NATIONAL EXAMS, MAY 2013

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

1. The EMF of a generator of 100 ohm internal impedance is a step-function of 27 volt amplitude. The generator drives an infinite transmission line of 50 ohm characteristic impedance and 2×10^8 m/s propagation velocity. 10 km from generator terminals a 50 ohm resistor is connected across the line.

   (i) What is the duration of and energy contained in the first segment of the signal propagating on the infinite section of the line, and

   (ii) What is the steady state power delivered to the infinite section?

2. A transmission line of 50 ohm and 3×10^8 m/s propagation velocity respectively is required to deliver maximum possible power at 300 MHz to a load consisting of a 100 ohm resistor in parallel with a 50 ohm capacitive reactance. The load is to be matched to the line by employing a short-circuited section of an adjustable length of line identical to the main transmission line and a 25 cm long section of transmission line of 3×10^8 m/s propagation velocity and adjustable characteristic impedance.

   Develop the necessary matching network employing two assets specified above.
   Aid: $Z(s)\,Z(s \pm \lambda/4) = Z_0^2$

3. A square loop of wire of 10 turns and 100 cm^2 area, located in rotating vertical planes rotates at 3600 RPM about its vertical axis in a horizontal, uniform magnetic field of 0.2 teslas. The EMF induced in the loop drives a resistive load of 10 ohms.

   Calculate:

   (i) the average power delivered to the load, and

   (ii) the RMS value of the torque acting on the loop.

   Disregard in your calculations the effect of the self-inductance of the loop.

4. Inside dimensions of an air-filled rectangular waveguide are 25 mm × 15 mm. Determine the attenuation of the lowest mode of a 5 GHz signal and express it in unites of dB/cm.

5. A 10 GHz plane wave vertically polarized (electric field) of power density of 1 W/m^2 propagates in horizontal direction and is reflected at 45° angle of incidence by a vertical conducting plane.

   Determine:

   (i) the RMS value of the surface current density pattern induced on the reflecting surface, and

   (ii) the direction of the surface current density.

6. Voltage constraint for a transmission line of 50 ohm and 3×10^8 m/s characteristic impedance and propagation velocity respectively is 2000 volts peak at 300 MHz.

   Determine for 300 MHz signals:

   (i) the lowest upper bound on power that the line can deliver to a load producing 1.5 standing wave ratio, and

   (ii) the longest length of the line for which, under favourable circumstances the above restrictions may be relaxed.

7. A transmission line consists of two flat parallel ribbons 10 mm wide separated by a 0.1 mm thick layer of dielectric of relating permittivity 2.25. Calculate the characteristic impedance and propagation velocity of the line (disregard effects of fringing fields).

8. Radiation resistance of a short current element for constant element length is proportional to signal frequency squared. A vertical current element radiates a 30 MHz signal into empty space. Maximum RMS electric field on a 10 km radius sphere is 500 μV/m. The element is moved to a horizontal conducting plane. The frequency is reduced to 10 MHz and the value of driving current is doubled.

(i) What is the RMS value of maximum electric field on a 20 km radius hemisphere centered on the element, and

(ii) Where does it occur?