockwise), –5dB
(b) Circular(clockwise),Linear, –5dB
(c) Circular(clockwise),Linear, –3dB
(d) Circular(anti clockwise), Linear, –3dB

5. The electric field of a plane wave propagating in a lossless non-magnetic medium is given by the following expression

$$E(x,t) = a_x 5\cos(2\pi \times 10^9 t + \beta z)$$
$$+ a_y 3\cos\left(2\pi \times 10^9 t + \beta z - \frac{\pi}{2}\right)$$

The type of the polarization is

[GATE - 2015]

(a) Right Hand Circular.
(b) Left Hand Elliptical.
(c) Right Hand Elliptical.
(d) Linear.

6. The electric field component of a plane wave traveling in a lossless dielectric medium is given by $\vec{E}(z.t)\hat{a}_y 2\cos\left(10^8 t - \frac{z}{\sqrt{2}}\right) V/m$ .The wavelength (m m) for the wave is _____.

[GATE - 2015]

7. The electric field of a uniform plane electromagnetic wave is

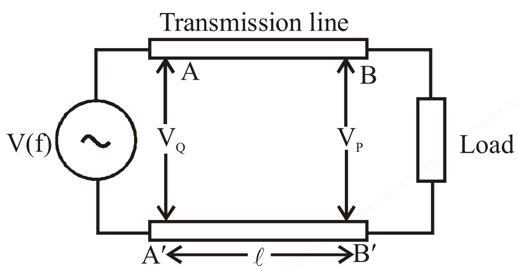
$$\vec{E} = (\vec{a}_x + j4\vec{a}_y)\exp[j(2\pi \times 10^7 t - 0.2z)]$$

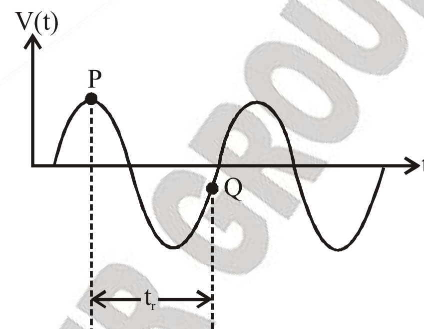
[GATE - 2015]

The polarization of the wave is
(a) Right handed circular

CHAPTER - 5
TRANSMISSION LINE

5.1 TRANSIT TIME EFFECT





1. No Signal can travel with infinite velocity. That is to say that if a voltage or current changes at some location, its effect cannot be felt instantaneously at some other location. There is a finite delay between the 'cause' and the effect. This is called the ' Transit Time' effect.
2. Consider the two-conductor line which is connected to a sinusoidal signal generator of frequency '*f*' at one end and a load impedance at the other end. Due to the transit time effect the voltage applied at AA' will not appear instantaneously at BB'.
3. Let the signal travel with velocity ν along the line. Then the Transit time

$$t_\gamma = \frac{l}{\nu}$$

Where l is length of line.
4. At some instant let the voltage at AA' be V_p. Then V_p. will appear at BB' only after t_γ. However, during this time the voltage at AA' changes to (say) V_Q.

5.1.1 Important Observation

1. Even for ideal conductors i.e., no resistance, there is a voltage difference between AA' and BB'
2. When is transmit-time effect important?
Ideally the transit time effect should be included in analysis of all electrical circuits. However if the time period of the signal $T=1/f$ is much larger than the transit time, we may ignore the effect of transmit time. That is, the transit time effect can be neglected if

$$T >> t_r$$

$$\frac{1}{f} >> \frac{1}{\nu}$$

$$\frac{\nu}{f} >> l$$

Since $\frac{\nu}{f}$ =wavelength λ, we get

$$\therefore \lambda >> l$$

ASSIGNMENT

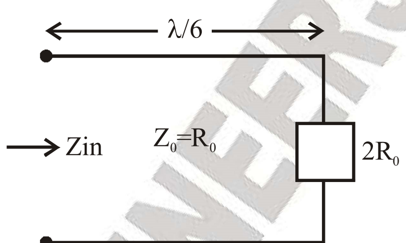
1. When $Z_1 > Z_0$, the VSWR on a line is its
(a) Normalized load impedance
(b) Normalized input impedance
(c) Characteristic impedance
(d) Load impedance

2. A lossless TL has a length of 50cm with L=10μH/m and C=40 pF/m. if it is operated at 30 MHz, its electrical length is
(a) 28º (b) 48º
(c) 108º (d) 40π

3. A line has a velocity of 1.5×10^8 m/s with an ideal dielectric having $\in_R$=4 between the cables. The line is
(a) Lossy but not having distortion
(b) Lossless and distortion
(c) Lossy and distortionless
(d) None of these

4. On a Smith chart the concentric circle with R= 0 circle is
(a) R=Constant circle (b) X=1 circle
(c) $|\Gamma|$=constant circle (d) None of these

