NATIONAL EXAMS, DECEMBER 2017

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

1. EMF of a generator of 377 ohm internal impedance is a series of 1 μs pulses of 38.8 KV amplitude and 10k Hz pulse repetition frequency. The generator drives an infinitely long transmission line of 377 ohm characteristic impedance and 3×10^8 m/s propagation velocity. A 377/2 ohm resistive load is connected across the line 10 km away from generator terminals.

   Sketch steady state pattern of generator terminal voltage as a function of time specifying relevant values of voltages and time intervals.

2. A transmission line of 50 ohm characteristic impedance and 3×10^8 m/s propagation velocity is terminated in a 50 ohm resistor. A short-circuited section of a line identical with the driving line is connected across the driving line at a point between the load and generator driving the line.

   What is the length of the short-circuited section if the load is matched to the line at 300 MHz and is isolated at 600 MHz?

3. Two 10 GHz (10^{10} Hz) plane waves propagate in free space in horizontal directions. Power densities of the waves are 10 W/m^2 each. One of the waves propagates 30^0 east of north and is horizontally polarized, the other propagates 30^0 west of north and is vertically polarized. Total electric field (superposition of individual wave fields) is circularly polarized in a set of vertical north-south planes.

   What is the separation of these planes and what is the amplitude of the circularly polarized electric fields in these planes?

4. Inside dimensions of a rectangular waveguide are 1 cm x 2.25 cm. The waveguide is filled with dielectric of relative permittivity 2.25.

What are cut-off frequencies of the three lowest propagating modes?

5. A 3000 MHz plane wave linearly polarized (electric field) in the horizontal direction propagates 60° up from north-west. Power density of the wave is 2 W/m^2. Magnetic field of the wave is monitored by a 10 turn loop of 25 cm^2 area and is located in vertical east-west plane.

   What is the RMS value of the EMF induced in the loop?

6. 2A current circulates in a horizontal loop consisting of a semicircle of 50 cm diameter fed by two infinitely long straight lines perpendicular to the semicircle diameter. Viewed from above the current in the loop circulates clockwise.

   What is the magnitude and direction of the horizontal component of magnetic field 25cm above the midpoint of the semicircle diameter?

7. Selfinductance L of an air core solenoid of circular cross-sector of area A, length d and number of turns N is approximately $\mu_o N^2 A/d$ for the case of $d >> A^{1/2}$ and $N >> d/A^{1/2}$. Two identical solenoids are spatially arranged to form a solenoid of length 2d and number of turns 2N. In case (i) the connection of wires is such that currents in the two solenoids circulate in same sense while in case (ii) the connection is such that currents circulate in opposite sense.

   What are values of selfinductances of the combined solenoid for cases (i) and (ii)?

8. Two 1 m long current elements radiate a 5 MHz signal into free space. One element is vertical, the other horizontal. Current amplitudes of the two elements are same, the

phases of the two currents are 90 ° apart. Maximum value of power density on a 1 km sphere centered on the common location of the two elements is 10^{-7} W/m ^{2} for each.

Where on a 1 km sphere will the total electric field (superposition of the two fields) be linearly polarized and what will be the RMS amplitude thereof?