NATIONAL EXAMS, DECEMBER 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: $\varepsilon_0 = 8.85 \times 10^{-12}\ F/m$, $\mu_0 = 4\pi \times 10^{-7}\ H/m$

1. A 1 μs long pulse containing 1J energy travels on a transmission line of characteristic impedance and propagation velocity 377 ohms and 3×10^8 m/s respectively. The line is terminated in a parallel connection of two infinitely long lines of the same properties as the driving line.

   What are the energies of the reflected pulse and pulses travelling on the two lines forming the load?

2. A section of a transmission line of 50 ohm characteristic impedance and 2×10^8 m/s propagation velocity is terminated in a parallel connection of a 50 ohm resistance and a capacitive reactance. The value of the capacitive reactance at 300 MHz is 100 ohms.

   How long is the section if at 300 MHz the input impedance of the circuit is real and what is the value thereof?

3. Two 10 GHz plane waves propagate horizontally in opposite directions in free space. The power density of each wave is 10 KW/m^2. One of the waves is polarized (electric field) in the vertical direction, the other in the horizontal one. At a point in space the electric fields of the two waves are in phase.

   What is the shortest distance between the point mentioned above and a point at which the combined electric field of the two waves is circularly polarized and what is the RMS amplitude thereof?

4. The characteristic impedance of a transmission line is 50 ohms. The line delivers power to a load at a frequency at which a standing wave of 1.5 standing wave ratio is set up on the line. The upper limit of allowed voltage on the line is 5 KV peak.

   What is the upper limit on the power that can be delivered to the load by the line, if the line is longer than one half of the wavelength? Could the answer be different if the line were shorter than one half of the wavelength?

5. Inside dimensions of an air filled rectangular waveguide are 1 cm × 2.25 cm.

   What are the modes that will propagate in the waveguide at 15 GHz and what is the longest guide wavelength among these modes?

6. Calculate the selfinductance of a cylindrical, tightly wound solenoid of total number of turns N, cross-section area A, length $l(l^2 \gg A)$, with a cylindrical core of cross-section A of magnetic material of relative permeability $\mu = 10$ and length d smaller than l, i.e. $l = d + s$.

7. A circular loop of 400 cm^2 area and 45 turns located in vertical plane rotates at 3600 RPM about its vertical diameter. The loop is located in a uniform DC horizontal magnetic field of 0.2 teslas. The EMF induced in the loop drives a load the impedance of which is 40 + j40 ohms at 60 Hz.

   Calculate the time averaged mechanical power required to drive the loop. Disregard in your calculations the effect of the selfinductance of the loop.

8. A 1 m long vertical current element located on a conducting ground plane radiates a 10 MHz signal. 10 km away from the element on the ground plane the power density of the signal is 2.62×10^{-13} W/m^2.

   What are the magnitude and direction of magnetic field intensity vector $\vec{H}$ of the radiated field at a point 2 km radially away from the radiator and 30° up?