

**NATIONAL EXAMS, MAY 2015**

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

1. The EMF of a generator of 100 ohm internal impedance is a step-function of 24 volt amplitude. The generator drives a 20 km long section of open-circuited, lossless transmission line of 50 ohm characteristic impedance and  $2 \times 10^8$  m/s propagation velocity. A 150 ohm resistor is connected across the line 10 km away from the generator. The step-function is launched on the line at time  $t = 0$ .

Determine:

- (i) the time of arrival of the initial voltage at the 150 ohm resistor,
  - (ii) the amplitude of the initial voltage and,
  - (iii) the final steady state voltage across the resistor.
2. A 300 MHz generator of 50 ohm internal impedance drives a load through a section of a transmission line of 50 ohm characteristic impedance and  $3 \times 10^8$  m/s propagation velocity. The load consists of a parallel connection of a 50 ohm resistor and a 10.7 pF capacitor. Connected across the load is an open-circuited section of a transmission line with electrical characteristics identical to the driving line.

For what length of the open circuited section will the load and generator be matched?

3. A circular wire loop of  $10 \text{ cm}^2$  area and 10 turns rotates at 3600 RDM about its diameter in a DC, uniform magnetic field of  $10^{-5}$  teslas pointing north and  $30^\circ$  down.
  - (i) For what orientation of the rotation axis will the EMF induced in the loop be maximum and,
  - (ii) What will be the RMS value of the maximum?
4. A horizontal current loop consists of two parallel straight line sections 50 m long and 5 m apart joined at both ends by semicircular jumpers.

Calculate with 5% accuracy the value of loop current required to produce a field of  $10^{-5}$  teslas at the centres of the jumpers.

5. Internal dimensions of an empty (i.e. no dielectric) rectangular waveguide are  $2.5 \text{ cm} \times 1 \text{ cm}$ .

What is the range of frequencies for which only one mode will propagate in the waveguide?

6. A 60 Hz generator of zero internal impedance drives through a 1:5 step-up transformer a 1250 km long (i.e. one quarter wavelength) section of a transmission line of 1000 ohm characteristic impedance and  $3 \times 10^8$  m/s propagation velocity. The line is terminated by resistive loads absorbing between 4 and 5 megawatts at constant 100 KV voltage.

Calculate the percentage variation of generator EMF required to keep load voltage at 100 KV as the load power changes from 5 MW to 4 MW.

Assistance :  $Z(s)Z\left(s \pm \frac{\lambda}{4}\right) = Z_0^2$

7. Two 10 GHz plane waves propagate horizontally in free space in opposite directions. Power densities in each wave are equal at 1 microwatt/m<sup>2</sup>. One of the waves is polarized vertically the other horizontally. At a point in space the combined field of the two waves is linearly polarized.

What are the shortest distance and direction from the above mentioned point to a point at which the combined field of the two waves is circularly polarized and what is the amplitude of the field?

8. A 1 m long vertical current element located in the surface of a conducting ground plane radiates a 10 MHz signal. 5 km away from the element, on the ground plane the RMS amplitude of 10 MHz electric field is 1 microvolt/m. A 0.2 m long vertical current element located 2.89 km above the 10 MHz radiator radiates a 30 MHz signal. The amplitude of the 30 MHz current is one tenth of the 10 MHz current.

What is the vertical component of the 30 MHz electric field at the 5 km point on the ground plane?