系所組別：電腦與通信工程研究所丙組

考試科目：電磁學及電磁波 考試日期：0223，節次：2

※ 考生請注意：本試題可使用計算機

For your reference: $\varepsilon_0 = 10^{-9}/36\pi$ (F/m); $\mu_0 = 4\pi\times10^{-7}$ (H/m); $\eta_0 = 120\pi$ (Ω)

Permitivity ε ($=\varepsilon_r\varepsilon_0$); Permeability μ ($=\mu_r\mu_0$); Conductivity σ

一、簡答題 (Answer Briefly) : (25%).

1. Given an EM-wave with the field components of $\vec{E}(\vec{R};t) = \mathrm{Re}[\vec{E}_0(\vec{R})\cdot e^{j\omega t}]$ and $\vec{H}(\vec{R};t) = \mathrm{Re}[\vec{H}_0(\vec{R})\cdot e^{j\omega t}]$ propergating along the direction of $\vec{R}$. What are the instantaneous power flow density and the average power flow density that the EM-wave carries? (5%)
2. What are the boundary conditions for the normal and tangential components of $\vec{E}$ and $\vec{H}$ at the interface between two kinds of materials with (ε_1, μ_1) and (ε_2, μ_2), respectively. (5%)
3. Please tell the TM wave from the TEM wave by the directions of vector field components. (5%)
4. What is the intrinsic impedance of a lossy material with (ε, μ, σ)? What does it mean if the intrinsic impedance value contains an imaginary-number part? (5%)
5. Given $\mathbf{P_{in}}$: the energy power into an antenna, $\mathbf{P_{rad}}$: the energy power radiated from the antenna to the space, and $\mathbf{P_{loss}}$: the energy loss in the antenna. Find the radiation efficiency of the antenna? (5%)

二、計算題 (Calculations): (75%)

1. As shown in **Fig.1** is the cross section of an infinite air-filled coaxial cable with a spacer structure between the conductors. The spacers are made out of an imperfect dielectric ($\varepsilon = 4\varepsilon_0$, $\mu=\mu_0$) of conductivity of $\sigma = 10^{-3}$ S/m and the cross section is defined by an angle $\alpha = 60^\circ$. The conductor radii are ***a*** and ***b***, respectively. Assumed the air dielectric constant is ε_0 with no loss. [note: you can keep ε_0 and μ_0 in your answer expressions.]

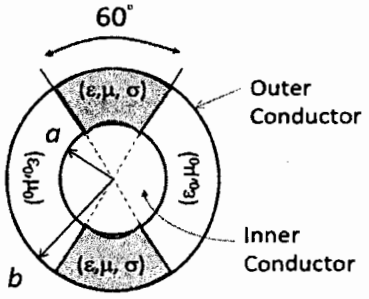

Fig. 1
Cross section of a coaxial cable

(1) What is the conductance per unit length of this cable. (5%)

(2) What is the total capacitance per unit length of this cable? (5%)

If a uniform current flows into the inner conductor and returns back from the outer conductor, find

(3) the total inductance per unit length, including the internal-inductance of the inner conductor, of this coaxial cable under static-field approximation. (5%)

2. A lossless **75-Ohm** transmission line is terminated in an unknown load impedance $\mathbf{Z_L}$. The measured voltage standing wave ratio (VSWR) is 3. The first voltage minimum is located at 6 cm from the load. The distance between successive voltage minima is 15 cm. Please find

(1) the reflection coefficient Γ. (5%)

(2) the load impedance $\mathbf{Z_L}$. (5%)

(3) the first distance from the load where the input impedance toward the load will be a maximum real number. Also find this maximum value of equivalent impedance. (5%)

（背面仍有題目，請繼續作答）

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3. An air-filled rectangular waveguide has a cross section with the aspect ratio of ***a/b*** = 2 and a dominant-mode cutoff frequency of 0.908 GHz. If the measured guide wavelength is 30 cm. Find

(1) the operation frequency; (5%)

(2) the waveguide cross section dimensions (that is, ***a*** = ? and ***b*** = ?); (5%)

(3) the wave number. (5%)

4. The far fields of a Hertzian dipole (as illustrated in **Fig. 2** when R >> $d\ell$) can be expressed as

$$\vec{H}_\phi = \hat{a}_\phi \cdot j\frac{I\,d\ell}{4\pi}\left(\frac{e^{-j\beta R}}{R}\right)\beta\sin\theta$$

$$\vec{E}_\theta = \hat{a}_\theta \cdot j\frac{I\,d\ell}{4\pi}\left(\frac{e^{-j\beta R}}{R}\right)\eta_0\beta\sin\theta$$

(1) Plot the E-plane and H-plane radiation patterns and find the 3-dB beamwidth. (5%)

(2) Find the directive gain $G_D(\theta, \phi)$ and the directivity **D** (in dB). (5%)

(3) Find the radiation resistance. (5%)

5. The lossless LC matching network shown in **Fig. 3** is used to match a **50-Ohm** transmission line (T.L.) to the input of an RF transistor operated at 2.4 GHz. The input reflection coefficient for the transistor is $\Gamma = 0.6\angle -150°$, measured from a **50-Ohm** system. Find the values of L and C for the conjugate matching condition. (15%)

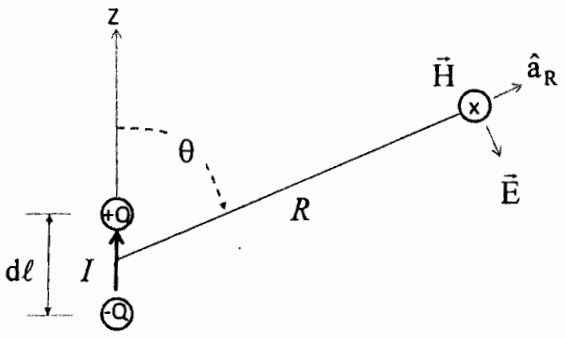

Fig. 2 A Hertzian dipole

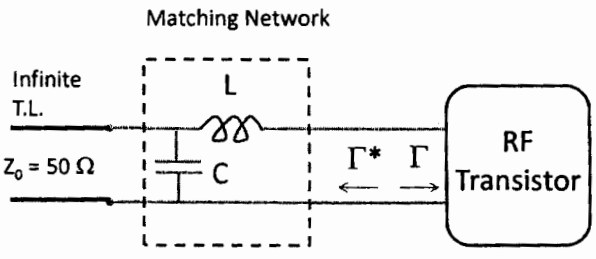

Fig. 3 LC matching network