

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: $\epsilon_0 = 8.85 \times 10^{-12} \text{ F/m}$, $\mu_0 = 4\pi \times 10^{-7} \text{ H/m}$

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 $2.5 \text{ cm} \times 1 \text{ cm}$. 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 $2.2 \times 10^{-3} \text{ V/m}$ 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?