NATIONAL EXAMS, MAY 2016

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: $\varepsilon_0 = 8.85\times10^{-12}\ F/m$, $\mu_0 = 4\pi\times10^{-7}\ H/m$

1. EMF of a generator of 50 ohm internal resistance is a step-function of 12 V volt amplitude. The generator drives a load through a 10 km long section of a transmission line of 50 ohm characteristic impedance and 2×10^8 m/s propagation velocity. The load consists of parallel combination of two infinitely long transmission lines of same characteristics as the 10 km long section specified above.

   Plot generator terminals current in time interval 0 to 150 μs, with $t = 0$ the starting time of the EMF step-function.

2. A 300 MHz generator drives a load through a 30 cm long section of transmission line of 50 ohm characteristic impedance and 3×10^8 m/s propagation velocity terminated in a 50 ohm resistor in parallel with 1.59×10^{-8} H inductance.

   What is the standing wave ratio on the driving line section? At some point on the line the impedance is real. What is the value of impedance at this point on the 30 cm long driving section?

3. Two 10 GHz (10^{10} Hz) plane waves propagate in free space in opposite horizontal directions. One of the waves is polarized in the horizontal direction, the other in the vertical. Power density of the vertically polarized wave is 9 W/m^2, that of the other is 3 W/m^2. At points in space the two waves are in phase.

   At one of these points give the following:

   (i) electric field polarization,

   (ii) RMS electric field amplitude and,

   (iii) polarization at a point 3/8 cm away in the line of propagation direction from the in-phase point mentioned above?

4. Inside dimensions of a rectangular waveguide are 2.25 cm×1cm.

   What are the shortest and longest guide wavelengths of propagating modes of a 20 GHz (2×10^8 Hz) signal?

5. Cross-section of a tightly wound 10 cm long, 500 turns solenoid is a circle of 5 mm diameter. Inserted into the solenoid is a 5 cm long slab of 5 mm diameter of ferromagnetic material of relative permittivity 20.

   Calculate inductance of the solenoid and stored magnetic energy for the case of 10 mA current in the solenoid.

6. A transmission line consists of two parallel metallic ribbons 2 cm wide separated by a dielectric plate of relative permittivity 2.25, and 2 cm×0.5 mm rectangular cross-section.

   Calculate, neglecting fringe field effects values of capacitance and inductance per meter length of the line and its characteristic impedance and propagation velocity.

7. Distributed parameters of a lossy transmission line are : 25 μH/m, 160 pF/m (p = 10^{-12}), series resistivity 0.01 Ω/m and shunt conductivity 10^{-7} 1/Ωm.

   Calculate propagation velocity and loss of the line for a 1 MHz signal.

8. A 50 cm long vertical current element radiates a 20 MHz signal into free space. Power density 10 km away on a horizontal plane passing through the element is 10^{-8} W/m^2.

   What are magnitude and direction of magnetic field 5 km away from the element radially, in the easterly direction and 30° elevation above the horizontal plane referred to above?