NATIONAL EXAMS, MAY 2014

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. A pulse generator of internal impedance of 377 ohm drives an infinite transmission line of 377 ohm characteristic impedance and 3×10^8 m/s propagation velocity respectively. The EMF of the generator is a single 1 microsecond pulse of one kilovolt amplitude. 10 km from generator terminals a 754 ohm resistor is connected across the line and another 754 ohm resistor is connected 1 km further down the line.

   Plot amplitudes versus time of first three pulses, including the outgoing pulse occurring at the generator terminals.

2. A transmission line of 50 ohm characteristic impedance and 2×10^8 m/s propagation velocity drives a load consisting of parallel combination of a 50 ohm resistor and two 25 cm long sections of the 50 ohm, 2×10^8 m/s transmission line. One of the sections is open circuited, the other short circuited.

   (i) What are the two lowest frequencies at which no power will be delivered to the 50 ohm load and,

   (ii) what is the lowest frequency at which the 50 ohm resistor will be matched to the line?

3. The diameter of the internal conductor of a coaxial line is 1 mm, the relative permittivity of the inter-conductor medium is 2.25, and the characteristic impedance of the line is 50 ohms.

   What are:

   (i) the diameter of the outer conductor and,

   (ii) the propagation velocity of the line?

4. A 1000 MHz plane wave propagating in free space is normally incident on a flat surface of seawater. The relative permittivity of seawater is 81, its resistivity is 1 ohm meter.

   What fraction of incident power will penetrate into seawater?

5. Inside dimensions of a rectangular waveguide are 2.5 cm × 1 cm. The waveguide is filled with dielectric of relative permittivity 2.25. A 5000 MHz signal is propagating in the guide.

   What are:

   (i) the guide wavelength of the signal and,

   (ii) attenuation of the signal (expressed in units of dB/cm) if the signal is launched into the waveguide with dielectric removed?

6. Magnetic field of a 10 GHz (10^{10} Hz) plane wave propagating in free space is horizontally polarized in north-east, south-west direction. Electric field is inclined at 45° to the vertical. EMF induced by magnetic field in a 1 cm^2 area, single loop coil is 60V RMS for optimum orientation of the coil.

   Determine:

   (i) power density of the wave and,

   (ii) propagation vector $\vec{k}$ expressed in the east-north-up cartesian coordinate system.

7. Two vertical current elements are located at the same point on a perfectly conducting horizontal ground plane. One radiates a 10 MHz and the other a 5 MHz signal. The lengths of the two elements are identical. The RMS current of the 10 MHz radiator is double that of 5 MHz radiator. At a point 10 km away from the radiators on the ground plane the electric field of the 10 MHz signal is 2.2×10^{-3} V/m RMS.

   What is the RMS value of the vertical component of the 5 MHz signal at a point 2 km above the point on the ground plane 3.5 km away from the radiators?

8. The dipole moment of an electrical dipole is 10^{-8} C m. The vertical dipole pointing up is located 2 m above a horizontal conducting plane.

   What is the magnitude and direction of electric field on the conducting plane directly below the dipole?