Code No: R7220405 **1**

II B.Tech. II Semester(R07) Regular Examinations, April/May 2009
EM WAVES AND TRANSMISSION LINES
(Electronics & Communication Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE questions
All questions carry equal marks

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1. (a) Prove that the electric field intensity due to an infinite line charge falls off inversely with the distance to the line charge.
   (b) The finite sheet $0 \leq x \leq 1, 0 \leq y \leq 1$ on the $z = 0$ plane has a charge density $\rho_x = xy\,(x^2 + y^2 + 25)^{1.5}\,nC/m^2$. Find the total charge on the sheet and the electric field vector E at (0,0,5).
2. (a) The electric field in air is given by $E = \rho t \exp(-\rho - t) a_\phi V/m$; find B and J.
   (b) The interface $4x - 5z = 0$ between two magnetic media carries current $35a_y A/m$, if $H_1 = 25a_x - 30a_y + 45a_z A/m$ in region $4x - 5z \leq 0$ where $\mu_{r1} = 5$, calculate H_2 in region $4x - 5z \geq 0$ where $\mu_{r2} = 10$.
3. (a) Determine magnetic field intensity H at any point in free space due to any straight filamentary conductor of finite length directed along z-axis.
   (b) A circular loop located on $x^2 + y^2 = 9, z = 0$ carries a direct of 10 A along a_φ. Determine magnetic field intensity H at (0,0,4) and (0, 0, -4).
4. (a) Derive the expressions for the phase shift constant and attenuation constant of plane wave propagating in a lossy dielectric medium.
   (b) A plane wave propagating through a medium with $\varepsilon_r = 8, \mu_r = 2$ has $E = 0.5exp(-0.33z)$ $sin(10^8 t - \beta z) a_x V/m$.. Determine wave velocity, wave impedance and the magnetic field intensity.
5. (a) State and prove the Poynting's theorem with regard to EM wave propagation.
   (b) At frequencies of 1,100 and 3000 MHz, the dielectric constant of ice made from pure water has values of 4.15,3.45, and 3.20 respectively, while the loss tangent is 0.12, 0.035, and 0.0009, also respectively. If a uniform wave with an amplitude of 100V/m at z=0 is propagating through such ice, find the time-average power density at z = 0 and z=10m for each frequency.
6. Derive general field expressions for TM mode in parallel plane wave guides form Maxwell' equations.
7. (a) Derive the expression for characteristic impedance of a transmission line in terms of primary constants of the line.
   (b) A telephone line has $R = 30$ ohms/km, L=100 mH/Km, C=20 $\mu F/Km$, and $G = 0$. At frequency of 1 kHz, determine the characteristic impedance of the line, the propagation constant and the phase velocity.
8. (a) Show that the current reflection coefficient at any point on the line is negative of the voltage reflection coefficient at that point.
   (b) A telephone line has the following parameters. $R = 40\Omega/m, G = 400\mu S/m, L = 0.2\mu H/m, C = 0.5nF/m$. If the line operates at 10MHz, calculate the characteristic impedance and velocity. After how many meters will the voltage drop by 30 dB in the line ?

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1. (a) State Coulomb's law. Discuss about the Coulomb vector force on point charges say Q_1 and Q_2 with suitable example.
   (b) Point charges 5 nC and -2 nC are located at (2, 0, 4) and (-3, 0, 5) respectively. Determine the force on a 1 nC point charge located at (1, -3, 7). What will be the electric field vector E at (1, -3, 7)?
2. (a) Derive an expression for magnetic vector potential A for surface currents.
   (b) The magnetic vector potential of a current distribution in free space is given by A=$15e^{-\rho}\sin\varphi a_z$ Wb/m. Find H at (3,$\pi/4$, -10). Also find the flux through ρ=5, 0$\leq \varphi \leq \pi/2, 0 \leq z \leq 10$.
3. (a) What is Faraday's law? Using the law, derive one of the Maxwell's equations for time varying fields.
   (b) The surface y=0 is a perfectly conducting plane, while the region y>0 has $\epsilon_r = 5, \mu_r = 3,$ and $\sigma = 0$. Let E=20 cos($2 \times 10^{10}t - 2.58z)a_y$ V/m for y>0, and find at t=6ns;
   i) H at point P(2, 0, 0.3); ii) Linear current density K at P.
4. (a) Define phase velocity, and group velocity. Describe them with suitable examples.
   (b) A 1MHz plane wave is propagating in fresh water. At this frequency, losses in water are known to be small such that $\mu_r = 1$, and $\epsilon_r = 81$. Calculate i) phase constant, ii) phase velocity, iii) intrinsic impedance of the uniform plane wave. Determine electric and magnetic field components of the wave. Assume the electric field intensity has maximum amplitude of 0.1 V/m.
5. (a) Illustrate the power balance for EM fields with suitable sketches. Get the expression for time average power crossing from a given surface S and time average Poynting vector.
   (b) A uniform plane wave in air with H = $4\sin(\omega t - 5x)a_y$ A/m is normally incident on a plastic region with parameters $\epsilon = 4\epsilon_0, \mu = \mu_0, \sigma = 0$. Obtain the total electric field in air, and calculate the time average power density in the plastic region.
6. (a) Obtain expressions for the cut-off frequency and velocity in the rectangular waveguide from the field expressions for TE modes.
   (b) Discuss about the impossibility of TEM waves in rectangular waveguides.
7. (a) Deduce the expressions for secondary parameters in terms of primary constants of transmission line.
   (b) A generator of 1 volt,1000cycles, supplies power to a 100 mile open-wire line terminated in 200 ohms resistance. The line parameters are R=10.4Ω /mile, L=0.00367 H/mile, G=0.8×10^{-6} mho/mile, and C=0.00835μ F/mile. Compute the secondary constants of the line.
8. (a) Show that a lossy transmission line of length 'l' has an input impedance of $Z_0\ tanh\gamma l$ when shorted and $Z_0\ coth\gamma l$ when open.
   (b) A quarter-wave lossless 100 ohm line is terminated by a load of 210 ohms. If the voltage at the receiving end is 80 V, what is the voltage at the sending end?

