NATIONAL EXAMS, MAY 2012

07-ElecA7, Electromagnetics

3 hours duration

Notes:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. Candidates may use one of two calculators, the Casio or Sharp approved models. This is a closed book exam.

3. Any five questions constitute a complete paper. Only the first five questions as they appear in your answer book will be marked.

4. All questions are of equal value.

5. Aids: $\varepsilon_0 = 8.85 \times 10^{-12}\, F/m$, $\mu_0 = 4\pi \times 10^{-7}\, H/m$

1. Power density in a single frequency linearly polarized plane wave propagating in vacuum is 1 mW/m^2.

   What are the RMS values of electric and magnetic flux density vectors?

2. The wavelength of a horizontally (electric field) polarized plane wave propagating in vacuum is 0.5 microns ($0.5 \times 10^{-6}\, m$). The wave is reflected from a horizontal conducting plane. The incident and reflected wave set up a pattern of dark and bright horizontal surfaces. The periodicity of the pattern is 1 micron.

   What is the angle between the direction of wave propagation and vertical?

3. Internal impedance and EMF of a generator are 377 ohms and a pulse of 2 volts amplitude and 1 microsecond duration respectively. The generator drives an infinite transmission line of 377 ohms characteristic impedance and 3×10^8 m/s propagation velocity. The leading edge of the pulse is launched on the line at $t = 0$. 10 km from the generator terminals a 377 ohm resistor is connected across the line.

   Calculate:

   (i) arrival time of the reflected pulse at the generator terminals,

   (ii) energy contained in the reflected pulse, and

   (iii) amplitude and polarity of the current in the pulse.

4. Characteristic impedance and propagation velocity of a coaxial transmission line are 50 ohms and 2×10^8 m/s respectively. The space between inner and outer conductors of the line is completely filled with dielectric material.

   Calculate:

   (i) capacitance and inductance of the line per meter length, and

   (ii) relative permittivity of the dielectric medium.

5. A circularly polarized 2 GHz plane wave of 38 mW/m^2 power density propagates horizontally in NW direction. The magnetic field of the wave is monitored by a 3 cm diameter loop located in a slowly rotating vertical plane.

   Determine:

   (i) the orientation of the plane for which the induced EMF in the loop will be maximum, and

   (ii) the RMS value of the maximum.

6. A 5 cm radius circular current loop located in a horizontal plane carries a 2A current. Viewed from above the current circulates clockwise.

   What is the magnitude and direction of magnetic flux density vector at a point 5 m away horizontally. Use appropriate approximation (magnetic dipole).

7. A 100 turn coil is wound around a toroidal ferromagnetic core. The radius of the torus axis is 5 cm, the radius of circular cross-section is 1 cm. The relative permittivity of the torus material is 50. A 5 mm gap is cut in the torus.

   What current in the coil is required to produce a field of 0.2 teslas in the gap?

8. A short vertical current element hovering in free space 500 m above a notional horizontal plane radiates a single frequency signal the wavelength of which is orders of magnitude smaller than 1000 m. At a point on the horizontal plane 866 m away from the point directly below the current element the radiated electric field intensity is 30 mV/m RMS.

   If the notional horizontal plane was replaced by a perfectly conducting ground plane, what would be the magnitude and direction of electric field at the point specified above?