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

1. A pulse generator of 377 ohm internal impedance generates a series of 1 microsecond pulses. The EMF of the pulses is such that if they are launched on 377 ohm resistive load they would deliver 2J of energy to the load. The generator drives an infinite transmission line of 377 ohm characteristic impedance and 3×10^8 m/s propagation velocity. 5 km from generator terminals a 377 ohm resistive load is connected across the line.

   (I) What is the energy contained in a reflected pulse and

   (II) what is the highest pulse repetition frequency for which the outgoing and reflected pulses would not overlap at the generator terminals? Plot as a function of time powers of the first two reflected pulses arriving at the generator terminals.

2. A 50 ohm resistive load is driven by a transmission line of 50 ohm characteristic impedance and 2×10^8 m/s propagation velocity. Connected across the load is a short-circuited section of the line 50 cm long.

   What are the two lowest frequencies such that for one of them no power will be delivered to the load, while for the other the load is matched to the line?

3. A horizontal metallic bar 3m long rotates at 600 RPM about vertical axis passing through one end of the bar. The bar rotates in uniform vertical magnetic field of 10^{-5} teslas.

   What is the voltage induced between the two ends of the bar?

4. A linearly polarized 10 GHz plane wave of 0.01 W/m^2 power density propagates in empty space. Direction of propagation is 30° away from vertical, magnetic field of the wave is horizontal.

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

5. A 6GHz wave propagates in a rectangular waveguide of 2.5 cm x 1 cm dimension. The waveguide is filled with dielectric of relative permittivity of 2.25. At a point along the waveguide the dielectric filling is terminated.

   How far into the empty waveguide will the amplitude of the wave be reduced to 10% of its value at the transition from filled to empty waveguide?

6. A particle of charge -1.6×10^{-19} C (electron) moves along a horizontal, circular path of 10^{-10} m radius. The frequency of the circulation is 2×10^{15}Hz. Viewed from above the circulation is clockwise.

   What is the direction and magnitude of magnetic field density rector B at a point 10^{-10} m above the center of the circular path?

7. A transmission line consists of two coaxial metallic pipes. The inner diameter of the outer pipe is 10 mm. The outer diameter of the other is 5 mm. The inner pipe is covered by a 1 mm thick layer of dielectric of relative permittivity 2.25.

   Determine characteristic impedance and propagation velocity of the line.

8. A short vertical current element (AC dipole) radiates a signal of wavelength λ into empty space. The wavelength λ is much longer than the length of current element.

   At what horizontal distance from the center of the current element will the radiation magnetic field be equal to Biot-Savart field of the current element?

   Aid: $|E_{rad}| = Z_0 \ell I \sin \Theta \, k/4\pi r$.