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

1. The EMF of a generator of 100 ohm internal impedance is a step-function of 24 volt amplitude. The generator drives a 20 km long section of open-circuited, lossless transmission line of 50 ohm characteristic impedance and 2×10^8 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 3×10^8 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 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° 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 cm × 1 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 3×10^8 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 : $Z(s)Z\left(s \pm {}^{\lambda}/_{4}\right) = Z_0^2$

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^2. 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?