

II B.Tech I Semester Supplementary Examinations, February 2008
ELECTROMAGNETIC WAVES AND TRANSMISSION LINES
(Electronics & Instrumentation Engineering)

Time: 3 hours

Max Marks: 80

Answer any FIVE Questions
 All Questions carry equal marks

1. (a) State and explain Coulomb's law. Obtain an expression in vector form.
 (b) Two uniform line charges of density 8nC/m are located in a plane with $y = 0$ at $x = \pm 4\text{m}$. find the E- field at a point $P(0\text{m}, 4\text{m}, 10\text{m})$ [6+10]
2. (a) State Biot- Savart law
 (b) Derive an expression for magnetic field strength, H , due to a finite filamentary conductor carrying a current I and placed along Z - axis at a point 'P' on y -axis. Hence deduce the magnetic field strength for the length of the conductor extending from $-\infty$ to $+\infty$. [4+12]
3. A square filamentary loop of wire is 25 cm on a side and has a resistance of 125Ω per meter length. The loop lies in $z=0$ plane with its corners at $(0,0,0)$ $(0.25,0,0)$, $(0.25,0.25,0)$ and $(0,0.25,0)$ at $t=0$ the loop is moving with velocity $v_y = 50\text{m/s}$ in the field $B_z = 8\cos(1.5 \times 10^8 t - 0.5x)\mu\text{T}$. Develop a function of time which expresses the ohmic power being delivered to the loop. [16]
4. (a) For good dielectrics derive the expressions for α, β, ν and η .
 (b) For a uniform plane wave in space $\lambda = 12\text{cm}$. In a loss less material of unknown characteristics $\lambda = 8\text{cm}$. In this material $E = 50\text{V/m}$, $H = 0.1\text{ A/M}$ find f , $\mu r \in r$. [8+8]
5. (a) Define surface impedance and explain how it exists.
 (b) In free space ($z \leq 0$), a plane wave with $H = 10 \cos(10^8 t - \beta z) \hat{a}_x \text{ mA/m}$ is incident normally on a loss less medium ($\epsilon = 2\epsilon_0, \mu = 8\mu_0$) in region $Z \geq 0$. Determine the reflected wave H_r, E_r and the transmitted wave H_t, E_t . [8+8]
6. (a) Define and derive the equations for phase and group velocities in a parallel plane guide. On which factors do they depend ?
 (b) Derive the relation $\lambda = \frac{\lambda_c \lambda_g}{\sqrt{\lambda_g^2 + \lambda_c^2}}$ where λ is free space wave length, λ_g is the wave length measured in the guide, and λ_c is the cut off wave length. [8+8]
7. (a) Starting from the equivalent circuit, derive the transmission line equations for V and I , in terms of the source parameters
 (b) Give T and π equivalent network representation for a transmission line [10+6]

8. (a) Explain what is meant by voltage reflection coefficient in a transmission line. The voltage reflection coefficient due to load connected to a lossless transmission line of characteristic impedance $100\ \Omega$ and working at 3 GHz is $0.5\angle 45^\circ$. Assuming the load voltage to be 10 V , calculate the r.m.s voltage and current at intervals of one fourth wave length from the load up to a distance 5 cm .
- (b) A $75\ \Omega$ line is terminated by a load of $120 + j80\ \Omega$. Find the maximum and minimum impedances on the line. [10+6]

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2. (a) Obtain an expression for differential magnetic field strength dH due to differential current element $I dl$ at the origin in the positive Z- direction.
 (b) Find the magnetic field strength, H at the centre of a square conducting loop of side '2a' in $Z=0$ plane if the loop is carrying a current , I , in anti clock wise direction. [6+10]
3. (a) Explain faraday's law for time varying fields.
 (b) Verify that the displacement current in the parallel plate capacitor is the same as the conduction current in the connecting wires. [8+8]
4. (a) A plane sinusoidal electromagnetic wave travelling in space has $E_{max} = 1500\mu\text{V/m}$
 i. Find the accompanying H_{max}
 ii. The average power transmitted
 (b) The electric field intensity associated with a plane wave travelling in a perfect dielectric medium is given by $E_x(z, t) = 10 \cos (2\pi \times 10^7 t - 0.1 \pi z)\text{V/m}$ [4+4+8]
 i. What is the velocity of propagation
 ii. Write down an expression for the magnetic field intensity associated with the wave if $\mu = \mu_0$
5. (a) State and prove Poynting theorem.
 (b) In a non-magnetic medium $E = 4 \sin((2\pi \times 10^7 t - 0.8 \pi x) a_z \text{ V/m}$. Find
 i. the time-average power carried by the wave
 ii. total power crossing 100 cm^2 of plane $2x+y = 5$. [8+8]
6. For a parallel plane wave guide of 2.5 cm separation, determine all the propagation characteristics, for a signal at 8 GHz, for
 (a) TE_{10} waves
 (b) TEM waves

Explain the terms used.