5. The input impedance of the line shown below is



(a) $2R_0$ (b) $\frac{R_0(2+j\sqrt{3})}{(1+j2\sqrt{3})}$
(c) $\frac{R_0}{2}$ (d) $R_0\left(\frac{1+j}{1-j}\right)$

6. A certain line having R_0 = 400Ω and length =λ, is = open at both ends. The impedance at a point λ/4 from one end is
(a) 0 (b) 400Ω
(c) ∝ (d) 200Ω

7. A 50Ω lossless line is terminated by a load impedance of 75Ω. If the signal power is 100mW, the power dissipated by the load is
(a) 80 mW (b) 20 mW
(c) 96 mW (d) 4 mW

8. A short circuited line has
$Z_{in} = jZ_0/\sqrt{3}$ The Length of the line is
(a) λ/8 (b) λ/6
(c) λ/12 (d) λ/4

9. A TL has an attenuation of 0.3 dB/km. After 10km from the source, the fraction of the power is
(a) 1/2 (b) 1/3
(c) 1/4 (d) 1/10

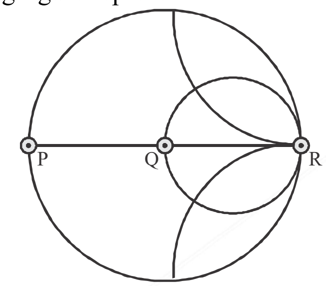
10. A lossy TL is terminated by load Z_L and has Characteristic impedance Z_0 and open circuit input impedance Z_{OC}. The Z_{in} of the line is
(a) $\frac{Z_0^2(Z_{OC}+Z_L)}{Z_0^2+Z_LZ_{OC}}$ (b) $\frac{Z_0^2(Z_L-Z_{OC})}{Z_0^2-Z_LZ_{OC}}$
(c) $\frac{Z_{OC}^2}{Z_0^2+Z_LZ_{OC}}$ (d) $\frac{Z_0^2+Z_LZ_{OC}}{Z_L+Z_{OC}}$

11. A line of 75Ω impedance is terminated with 100Ω load. Its maximum impedance on the line is
(a) 100Ω (b) 56Ω
(c) 156Ω (d) 126Ω

12. Which of the following circles will never intersect each other on a Smith chart?
(a) R=0 circle and X=1 circle
(b) R=1 circle and X=0 circle
(c) R=∞ circle and X=0 circle

GATE QUESTIONS

1. The points P, Q and R shows on the Smith chart (normalized impedance chart) in the following figure represent:



[GATE - 2018]

(a) P : Open Circuit, Q : Short Circuit, R : Matched Load
(b) P : Open Circuit, Q : Matched Load, R : Short Circuit
(c) P : Short Circuit, Q : Matched Load, P : Open Circuit
(d) P : Short Circuit, Q : Open Circuit, P : Matched Load

2. A lossy transmission line has resistance per unit length R = 0.05 Ω/m. The line is distortionless and has characteristic impedance of 50 Ω. The attenuation constant (in Np/m correct to three decimal places) of the line is __________.

[GATE - 2018]

3. A two wire transmission line terminates in a television set. The VSWR measured on the line is 5.8. The percentage of power that is reflected from the television set is ______.

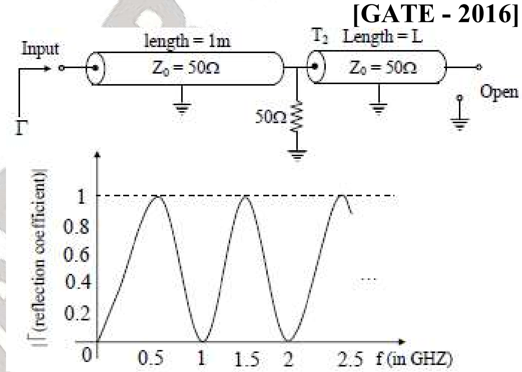
[GATE - 2017]

4. The voltage of an electromagnetic wave propagating in a coaxial cable with uniform characteristic impedance is $V(\ell) = e^{-\gamma\ell + j\omega t}$ Volts, where ℓ is the distance along the length of the cable in meters, $\gamma = 90.1 + j40)m^{-1}$ is the complex propagation constant, and $\omega = 2\pi \times 10^9$ rad/s is the angular frequency. The absolute value of the attenuation in the cable in dB/meter is ______.

[GATE - 2017]

5. A microwave circuit consisting of lossless transmission lines T_1 and T_2 is shown in the figure. The plot shows the magnitude of the input reflection coefficient Γ as a function of frequency f. The phase velocity of the signal is transmission lines is 2×10^8 m/s.

