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：0222，節次：2

※ 考生請注意：本試題可使用計算機。 請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

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

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

一、簡答題 (Short-Answer Questions) : (20%)

1. (a) In a free space, given the vector electric field $\vec{E}$ and the scalar electric potential V. Please write out the relation between $\vec{E}$ and V in a formula expression. (4%)

   (b) On the other hand, given the vector magnetic field $\vec{H}$ and the vector magnetic potential $\vec{A}$, please write out the relation between $\vec{H}$ and $\vec{A}$ in a formula expression. (4%)

2. State the Faraday's induction law in a formula expression. Please clearly define the physical quantity notations you used. (4%)

3. What is the boundary condition for the tangential component of electric fields between the interface of two dielectric media. (4%)

4. Let ***a*** (referred to x-axis) and ***b*** (referred to y-axis) be the cross section sides of a rectangular waveguide. Which mode (TM_{mn} or TE_{mn}) is the dominant mode of the wave propagating along the z-axis in a rectangular waveguide if ***a*** > ***b***? (4%)

二、計算題 (Calculations): (80%)

1. A current ***I*** flows in a long solenoid coil with ***n*** closely wound coil-turns per unit length. An iron core is composed of two sections of magnetic materials as shown in **Fig. 1**. The cross-sectional area of this iron core is *S*. The permeabilities of these two sections are μ_1 and μ_2, respectively. Assumed the permeability of free-space is μ_0. Determine the force acting on the core if it is withdrawn to the position shown in **Fig. 1**. (8%)

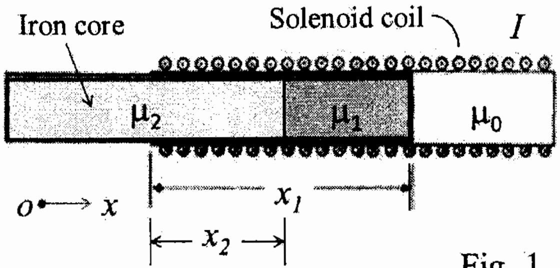

Fig. 1

2. A lossy dielectric with the parameters of permittivity $\varepsilon=4\varepsilon_0$ (F/m), permeability $\mu=\mu_0$ (H/m), and conductivity $\sigma = \frac{1}{100\pi}\times10^{-2}$ (S/m) is considered. A TEM wave with a frequency of 100 MHz is incident normally onto a plane interface of the air and the lossy dielectric. What is the phase difference (in degrees) of the electric field intensities between the incident wave in the air and the transmitted wave in the lossy dielectric? (8%)

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3. A two-wire transmission line system is as shown in **Fig. 2**. Assumed the length of the transmission line is infinite. Both the conducting lines have a radius of ρ and they are separated by a distance **D**. Assumed that ρ **<<** **D**.

(a) Determine the capacitance per unit length between the two conducting lines. (8%)

(b) Determine the inductance per unit length between the two conducting lines. (8%)

(c) Determine the internal inductance per unit length of these two conducting wires. (8%)

(d) If a conduction sliding bar is put on the transmission lines, then a conduction current *I* flowing along one of the conducting wires will be returned to the another one by way of the conduction bar. Find the magnitude of the force acted on the sliding bar due to the magnetic flux density induced between the transmission lines. (8%)

