NATIONAL EXAMS, DECEMBER 2012

07-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. The EMF of a generator of 50 ohm internal resistance is a step-function of 16 volt amplitude. The generator drives a 10 km long section of a transmission line of 50 ohm and 3×10^8 m/s characteristic impedance and propagation velocity respectively. The line is terminated in a 50 ohm resistor. Half-way between the 50 ohm termination and generator terminals a 100 ohm resistor is connected across the line.
   (i) How long after launching the step-function on the line will a steady state condition on the line be established, and
   (ii) What are the steady state currents at (a) generator terminals, (b) through the 100 ohm resistor, and (c) the 50 ohm termination?

2. The internal resistance of a 100 MHz generator is 50 ohms. The generator drives a section of a transmission line of 50 ohm characteristic impedance and 3×10^8 m/s phase velocity. The transmission line is terminated in a parallel combination of (a) 50 ohm resistor, (b) 50 ohm capacitance, and (c) 37.5 cm long short-circuited section of a 3×10^8 m/s transmission line of adjustable characteristic impedance. What should be the value of the adjustable characteristic impedance required to match the load to the generator?

3. Characteristic impedance and propagation velocity of a coaxial transmission line are 50 ohms and 2×10^8 m/s respectively. The radius of the inner conductor of the line is 1 mm. What is the radius of the outer conductor?

4. A circularly polarized 500 MHz plane wave propagates in free space. The direction of propagation is west and 30° up. The power density of the wave is 0.1 W/m^2. Magnetic field of the wave is monitored by a circular loop of 10 cm^2 area located in a north-south vertical plane. What is the RMS value of EMF induced in the loop?

5. Internal dimensions of an air filled rectangular waveguide are 1 cm × 2.4 cm.
   (i) How many 20 GHz modes can propagate in the waveguide and,
   (ii) What is the phase velocity of the slowest mode?

6. Maximum allowed voltage on a transmission line at a particular frequency is 1000 volts peak. The characteristic impedance of the line is 50 ohms. The line drives a load producing a SWR of 1.2 at the frequency. The line is longer than half of the wavelength. What is the maximum power that the line can deliver to the load?

7. A 1 m long vertical current element located on a horizontal conducting ground plane radiates a 10 MHz signal. On a point 5 km away on the ground plane the power density of the signal 5×10^{-8} W/m^2. What would be the power density at the same point if the radiating element was to be moved 2.9 km vertically upwards?

8. A horizontally polarized plane wave of 0.6×10^{14} Hz travels in a medium of relative permittivity 1.69. It impinges at 60° angle of incidence on a horizontal surface separating the medium from free space and is totally reflected from it. What is the phase of reflected wave with respect to that of the incident wave at the reflecting surface?