[GATE - 2016]



6. The propagation constant of a lossy transmission line is (2 +j5) m-1 and its characteristic impedance is (50 + j0) Ω at ω = 10^6 rad S^{-1}. The values of the line constants L,C,R,G are, respectively.

[GATE - 2016]

(a) L = 200 μH/m, C = 0.1μF/m, R = 50 Ω/m, G = 0.02 S/m
(b) L = 250 μH/m, C = 0.1μF/m, R = 100 Ω /m, G = 0.04 S/m
(c) L = 200μH/m, C = 0.2μF/m, R = 100 Ω /m, G = 0.02 S/m
(d) L = 250μH/m, C = 0.2μF/m, R = 50 Ω /m, G = 0.04 S/m

7. A coaxial cable is made of two brass conductors. The spacing between the conductors is filled with Teflon (ε_r = 2.1, tan δ=0). Which one of the following circuits can represent the

CHAPTER - 6
WAVE GUIDE'S

6.1 INTRODUCTION

The guided structure used for transmission and reception of signal from transmitter to antenna and antenna to receiver at microwave frequency. At high frequency take place in E/H format in contrast low frequency V/I format. The propagation of energy at high frequency can be both guided or unguided wireless transmission is the example of later and guided structure is example of former. At high frequency the waves at reflected from the walls of the guided structure through the phenomena of reflection. If the guided walls are not perfectly conducting then wave absorption take place which result in the wave losses as discussed earlier in EM wave propagation. The material in side guided structure is dielectric material which also should be perfectly dielectric otherwise this dielectric loss will be the second contributing factor for the wave loss and these wave losses appear in from of attenuation.

α_d = dielectric loss

α_c = conduction loss

$\alpha = \alpha_c + \alpha_d$ Total loss

6.1.1 Dispersive Wave Nature

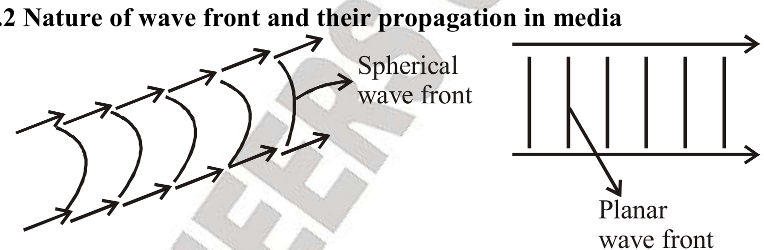
1. $E(x, y, z, t)_{(x, y, z)}$

2.$H(x, y, z, t)_{x, y,z)}$

3. High frequency wave are practically dispersive spreading out and obeying "Huygen wave principle" that every ray is a source of secondary emission.

4. This is the cause of diffraction or diffusion property of EM wave which is the advantage of broadcast application but serious disadvantage in point-point communication. Hence wave guide are used to confine the wave with in specific bounds.

6.1.2 Nature of wave front and their propagation in media



6.1.3 There are three Guided Wave Structure

1. Parallel plate waveguide

2. Rectangular waveguide

3. Circular waveguide

ASSIGNMENT

1. A parallel plane waveguide has a separation of 2.5 cm. If the frequency of operation is 200 GHz, the wave angle of the wave is
(a) $\sin^{-1}(3/11)$ (b) $\sin^{-1}(3/22)$
(c) $\sin^{-1}(9/11)$ (d) $\sin^{-1}(9/22)$

2. The dominant mode f_c for a guide is 8 GHz with air separating the parallel plates of the guide. If as dielectric of $\in_R>1$ is, introduced between the guides then f_c
(a) Increases (b) Decrease
(c) Remains constant (d) Data insufficient

3. In a parallel plane guide of 2 cm separation, 25GHz belongs to
(a) 1st mode (b) 2nd mode
(c) 3rd mode (d) Dominant mode

4. In a guide a common wave angle is shared by two frequencies
(a) When they belong to the same mode
(b) When they belong to the dominant mode
(c) When they belong to different modes
(d) None of these

5. A wave guide of (4 × 7) cm has air between the guide walls. The H_x field is

$$H_X = 2\sin\left(\frac{\pi x}{a}\right)\cos\left(\frac{3\pi y}{b}\right)\sin(\omega t-\beta z)$$

The mode of operation for guide is
(a) TE_{13} or TM_{13} (b) TE_{31} or TM_{31}
(c) TE_{26} or TM_{26} (d) TE_{62} or TM_{26}

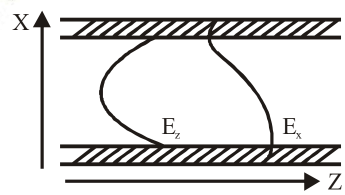
6. An air filled rectangular wave guide has a dominant mode cutoff of 9 GHz. One of the dimension of the guide is
(a) 4.3 cm (b) 0.8 cm
(c) 3.3 cm (d) 1.66 cm