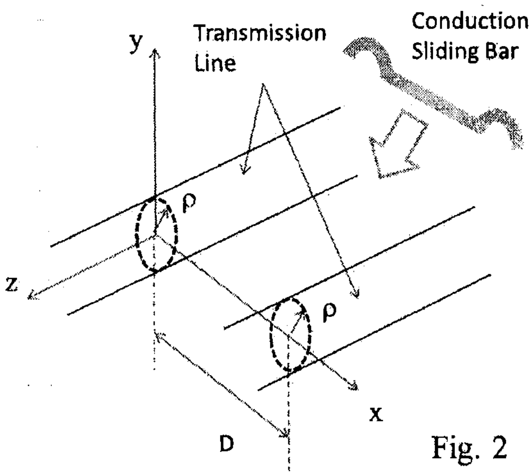

Fig. 2

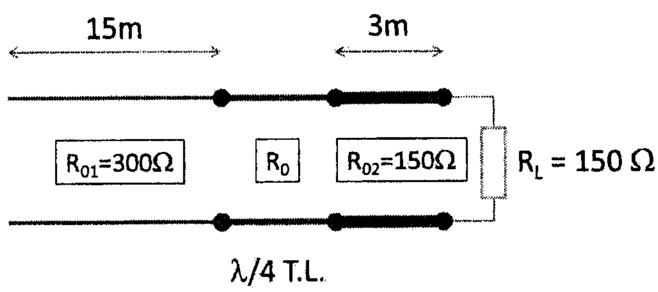

Fig. 3

4. As shown in **Fig. 3**, a 15-m length of 300-Ω line must be connected to a 3-m length of 150-Ω line that is terminated in a 150-Ω resistor. Assuming the lossless condition for the air-dielectric lines and operation at a fixed frequency of 50 MHz.

(a) To find the R_0 and the length for a quarter-wave section of line (i.e., a quarter-wave transformer) to match the two lines for a VSWR = 1 on the main line. (4%)

(b) If no transformer is used, what is the VSWR on the main line? (4%)

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5. Given an EM-wave with the field components of $\vec{E}(\vec{R};t) = \text{Re}[\vec{E}_0(\vec{R}) \cdot e^{j\omega t}]$ and $\vec{H}(\vec{R};t) = \text{Re}[\vec{H}_0(\vec{R}) \cdot e^{j\omega t}]$ propagating along the direction of $\vec{R}$ in a lossy dielectric where there is no charge density.

(a) Please write out Maxwell's equations in phasor forms for the above-mentioned fields. (8%)

(b) From the above equations you have written out and the homogeneous vector wave equations for the electric field and the magnetic field (i.e., $\nabla^2 \vec{E}_0(\vec{R}) - \gamma^2 \vec{E}_0(\vec{R}) = 0$ and $\nabla^2 \vec{H}_0(\vec{R}) - \gamma^2 \vec{H}_0(\vec{R}) = 0$, where $\gamma = \alpha + j\beta$ is the propagation constant; α is the attenuation constant; β is the phase constant), prove that: (8%)

$$\alpha = \omega\sqrt{\frac{\mu\varepsilon}{2}}\left[\sqrt{1+\left(\frac{\sigma}{\omega\varepsilon}\right)^2} - 1\right]^{1/2} \text{ (Np/m)} \quad \text{and} \quad \beta = \omega\sqrt{\frac{\mu\varepsilon}{2}}\left[\sqrt{1+\left(\frac{\sigma}{\omega\varepsilon}\right)^2} + 1\right]^{1/2} \text{ (rad/m).}$$

6. As shown in **Fig. 4**, a transmitting-receiving antenna system is considered. The antennas are separated by a distance **R** in free space. The transmitting antenna has an effect area $\mathbf{A_{et}}$ and directive gain $\mathbf{G_{dt}}$. The receiving antenna has an effective area $\mathbf{A_{er}}$ and directive gain $\mathbf{G_{dr}}$. If the transmitting power is $\mathbf{P_t}$, please find the received power $\mathbf{P_r}$ at the receiving antenna end. Assumed the ideal matching networks are lossless. (8%)

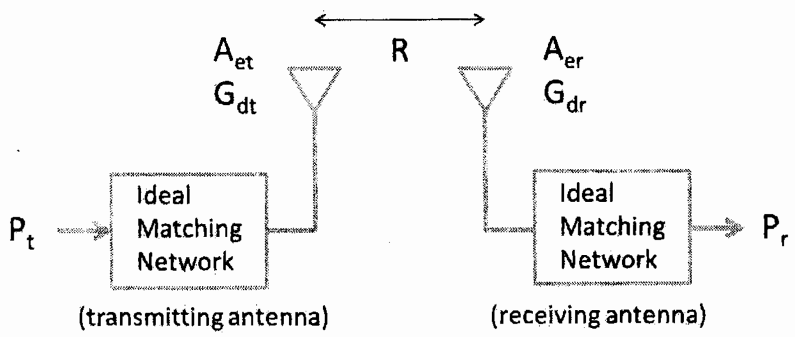

Fig. 4