NATIONAL EXAMS, DECEMBER 2016

98-Phys-A3 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. Internal impedance of a pulse generator is 377 ohms, its EMF is a series of 1 μs pulses with 10 KHz pulse repetition frequency. The generator drives a 10 km long section of a transmission line of 377 ohm characteristic impedance and 3×10^8 m/s propagation velocity. The section is terminated in a load resistor of 377/2 ohms. The energy contained in each outgoing pulse is 1 J.

   Describe generator terminal voltage specifying relevant voltage values and time intervals.

2. A length of transmission line of 50 ohm characteristic impedance and 3×10^8 m/s propagation velocity and longer than 50 cm is terminated in a short circuit. 50 cm away from the short circuit a 50 cm long, open circuited section of transmission line of identical properties as the original line is connected across the line, creating a termination consisting of parallel connection of 50 cm long sections of open circuited and short circuited line sections.

   (i) What is the impedance of the termination at 300 MHz?

   (ii) Find a frequency closest to, but not 300 MHz, for which the impedance of the termination will again be zero.

   (iii) Find a frequency for which the impedance of the termination will be infinite.

3. A transmission line consists of two coaxial metallic cylinders of 5 mm and 1 cm radii. The inner cylinder is coated by a 2 mm thick layer of dielectric of relative permittivity 2.25.

   Calculate characteristic impedance and propagation velocity of the line.

4. Two 10 GHz (10^{10} Hz) plane waves propagate in free space in horizontal directions. One of the waves propagates due north, the other due east. One of the waves is polarized (electric field) in horizontal direction, the other in vertical one. Power densities of the two waves are 1 W/m^2 each. At a point A in space the total electric field (sum field) is linearly polarized.

   (i) What is the RMS amplitude of electric field at that point?

(ii) What is the location of a point closest to A at which the total field is circularly polarized?

5. A vertical circular loop of 25 cm^2 area and 20 turns rotates at 2500 RPM about its vertical axis. The loop is a direction-finding antenna on an aircraft flying horizontally north-west at 200 km/hr. in a magnetic field of 10^{-5} teslas pointing north and 45° down.

(i) Calculate EMF induced in the loop.

(ii) Will the horizontal motion of the aircraft contribute to the induced EMF?

(iii) At what orientation of loop will the value of induced EMF be zero?

6. Inside dimensions of a waveguide cavity are 2cm × 1cm × 2.3cm.

What are two lowest resonant frequencies of the cavity?

7. A square loop of 10 cm, 10 turns, and 1A current is located in an east-west vertical plane and the current, when viewed due north circulates clockwise. The loop is located in a magnetic field of 0.1 teslas pointing up.

What is the value and direction of the torque exerted by the field on the loop?

A short horizontal current element radiates a 10 MHz signal into free space. At a point 1 km directly above the element the electric field intensity is 100 μV/m.

(i) What is the signal power density at a point 2 km away from the element horizontally and 30° up?

(ii) What would be the power density referred to in (i) above in a system identical to the one specified above except that the signal frequency would be reduced to 5MHz?