Centre for Applied Research in Electronics, I.I.T. Delhi Nov 23, 2016

ELL713 Major

[x,y,z in bold font represent the unit vectors, $\varepsilon_0 = 8.8 \times 10^{-12}$; $\mu_0 = 4\pi \times 10^{-7}$]

Marks: 4+3+3+3+3+3+3+4+7+7 , Time 2 hrs.

1. Complete the equation of Maxwell in time domain integral form :

$$\oint_C \vec{E}.d\vec{l} = \; ?$$ Define all the symbols used.

2. For a lossless transmission line, if velocity = 0.9c and characteristic impedance is 100Ω , what are the values of inductance and capacitance per unit length ?

3. A microstrip with strip width = 2 mm, dielectric thickness = 1mm, uses a hypothetical dielectric with resistivity = 1 Ωm. What is the conductance per unit length (assume current flows strictly normal to the strip and ground) ?

4. A plane wave propagates in air at frequency ω, along –y , and has magnetic field purely z-directed. What is the expression for the electric field (assume real peak value is 'A') in time domain ?

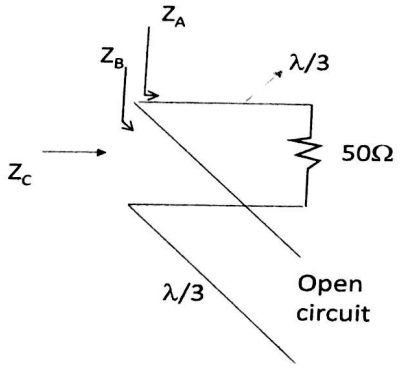
5. A waveguide with cross-section a x b in the x-y plane, has narrow walls (the 'b' dimension) made of a hypothetical metal which offers 0 resistance to y-directed currents, but shows a small resistivity ρ to z-directed currents. The broad walls are lossless. What is the attenuation constant for TE_{10} mode ? For a normal waveguide, the formula is :

$$\alpha = \frac{\frac{\rho}{\delta}}{a^3 b\beta k\eta}(2b\pi^2 + a^3k^2), where\ \eta = \sqrt{\mu/\epsilon}$$

6. What are the four S-parameters of an ideal transformer with turns ratio N:1 ? Port 1 is the primary and port 2 is the secondary. Reference is 50Ω for both ports.

7. If the electric field in air is $\mathbf{E} = \mathbf{x}E_0\, e^{[\alpha+j\beta](z-y)/\sqrt{2}}$ then find the time-averaged real Poynting vector.

8. For the following circuit using two 100Ω lossless transmission line segments , calculate Z_A , Z_B and Z_C using the Smith Chart. Z_A is looking into the line connected to the resistor, Z_B is looking into the shunt branch and Z_C is the final input impedance.



9. A waveguide of cross-section (x-y plane) 2cm x 1cm at 20GHz is filled with lossless material of $\varepsilon_r = 1$ and $\mu_r = 4$ in the region $z > 0$. In the region $z < 0$, an incident electric field of peak value 1 V/m propagates in air along +z , and there is also a reflected electric field propagating along –z. In the $z > 0$ region there is only a transmitted electric field propagating along +z. Find the peak values of the transmitted and reflected electric fields. Assume **TE_{01} mode** for all waves.

10. A dielectric-filled rectangular waveguide has 1.5 GHz cut-off frequency (calculated ignoring dielectric loss). This dielectric which fills the waveguide has dielectric constant 2.5 and loss tangent of 10^{-3} assumed to be independent of frequency. Find the phase and attenuation constants (i.e. α, β) for the dominant mode at 3 GHz. Assume the walls of the waveguide to be made of ideal conductor.