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Code No: R7220405 **3**

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1. (a) Derive the expression for electric field intensity E at any point in free space due to an electric dipole.
   (b) Point charges $Q_1 = 1nC, Q_2 = -2nC, Q_3 = 3nC$ and $Q_4 = -4nC$ are positioned one at a time and in that order (0,0,0), (1,0,0),(0,0,-1) and (0,0,1) respectively. Calculate the energy in the system after each charge is positioned.

2. (a) With suitable sketches, derive the expression for magnetic field intensity H of finite current element.
   (b) Use Biot-Savart law to find H at(0,0,4) in a circular loop located on $x^2 + y^2 = 9$,z=0 carries a direct current of 10 A along a_ϕ.

3. Explain the boundary conditions of EM fields at the interface of any two media in detail by considering all possible cases.

4. (a) Derive wave equation from the Maxwell's equations and describe various parameters involved in it.
   (b) Show that uniform plane wave travels in free space with velocity of light.

5. (a) Derive a suitable expression for transmission coefficient when a plane wave incident at some angle at the interface of two media. Consider parallel polarization only.
   (b) A uniform plane wave is incident from air onto glass at an angle from the normal of 30^0. Determine the fraction of the incident power that is reflected and transmitted for parallel polarization. Assume glass has refractive index n_2 =1.45.

6. Derive general field expressions for TE mode in guided medium from Maxwell's equations.

7. (a) Using expressions of wave amplitudes in a transmission line, deduce the relation for characteristic impendence of the line.
   (b) A transmission line operating at 500MHz has z_0 =80 ohms, α =0.04Np/m, β=1.5 rad/m. Find the line parameters R, L, G, and C.

8. (a) What is a Smith chart? What are the applications?
   (b) Using a Smith chart, calculate the position and length of a stub designed to match a 100ohm load to a 50 ohm line, the stub being short circuited. If this matching is correct at 63MHz, what will be the SWR on the main line at 70MHz? Note that the load is a pure resistance.

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Code No: R7220405 **4**

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1. (a) A parallel plate capacitor with free space between the plates is connected to a constant source of voltage. Determine how electrostatic energy W_E ,capacitance C, total charge Q, and surface charge density ρ_s change as dielectric of $\epsilon_r = 2.0$ is inserted between the plates.
   (b) In spherical co-ordinates, potential V=0 for r=0.1m and V=100 V for r=2.0m. Assuming free space between these concentric spherical shells, find E and D.

2. (a) Derive the expressions for magnetic field intensity H in different regions of long co-axial transmission line.
   (b) An isotropic material has magnetic susceptibility of 3 and magnetic flux density $B = 10ya_x mWb/m^2$.Determine J, H, and μ_r.

3. (a) The electric field in air is given by $E = \rho t\ exp(-\rho - t)a_\phi V/m$; find B and J.
   (b) An antenna radiates in free space and $H = \frac{12\sin\theta}{r}\cos(2\pi \times 10^8 t - \beta r)a_\theta mA/m$,find the corresponding E in terms of β.

4. (a) Prove that for a good conductor, the intrinsic impedance of a plane wave $\eta = \frac{1+j}{\sigma\delta}$
   (b) A uniform plane wave propagating in a medium has $2\exp(-\alpha Z)\cos(10^8 t - \beta Z)a_y V/m$. If the medium is characterized by $\epsilon = \epsilon_{0,}\ \mu = 20\mu_o$ and $\sigma = 3$ mhos/m, find α, β and H.

5. (a) Derive suitable expression for transmission coefficient when a plane wave incident at some angle at the interface of two media. Consider perpendicular polarization only.
   (b) An EM wave travels in free space with electric field component $E = (10a_y + 5a_z)\cos(\omega t + 2y - 4z)V/m$. Determine the magnetic field component and time average power in the wave.

6. (a) Prove that the wave propagates through rectangular waveguide in its dominant mode is combination of two uniform plane waves.
   (b) A rectangular air-filled waveguide has a cross section of 80 × 40 mm. Find cut-off wavelength for dominant mode. How many modes are passed at 2.5 times cut-off frequency?

7. (a) Explain the concept of 'infinite line'.
   (b) A transmission line operating at $\omega = 10^6 rad/s$ has $\alpha = 8$ dB/m, $\beta = 1$ rad/m, and $z_0 = 60 + j40\Omega$, and is 2m long. If the line is connected to a source of 10 V, internal resistance of 40 Ω and terminated by a load of 20+j50 Ω, determine the input impedance, the sending end current, and the current at the middle of the line.

8. (a) What is a stub? Why are short-circuited stubs preferred to open-circuited ones? Explain.
   (b) With aid of Smith chart, calculate the position and length of short circuited stub matching a(180+j120)ohm load to a 300 ohm transmission line. Assuming that the load impedance remains constant, find the VSWR on the main when the frequency is
   (i) increased by 10%, (ii) doubled?

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