National Exams May 2003

98-Elec-A7

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: $\varepsilon_0 = 8.85 \times 10^{-12}\ F/m$, $\mu_0 = 4\pi \times 10^{-7}\ H/m$, $e = 1.6 \times 10^{-19} C$

1. A transmission line consists of two coaxial thin walled copper cylinders of 1mm and 3mm radii. The inner cylinder is covered by a 1mm thick layer of dielectric of relative permittivity 2.5.

   Determine:

   i) the characteristic impedance of the line and,

   ii) the propagation velocity thereof.

2. A circular 4 ampere current loop of 50cm radius lies in a vertical plane aligned parallel to the local terrestrial magnetic field. The terrestrial field is horizontal and its strength is 10^{-5} tesla. 1m away from the centre of the loop on its axis is a small magnetic compass.

   By what angle will the needle of the compass be deflected from magnetic north by the magnetic field of the loop?

3. Three protons are located at the centre of an equilateral triangle of 1Å (10^{-10} m) sides. One electron is located at each of the three vertices of the triangle.

   i) What is the electrostatic energy of the system and,

   ii) What is the magnitude and direction of electric field acting on an electron?

4. A 10MHz vertically polarized (electric field) plane wave propagates in an unknown horizontal direction. Magnetic field of the wave is monitored by a 50cm radius, single turn vertical loop, rotating slowly about its vertical axis. The EMF induced in the loop is maximum when the loop is in the NE-SW plane and the value of the maximum EMF is 10μ V RMS.

   Determine:

   i) possible directions of the wave propagations and,

   ii) power density of the wave.

5. EMF of a 50 ohm generator is a single, 2μ s long pulse of 2V amplitude. The generator drives a 1km long section of a 50 ohm, $2\times10^8\ m/s$ line terminated in an infinitely long 377 ohm, $3\times10^8\ m/s$ line.

   Determine the energies in:

   i) the outgoing pulse,

   ii) the reflected pulse and,

   iii) the pulse propagating on the 377 ohm line.

6. A 50 ohm, 200MHz generator drives a load consisting of parallel combination of a 50 ohm resistor and 15.9 pF capacitor through a 25cm long section of a 50 ohm, $2\times10^8\ m/s$ transmission line. The amplitude of the generator EMF is 2V RMS. What is the power delivered to the load?

7. Two transmitters located at sea level communicate with a receiver located 2km above sea level. The frequency of one transmitter is 5MHz. It is located 2km away horizontally from the receiver and drives a vertical, 1m long, 2 ampere RMS current element. The frequency of the other transmitter is 10MHz. It is located 3.5km away horizontally from the receiver and drives a 75cm long vertical 1.5 ampere RMS current element.

   Determine the ratio of the vertical components of electric fields of the two signals at the receiver site.

8. 100mW power of a 10GHz signal is launched into a 5cm long section of an air dielectric rectangular waveguide, the internal dimensions of which are 1cm × 0.5cm.

   Determine the signal power at the output of the section and express the ratio of input and output powers in decibel.

   In your calculations disregard reflection losses.