7. Two parallel conducting plates located at x = 2 and x = 12 behave like a waveguide. The TE wave has the following components zero.
(a) E_x, H_y, H_z (b) E_x, H_y, E_z
(c) E_y, H_x, H_z (d) E_y, H_x, E_z

8. Which of the following modes have the least cut off frequency for a rectangular waveguide of a × b sides with a > b?
(a) TE_{11}
(b) TE_{20}
(c) TE_{02}
(d) All have the same value of cutoff frequency

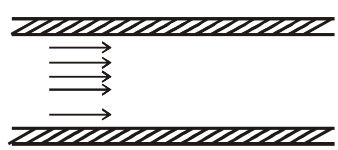
9. A guide has its dimensions as 2cm × 2cm. the ratio of the dominant mode cutoff frequencies in TE to TEM mode is
(a) 1:1
(b) 1:2
(c) 2:1
(d) $\sqrt{2}:1$
(e) $1:\sqrt{2}$
(f) None of these

10.



A wave having the above two components between the guide walls should be
(a) TE (b) TEM
(c) TM (d) None of these

11.



The above E/H field could possibly be representing a
(a) Wave which is completing a full cycle between the guide walls
(b) Wave which is completing a half cycle between the guide walls
(c) A wave which is completing a quarter cycle between the guide walls

GATE QUESTIONS

1. The cut-off frequency of TE_{01} mode of an air filled rectangular waveguide having inner dimensions a cm × b cm (a > b) is twice that of the dominant TE_{10} mode. When the waveguide is operated at a frequency which is 25% higher than the cut-off frequency of the dominant mode, the guide wavelength is found to be 4 cm. The value of b (in cm, correct to two decimal places) is ___________

[GATE - 2018]

2. Standard air filled rectangular waveguides of dimensions a = 2.29 cm and b = 1.02 cm are designed for radar applications. It is desired that these waveguides operate only in the dominant TE_{10} mode with the operating frequency at least 25% above the cut-off frequency of the TE_{10} mode but not higher than 95% of the next higher cutoff frequency. The range of the allowable operating frequency f is

[GATE - 2017]

(a) 8.19 GHz ≤ f ≤ 13.1 GHz
(b) 8.19 GHz ≤ f ≤ 12.45 GHz
(c) 6.55 GHz ≤ f ≤ 13.1 GHz
(d) 1.64 GHz ≤ f ≤ 10.24 GHz

3. Consider an air-filled rectangular waveguide with dimensions a = 2.286 cm and b = 1.016 cm. The increasing order of the cut-off frequencies for different modes is

[GATE - 2016]

(a) $TE_{01} < TE_{10} < TE_{11} < TE_{20}$
(b) $TE_{20} < TE_{11} < TE_{10} < TE_{01}$
(c) $TE_{10} < TE_{20} < TE_{01} < TE_{11}$
(d) $TE_{10} < TE_{11} < TE_{20} < TE_{01}$

4. Consider an air-filled rectangular waveguide with dimensions a = 2.286cm and b = 1.016cm. At 10GHz operating frequency, the value of the propagation constant (per meter) of the corresponding propagation mode is _______

[GATE - 2016]

5. The longitudinal component of the magnetic field inside an air-filled rectangular waveguide made of a perfect electric conductor is given by the following expression

$$Hz(x,y,z,t) = 0.1\cos(25\pi x)\cos(30.3\pi y)\cos(12\pi\times10^9 t-\beta z)(A/m)$$

The cross-sectional dimensions of the waveguide are given as a = 0.08 m and b = 0.033 m. The mode of propagation inside the waveguide is

[GATE - 2015]

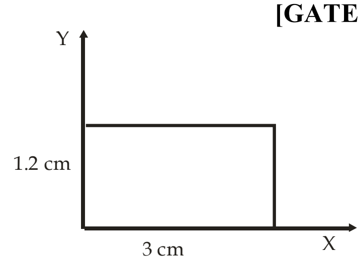
(a) TM_{12}
(b) TM_{21}
(c) TE_{21}
(d) TE_{12}

6. For a rectangular waveguide of internal dimensions a × b (a > b), the cut – off frequency for the TE_{11} mode is the arithmetic of the cut – off frequencies for TE_{10} mode and TE_{20} mode. If a = $\sqrt{5}$ cm, the value of b (in cm) is ___________.

[GATE - 2014]

7. The magnetic field among the propagation direction inside a rectangular waveguide with the cross-section shown in the figure is
$H_z = 3\cos(2.094\times10^2 x)\cos(2.618\times10^2 y)\cos(6.283\times10^{10}t-\beta z)$

[GATE - 2012]



The phase velocity v_p of the wave inside the waveguide satisfies
(a) $v_p > c$
(b) $v_p = c$
(c) $0 < v_p < c$
(d) $v_p = 0$