NATIONAL EXAMS, DECEMBER 2018

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: $\varepsilon_0 = 8.85 \times 10^{-12}\ F/m$, $\mu_0 = 4\pi \times 10^{-7}\ H/m$, e = 1.6 x 10^{-19}C.

1. EMF and internal impedance of a generator are a pulse and 377 ohms. The generator drives an infinitely long transmission line of 377 ohm characteristic impedance and 3×10^8 m/s propagation velocity. 10 km from the generator a resistor of 377 ohm is connected across the line, and another 377 ohm resistor is connected 1 km further away. Energy content in the incoming pulse is 1 joule.

   What is the upper bound of the pulse length that will produce the distinct reflected pulse? What is the energy content in the first reflected pulse returning to the generator? Will there be more than 2 reflected pulses?

2. All lines and sections thereof in this problem are lines of 50 ohm characteristic impedance and 2×10^8 m/s propagation velocity. A generator generates two signals of frequency 200 MHz (signal A) and 400 MHz (signal B). The generator drives a section of transmission line terminated in the parallel connection of two lines, lines A and B. Line A is terminated in a 200 MHz amplifier of input impedance of 50 ohms. Line B is terminated in a 400 MHz amplifier with 50 ohm input impedance. To protect amplifier A from 400 MHz signal a ¼ m long section of short-circuited line is connected across line A. To protect amplifier B from 200 MHz signal a 1/2 m long open-circuited section is connected across line B.

   What are the locations of the two protective stub sections if both signals A and B are to be matched to the common feed line?

3. Inside dimensions of rectangular, air filled waveguide are 2.5 cm x 1 cm.

   What are the two lowest modes of 15 GHz wave propagating in the waveguide and what are their propagation velocities?

4. A 10 GHz plane wave propagates in NW direction, 45^0 up. Power density of the wave is 4×10^{-8} W/m^2. Electric field in the wave is horizontal.

   What is the RMS value of the vertical component of the magnetic field of the wave?

5. A 2m long horizontal metallic rod is oriented NW-SE. If moves horizontally in a westerly direction at 30 m/s velocity in empty space. At one point it encounters a vertical north-south wall of uniform magnetic field 30 m thick. Magnetic field in the wall points up and its value is 10^{-5} teslas.

   Plot as a function of time the voltage of the NW tip of the rod with respect to the SE tip induced by motion of the rod through the wall of magnetic field.

6. Components of magnetic field Hx, Hy, Hg are;

   $Hx = H_0 \cos(\omega t - kz)$, $Hy = H_0 \sin(\omega t - kz)$, $Hz = 0$,

   With $H_0 = 10^{-3}$ A/m, $\omega = 2\pi \times 10^{10}$ Hz, $k = (2\pi/3)$ cm $^{-1}$.

   What are the electric field and average power density of the wave?

   Aid: $\bar{G} = (A, B, C)$, curl $\bar{G} = \left(\frac{\partial C}{\partial y} - \frac{\partial B}{\partial z}; \frac{\partial A}{\partial z} - \frac{\partial C}{\partial x}; \frac{\partial B}{\partial x} - \frac{\partial A}{\partial z}\right)$

7. A linearly polarized 10 GHz electromagnetic plane wave is normally incident on surface of mercury.

   At what depth in the mercury will the electric field of the wave be reduced to 10% of its incident value?

   Resistivity of mercury = 10^{-6} ohm meters.

8. Two vertical collocated current elements radiate electromagnetic field into empty space. One radiates at 10 MHz, the other at 30 MHz. Current amplitudes and element lengths of the two radiators are same. Maximum value of the power density of the 10 MHz signal on a 10 km radius sphere surrounding the radiator is 10^{-8} W/m^2.

   What in the RMS value of the vertical component of the 30 MHz electric field on the 5 km radius sphere at a point 30^0 away from directly overhead?