BITS-Pilani Dubai, International Academic City, Dubai

Second Semester, Academic Year 2007-2008

Evaluation Component : **Comprehensive Examination (Closed Book)**

EEE UC33 ELECTROMAGNETIC FILEDS AND WAVES

433

Date : 1st June, 2008 **Max. Marks: 90**

Duration: 3 Hours **Weightage: 40%**

Note: 1. ANSWER ALL QUESTIONS and ANSWER only to specific point being questioned;
2. Make assumptions, if any, but explicitly indicate the assumptions made;
3. "$\mathbf{a}_y$" represent unit vector in direction of the axis (y-axis here) in the specific coordinate system employed.
4. Students will be provided Graph sheets / Smith Charts, as may be required.

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1)

a) Four 10 nC positive charges are located in the z=0 plane at the corners of a square 8 cm on a side. A fifth 10nC positive charge is located at a point 8cm distant from the other charges. Calculate the magnitude of the total force on this fifth charge for $\varepsilon = \varepsilon_0$. (3.0 M)

b) A uniform line charge of 16 nC/m is located along the line defined by y=-2. z=5. If $\varepsilon = \varepsilon_0$: find (i) **E** at point P(1,2,3); (ii) **E** at that point in the z=0 plane where the direction of E is given by $(1/3)\mathbf{a}_y-(2/3)\mathbf{a}_z$. (2+3=5.0 M)

c) Find **E** at the origin if the following charge distributions are present in free space: point charge, 12nC at P(2,0,6); uniform line charge density, 3 nC/m at x=-2, y=-3; uniform surface charge density, 0.2 nC/m^2 at x=2. (2.0M)

2)

a) An empty metal paint can is placed on a marble table, the lid is removed, and both parts are discharged (honorably) by touching them to ground. An insulating nylon thread is glued to the center of the lid, and a penny, a nickel and a dime are glued to the thread so that they are not touching each other. The penny is given a charge of +5nC, and the nickel and dime are discharged. The assembly is lowered into the can so that the coins hang clear of all walls, and the lid is secured. The outside of the can is again touched momentarily to ground. The device is carefully disassembled with insulating gloves and tools. (i) what charges are found on each of the five metallic pieces? (ii) If the penny had been given a charge of +5nC, the dime a charge of -2nC, and the nickel a charge of -1nC, what would be the final charge arrangement have been? (2+3=5.0 M)

b) If a point charge Q lies at the origin, show that div **D** is zero everywhere except at the origin. Replace the point charge with a uniform volume charge density ρ_{v0} for $0 < r < a$. Relate ρ_{v0} to "Q" and "a" so that the total charge is the same. Find div **D** everywhere. (3+2+2=7.0 M)

3) A potential field in free space is expressed as V = 20 / (xyz) volts. Find the total energy stored within the cube $1<x,y,z<2$. What value would be obtained by assuming a uniform energy density equal to the value at the center of the cube? (4+2=6.0 M)

4)

a) Determine the energy stored per unit length in the internal magnetic field of an infinitely long, straight wire of radius "a", carrying uniform current I. (3.0 M)

b) Under some conditions, it is possible to approximate the effects of ferromagnetic materials by assuming linearity in the relationship of **B** and **H**. Let $\mu_r = 1000$ for certain material of which a cylindrical wire of radius 1 mm made. If I = 1 A and the current distribution is uniform, find (i) **B**; (ii) **H**; (iii)**M**; (iv) **J** and (v) **J** within the wire, $\mathbf{J}_b$. (10.0 M)

5)

a) Represent Transmission line as a four-terminal network and define each component of the representation. Starting from fundamentals, derive Transmission line wave equation and obtain an expression for the characteristic impedance of the line. (1+2+3=6.0M)

b) A transmission line having primary constants L, C, R and G has length "l" and is terminated by a load having complex impedance R_L+jX_L. At the input end of the line, a dc voltage source, Vo is connected. Asuming all parameters are known at zero frequency, find the steady-state power dissipated by the load if (i) R=G=0; (ii) R not equal to zero, G=0; (iii) R=0, G not equal to zero; and (iv) R and G both not equal to zero.

(1+1.5+1.5+2=6.0 M)

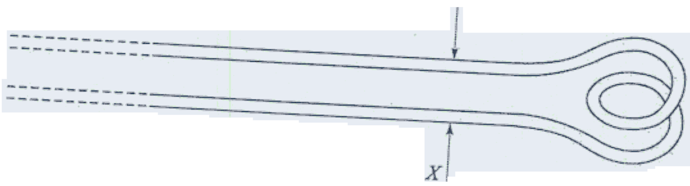
6)

a) A uniform 100-Ω transmission line is terminated in a resistive load of 500Ω. Use a shorted stub to match this load to the line. By employing Smith chart find (i) Distance d_1 from the load to stub; (ii) Distance or length d_2 of the stub; (iii)VSWR on d_1 line, and (iv)VSWR on stub

(4.0 M)

b) A 2-wire line constructed of lossless wire of circular cross section is gradually flared into a coupling loop that looks like a egg beater. At the point X, indicated by the arrow in figure below, a short circuit is placed across the line. A probe moved along the line and indicates that the first voltage minimum to the left of X is 16 cm from X. With the short circuit removed, a voltage minimum is found 5 cm to the left of X, and a voltage maximum is located that is 3 times the voltage of the minimum. Use Smith chart to determine (i) the operating frequency (ii)VSWR, s and (iii) the normalized input impedance of the egg beater as seen looking to the right at point X.

