

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:  $\epsilon_0 = 8.85 \times 10^{-12} \text{ F/m}$ ,  $\mu_0 = 4\pi \times 10^{-7} \text{ H/m}$

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  $2 \times 10^8$  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  $3 \times 10^8$  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  $3 \times 10^8$  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  $100 \text{ cm}^2$  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  $25 \text{ mm} \times 15 \text{ mm}$ . 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  $1 \text{ W/m}^2$  propagates in horizontal direction and is reflected at  $45^\circ$  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  $3 \times 10^8 \text{ m/s}$  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  $500 \mu\text{V/m}$ . 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?