國 立 清 華 大 學 命 題 紙

九十七 學年度第一學期 光電工程研究所 博士班研究生資格考試

科目 電磁理論 科號 共 3 頁 ＊請在試卷(答案卷)內作答

1. (14%) A voltage source of $2\cos\omega t$ (volts) is connected to a $\lambda/4$ 50Ω transmission line, which is in turn connected to a $\lambda/8$ 100Ω transmission line and then connected to a 50Ω load.

   (a) Find the input impedance of the entire system of two transmission lines plus a load. (8 pts)

   (b) The voltage across the 50Ω load is -1.13-j2.26. What is the time-average power dissipated in the load? (6 pts)

2. (16%) An air-filled parallel-plate metallic waveguide made with perfect conductor has a plate separation of 1 cm.

   (a) Assume electromagnetic waves are propagating between two parallel plates. How much phase shift is introduced in each air-conductor interface? Please calculate the reflection coefficient Γ at the interface to verify your answer. (6 pts)

   (b) Above what frequency can the modes TE1, TE2, TM0, TM1, and TM2 propagate? (5 pts)

   (c) What is the phase velocity for the TE1 mode at 20 GHz? (5 pts)

3. (20%) You are to consider reflection/transmission issue of a TM polarized plane-wave of vacuum wavelength λ between two semi-infinite, isotropic, loss-less media. The relative permittivity and relative permeability are given in the figure for each medium. In the questions below, you should clearly state your reasoning and show all of your works.

   (a) Write out the field expressions for the incident ($\mathbf{E}_i$, $\mathbf{H}_i$), reflected ($\mathbf{E}_r$, $\mathbf{H}_r$) and transmitted ($\mathbf{E}_t$, $\mathbf{H}_t$) waves. You should clearly designate the field orientations using the coordinate given in the figure. (4 pts)

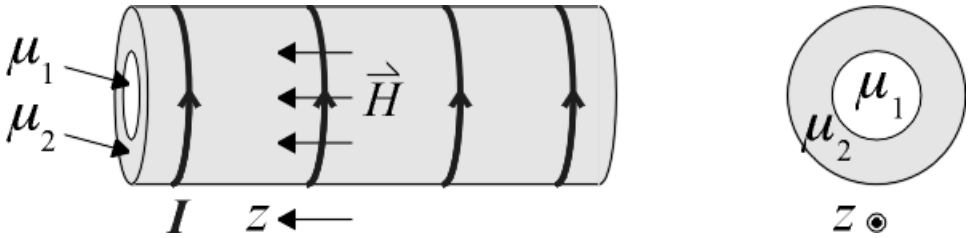
   (b) From your expressions, relate the reflection angle (θ_r) and refraction angle (θ_t) to the incident angle. (4 pts)

   (c) Find out the incident angle so there is no reflection, i.e., $r=E_r/E_i=0$. Express it in terms of the relative permittivities. (6 pts)

   (d) Using a power approach, express the transmission coefficient $t= E_t/E_i$ in terms of r, incident, refraction angles, and the permittivities. (6 pts)

4. (20%) This problem set investigates magnetic field in materials.

(a) A long hollow solenoid produces uniform magnetic field intensity $\vec{H} = \bar{a}_z nI$ and magnetic flux density $\vec{B} = \mu_0 \vec{H}$ in the interior, where n is number of turns per unit length, I is the current, and μ_0 is the permeability of air. If the solenoid is filled with two concentric cylinders with permeabilities of μ_1 , μ_2 ($\mu_1 > \mu_2 > \mu_0$), find $\vec{H}_1$, $\vec{B}_1$, $\vec{H}_2$, $\vec{B}_2$. (10 pts)



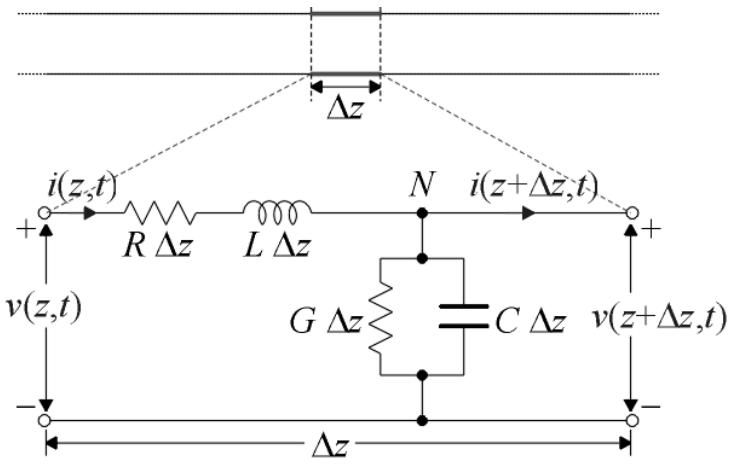
(b) Plot a magnetic dipole and the corresponding magnetic flux lines (conceptually). (5 pts)

(c) For liner magnetic materials, $\vec{B} = \mu_0(\vec{H} + \vec{M})$, where the magnetization vector $\vec{M}$ is defined as the volume density of magnetic dipole moment:

$$\vec{M} \equiv \lim_{\Delta v \to 0} \frac{\sum \vec{m}_k}{\Delta v}$$

By results of problem 4a, plot the induced surface and/or volume magnetization current densities $\vec{J}_{ms}$, $\vec{J}_m$ for the concentric cylinders. Justify your answer. (5 pts)

5. (10%) The following figure shows the equivalent circuit of an infinitesimal section of two-conductor transmission line of length Δz, where R, L, G, C represent resistance, inductance, conductance, and capacitance per unit length. Justify why L is connected in series, and why C is connected in parallel.



6. (20%) For this exam question, reasoning the logic in your answer is more important than getting a right answer. This means no credit is given to a correct answer without any explanation or a full credit could be given to a wrong answer with excellent reasoning.

In vacuum, two electrodes are arranged as follows. The cathode is on a cylindrical surface of radius R, and the anode is a conducting plate cutting the cylinder into two halves.

(a) Draw the electric field lines between the two electrodes. Explain the physical reason and basis of your drawing, in particular at the electrode surfaces.

(b) Draw the equipotential surfaces between the electrodes. Explain the physical reason and basis of your drawing. Note the edges of the electrodes.

(c) Describe and **explain** the trajectory of an electron emitted at (1) toward the anode.

(d) Describe and **explain** the trajectory of an electron emitted at (2) toward the anode.

(e) Would this device follow the Ohmic law V = R I, where V is the voltage applied between the electrodes, I is the electron current emitted from the cathode, and R is a constant? Explain your answer.