(6.0 M)



7)

a) A plane 100 MHz wave is incident normally on a solid ferrite-titanate slab of thickness d=10mm for which $\mu_r=\varepsilon_r=60(2 - j1)$. The medium, which is non-conducting, is backed by a flat conducting sheet. How much is the reflected wave attenuated, in dB, with respect to incident wave?

(5.0 M)

b) What is the polarization state of the reflected wave if a right circularly polarized wave is incident at an angle of 45° from air onto (i) a perfect conductor; (ii) polysterene (ε_r=2.7).

(2+3=5.0 M)

8)

a) Define the following w.r.t an Antenna (i)Basic radiation equation (ii) Beam area (iii) Main beam efficiency (iv) Directivity (v) effective aperture

(5.0 M)

b) An antenna radiates isotropically over a half-space above a perfectly conducting flat ground plane. If E=50mV/m (rms) at a distance of 1 Km, find (i) power radiated and (ii)the radiation resistance assuming antenna terminal current I = 3.5 A.

(2+2=4.0M)

9) Write a short note on

a) Fields in a Rectangular wave guide. (3.0 M)

b) Various antenna types and their corresponding field patterns. (3.0 M)

c) Maxwell's Equations in both differential and integral forms (2.0 M)

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BITS-Pilani Dubai, International Academic City, Dubai

Second Semester, Academic Year 2007-2008

Evaluation Component : **TEST-II (Open Book)**

EEE UC33 ELECTROMAGNETIC FILEDS AND WAVES

Date : 11th May 2008 **Max. Marks: 20**

Duration: 50 mts **Weightage: 20%**

Note:- 1. ANSWER ALL QUESTIONS and ANSWER only to specific point being questioned.
2. Make assumptions, if any, but explicitly indicate the assumptions made
3. Students will be provided Graph sheets / Smith Charts, as may be required.
4. Students are permitted to use the prescribed text (i.e., "Electromagnetics with Applications by Kraus/Fleisch") only.

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1) Assume 1 MHz plane wave having a maximum amplitude of its electric filed intensity equal to 0.1V/m is propagating in fresh water. Calculate the following parameters of the wave:
   a) phase constant,
   b) wavelength,
   c) phase velocity,
   d) intrinsic impedance
   e) Ex component of the wave and
   f) Hy component of the wave (6.0 M)

2) Obtain expression for the time-average Poynting vector of a TEM wave propagating in good conductor from fundamentals and prove that in a distance of skin depth, the power density is only 0.135 of its value at the surface. (3+1=4M)

3) Consider two fields in which one is left circularly polarized and the other is right circularly polarized; Assume both are of the same amplitude, frequency, and propagation direction, but there exist a phase shift of δ radians between the two. Derive an expression for the resultant Electric Filed intensity when they both are superimposed. Comment on the polarization of and the resulting angle with which field vector is oriented in the resultant superimposed field. (2+1+1=4M)

4) A parallel-plate transmission line (equivalent to guide for the wave), has plate separation d=1 cm, and is filled with Teflon. Determine the maximum operating frequency such that only a TEM wave will propagate. (2.0 M)

5) A differential current filament, acting as an antenna, has a length d and carries a current $I=I_0 \cos\omega t$. (in the positive z direction). The filament is aligned along z-direction symmetrical to the z-axis. Starting from fundamentals obtain expressions for H and E in spherical coordinates. (4.0 M)

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BITS-Pilani Dubai, International Academic City, Dubai

Second Semester, Academic Year 2007-2008

Evaluation Component : TEST-I (Closed Book)

EEE UC33 ELECTROMAGNETIC FILEDS AND WAVES

Date : 30th March. 2008
Duration: 50 mts

Max. Marks: 25
Weightage: 25%

Note:- 1. ANSWER ALL QUESTIONS and ANSWER only to specific point being questioned.
2. Make assumptions, if any, but explicitly indicate the assumptions made
3. Students will be provided Graph sheets / Smith Charts, as may be required.

1)

a) Four 3-pC charges are at the corners of a 1-m square. The two charges an the left side of the square are positive. The two charges on the right side are negative. Find the filed E at the center of the square. Assume $\varepsilon_r = 1$. (2.0 M)

b) Two long parallel conductors of a dc transmission line separated by 2 m have charges of $\rho_L = 5$ mC m^{-1} of opposite sign. Both lines are 8 m above ground. What is the magnitude of the electric field 4 m directly below one of the wires? (2.0 M)

2)

a) A 765-kV rms, 3-phase, 60 Hz transmission line has conductors spaced 16m. Their height is 12 m above ground. Each conductor is a bundle of smaller conductors. It has an effective diameter of 0.6 m. A fluorescent lamp bulb held 2 m above ground at point P under an outside conductor lights to full brilliance. No wires are connected to the bulb. What is the magnitude of the rms electric field at P? (3.0 M)

b) Write Maxwell's Equations in both Integral and Differential forms (4.0 M)

3) Starting from fundamentals derive the characteristic impedance of a transmission line representing the same as a four terminal network. (4.0 M)

4) A uniform 100-W transmission line is terminated in a resistive load of 500Ω. Use a shorted stub to match this load to the line. Find (5.0 M)

a) Distance d1 from the load to stub.
b) Distance or length d2 of the stub
c) VSWR on d1 line, and
d) VSWR on stub

5) Write a short note on

a) What is stub tuning? And why stubs for the tuning, in the context of transmission lines, instead use of a coil or a capacitor?. (3.0 M)

b) The electric field Ey of a TEM wave equals 100 V m-1 rms. Find (i) magnitude of velocity and Poynting vector |PV| in air (ii)velocity and |PV| in a lossless dielectric medium with $\varepsilon_r = 9$. (2.0M)

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