NATIONAL EXAMS, DECEMBER 2015

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

1. The EMF of a generator of 377 ohm internal impedance is a 2 μs long pulse of 12 volt amplitude. The generator drives a 10km long section of transmission line of 377 ohm characteristic impedance and 3×10^8 m/s propagation velocity. The section is terminated in a load consisting of parallel connection of two infinitely long transmission lines identical to the driving line.

   What is the energy content of pulses propagating on the two infinitely long lines?

2. A generator of 50 ohm resistive internal impedance and EMF frequency components of 300 MHz and 400 MHz drives a 50 ohm resistive load through a section of transmission line of 50 ohm characteristic impedance and 3×10^8 m/s propagation velocity. A short-circuited section of the identical line is connected parallel to the load.

   What is the length of the short-circuited section if it is to maintain the match of the load to the driving line at 300 MHz, and prevent the 400 MHz from reaching the 50 ohm load?

3. Characteristic impedance and propagation velocity of a transmission line are 50 ohms and 2×10^8 m/s respectively. The space between the inner and outer conductor is uniformly filled with a dielectric. The inner diameter of outer conductor is 1cm.

   Calculate the diameter of the inner conductor and relative permittivity of the dielectric.

4. Inside dimensions of a rectangular waveguide are $2.5\text{cm} \times 1\text{cm}$.

   How many modes of a 20 GHz signal can propagate in the waveguide?

5. Standing wave ratio (SWR) on a transmission line of 50 ohm characteristic impedance and 2×10^8 m/s propagation velocity is 1.5. Maximum allowed voltage on the line is 10 KV RMS.

   What is the limit on power that can be transmitted on the line?

6. A single frequency (monochromatic) plane wave propagating in free space is normally incident on plane surface of a medium the relative permittivity of which 1.69.

   What fraction of the power of the incident wave is reflected off the surface of the medium?

7. Power densities of two 10 GHz linearly polarized waves propagating in free space are $5\ \mu W/m^2$ each. The waves propagate in directions perpendicular to z-axis of an (x,y,z) cartesian coordinate system with one wave propagating 30° to the right, the other 30° to the left of the y-axis. The amplitude of total magnetic field (sum of magnetic fields of the two waves) is zero at origin.

   Determine:

   (i) RMS amplitude of electric field at origin and,

   (ii) position of at least one point at which the amplitude of the total magnetic field is maximum.

   Assistance: observe that the two waves set up a standing wave system.

8. A short vertical current element radiates a 10 MHz signal into free space. Maximum power density on a 10 km sphere surrounding the element is $10\ \mu W/m^2$.

   Calculate the RMS value of the vertical component of electric field on a 15 km radius sphere surrounding the element, 7.5 km above horizontal plane passing through the element for the case that the frequency of the current driving the element was increased to 20 MHz, keeping the amplitude constant.