[16]

7. (a) For any uniform transmission line for which R, L, C and G per unit length are Independent of position along the line. Show that the variation along the line of V and I Can always be represented by the exponential law
- (b) Derive an expression for the inductance and capacitance per unit length of coaxial transmission line. [8+8]
8. (a) Define the i/p impedance of a transmission line and derive the expression for it.
- (b) The characteristic impedance of a certain lines is $810 \angle 14^\circ \Omega$ and $\tau = 0.009 + j0.028$ per km. The line is terminated in a 200Ω resistor. Calculate the i/p impedance of the line if its length is 100 km. [8+8]

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1. (a) Obtain an expression for electric field intensity at a point, $P(x, y, z)$ due to a point charge located at $Q(x', y', z')$
 (b) Derive an expression for the electric field intensity due to an infinite length line charge along the z -axis at an arbitrary point $Q(x, y, z)$.
 (c) A charge of $-0.3\mu C$ is located at A (25, -30, 15) Cm and a second charge of $0.5\mu C$ is located at B (-10, 8, 12) Cm. Find the electric field strength, E at
 i. The origin
 ii. Point P (15, 20, 50) Cm [4+6+6]
2. (a) State Ampere's circuital law. Specify the conditions to be met for determining magnetic field strength, H , based on Ampere's circuital law
 (b) A long straight conductor with radius 'a' has a magnetic field strength $H = (Ir/2\pi a^2)\hat{a}_\phi$ within the conductor ($r < a$) and $H = (I/2\pi r)\hat{a}_\phi$ outside the conductor ($r > a$) Find the current density J in both the regions ($r < a$ and $r > a$)
 (c) Define Magnetic flux density and vector magnetic potential. [4+8+4]
3. (a) What is the inconsistency of Amperes law?
 (b) A circular loop conductor of radius 0.1m lies in the $z=0$ plane and has a resistance of 5Ω given $B=0.20 \sin 10^3 t \hat{a}_z$ T. Determine the current [8+8]
4. (a) Derive wave Equations for source free regions.
 (b) The electric field in free space is given by $E=50 \cos (10^8 t + \beta x)\hat{a}_y$ V/m
 i. Find the direction of propagation
 ii. Calculate β and the time it takes to travel a distance of $\lambda/2$
 iii. Sketch the wave at $t=0, T/4$ and $T/2$ [8+8]
5. For an incident wave under oblique incident from medium of ϵ_1 to medium of ϵ_2 with parallel polarization
 (a) Define and establish the relations for the critical angle θ_C and Brewster angle θ_{Br} for non-magnetic media with neat sketches.
 (b) Plot θ_C and θ_{Br} versus the ratio of ϵ_1/ϵ_2 [8+8]
6. (a) Discuss the nature of variation of wave impedances for TE, TM and TEM waves with frequency in a parallel plane wave guide.

- (b) Define and derive the equations for phase and group velocities in a parallel plane guide. On which factors do they depend. [8+8]
7. (a) What are the different types of losses in transmission lines?
- (b) A co-axial cable has following parameters $Z_0 = 50$ ohms, $L = 20$ KM if the power input is 1 watt and the attenuation constant is 1.5dB/km, find the output power of the cable provided it is terminated by Z_0 . Also determine the out put current. [8+8]
8. (a) Explain the significance and Utility of $\lambda/8$, $\lambda/4$, and $\lambda/2$ Line.
- (b) A low transmission line of 100Ω characteristic impedance is connected to a load of 400Ω . Calculate the reflection coefficient and standing wave ratio. Derive the Relationships used. [8+8]

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1. (a) Define conductivity of a material.
 (b) Apply Gauss's law to derive the boundary conditions at a conductor-dielectric interface.
 (c) In a cylindrical conductor of radius 2mm, the current density varies with distance from the axis according to $J = 10^3 e^{-400r} \text{ A/m}^2$. Find the total current I. [4+6+6]
2. (a) Obtain an expression for differential magnetic field strength dH due to differential current element I dl at the origin in the positive Z- direction.
 (b) Find the magnetic field strength, H at the centre of a square conducting loop of side '2a' in Z=0 plane if the loop is carrying a current , I, in anti clock wise direction. [6+10]
3. (a) Derive Maxwell's equations from their basics.
 (b) Given the time-varying magnetic field $B = (0.5\bar{a}_x + 0.6\bar{a}_y - 0.3\bar{a}_z) \cos 5000t$ T and a square filamentary loop with its corners at (2,3,0), (2,-3,0), (-2,3,0) and (-2,-3,0). Find the time varying current flowing in the general aφ direction if the total loop resistance is 400kΩ [8+8]
4. (a) Explain uniform plane wave propagation
 (b) A lossy dielectric has an intrinsic impedance of $200\angle 30^\circ \Omega$ at a particular frequency. If at that frequency, the plane wave propagating through the dielectric has the magnetic field component $H = 10e^{-ax} \cos(Wt - 1/2x) \bar{a}_y \text{ A/m}$. Find α and δ [8+8]
5. (a) Determine the resultant Electric and Magnetic fields of plane wave when it is incident on a perfect conductor normally.
 (b) A plane wave traveling in a medium of $\epsilon_r = 1, \mu_r = 1$ has an electric field intensity of $100 \times \sqrt{\pi} \text{ V/m}$. Determine the energy density in the magnetic field and also the total energy density. [8+8]
6. (a) Define and derive the equations for phase and group velocities in a parallel plane guide. On which factors do they depend ?
 (b) Derive the relation $\lambda = \frac{\lambda_c \lambda_g}{\sqrt{\lambda_g^2 + \lambda_c^2}}$ where λ is free space wave length, λ_g is the wave length measured in the guide, and λ_c is the cut off wave length. [8+8]

7. Write short notes on the following:

- (a) Energy stored in electrostatic field.
- (b) Boundary condition of a EM field.
- (c) Circular wave guide
- (d) Stub matching

[4 × 4]

8. (a) Explain the significance of V_{max} and V_{min} positions along the transmission line, for a complex load Z_R . Hence calculate the impedances at these positions.

- (b) An aerial of $(200-j300) \Omega$ is to be matched with 500Ω lines. The matching is to be done by means of low loss 600Ω stub line. Find the position and length of the stub line used if the operating wave length is 20 meters. [8+8]
