國立臺灣科技大學101學年度碩士班招生試題

系所組別： 電機工程系碩士班己二組

科　　目： 電磁學

(總分為100分)

**Problem 1: (15%)**

Consider a time-varying point source with a time-averaged radiated power of 1W. Answer the following questions:

(a) Evaluate the **time-averaged power density** at a distance 5 m from the source. **(5%)**

(b) At the same point, evaluate **the magnitude of the electric field** if the propagation medium is free space. **(5%)**

(c) What would be the result of (b) if the EM wave is instead propagating **in a material medium** with a dielectric constant of 4 and a relative permeability of 1? **(5%)**

**Problem 2: (15%)**

A 5-GHz uniform plane wave is propagating in a lossless dielectric medium along **the -*y* direction**. At $y = 0$ **and** $t = 0$, the electric field intensity in phasor form is

$$\mathbf{E}(y=0,t=0)=12\pi e^{+j\frac{\pi}{4}}\mathbf{a}_z \text{ (V/m).}$$

Assume the propagation constant is 100π rad/m and the permeability of the medium is $\mu_0$.

(a) What is the relative permittivity of the medium **(5%)?**

(b) Find **the instantaneous expression of the electric field** at an arbitrary point in the region $y < 0$ and $t > 0$. **(5%)**

(c) If the electromagnetic wave is excited by an infinite current sheet $\mathbf{J}_s(t) = -12\pi\cos(2\pi\times5\times10^9 t)\mathbf{a}_z$, determine **the location of this current source. (5%)**

**Problem 3: (20%)**

As shown in **Fig. 1**, consider a pair of infinitely long line charges, parallel to the z-axis having a uniform charge density $\rho_{L0}$ C/m for z > 0 and a uniform charge density $-\rho_{L0}$ C/m for z < 0. The separation between the two lines is $2a$. Find **the electric field intensity** at the point $P(0, a, 0)$ in the middle of the pair of line charges. (Hint: $\int\frac{xdx}{(x^2+a^2)^{3/2}}=\frac{-1}{\sqrt{x^2+a^2}}$)

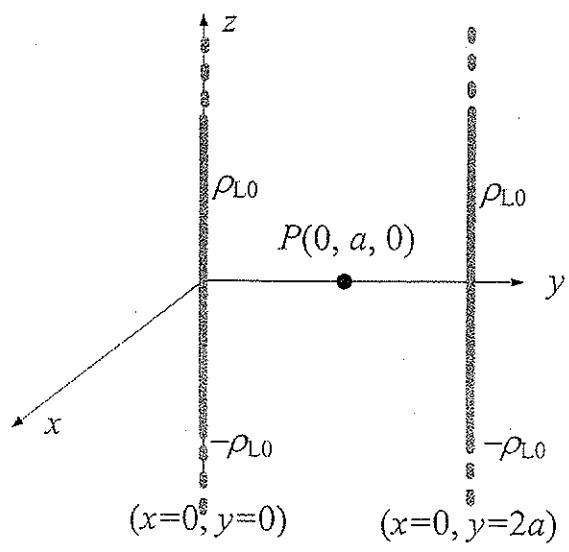


**Fig. 1**

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**Problem 4: (10%)**

The structure shown in **Fig. 2** is filled with a ceramic material ($\varepsilon = 9\varepsilon_0$, $\mu = \mu_0$), and the dimensions are $d = 2$ mm, $w = 4$ mm and $l = 8$ mm, respectively.

(a) Find the value of this inductor. **(5%)**

(b) Assume the quasistatic approximation is valid for $f < \dfrac{1}{20\pi l\sqrt{\mu\varepsilon}}$, find the maximum frequency $f_M$ for which the input behavior of the structure is essentially that of a inductor. **(5%)**

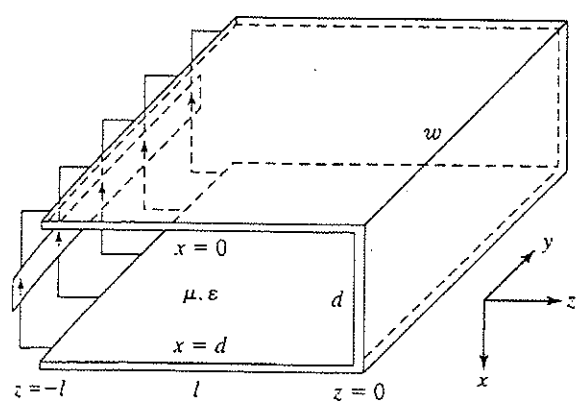


**Fig. 2**

**Problem 5: (20%)**

For the TDR system in **Fig. 3**, the TDR pulses are of amplitude 1 V, duration 10 ns, and repetition rate of 10 kHz.

(a) Find the reflection coefficient at "B" looking into the load. **(4%)**

(b) Find the reflection coefficient at "A" looking toward the load. **(4%)**

(c) Find the time and amplitude of the first reflected pulse. **(4%)**

(d) Find the time and amplitude of the second reflected pulse. **(4%)**

(e) Find the time and amplitude of the third reflected pulse. **(4%)**

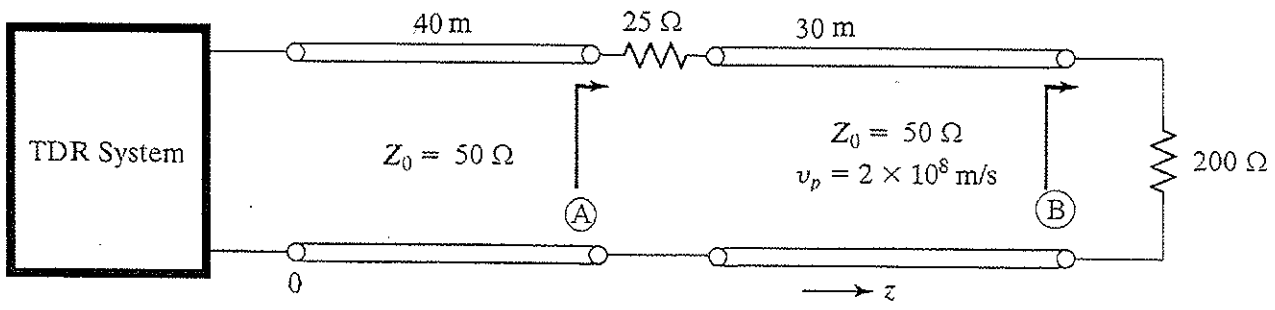


**Fig. 3**

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**Problem 6: (20%)**

A transmission line of characteristic impedance of 50 Ω and $v_p = 2 \times 10^8$ m/s is terminated with a resistor of 40 Ω in series with an inductor of 80 nH, as shown in **Fig. 4**.

(a) Find the load impedance at 120 MHz. **(5%)**

(b) Find the reflection coefficient at the load in polar format. [magnitude and angle] **(5%)**

(c) We want to achieve impedance matching using the quarter wavelength transformer approach as shown below. Assume the transmission line characteristic impedance cannot be made greater than 50 Ω, find the shortest line length $d_q$ [in terms of meter] and transformer line characteristic impedance $Z_q$. [You can use either Smith chart of analytical approach to find the solutions. If you use the Smith chart approach, describe "briefly" how you derived the answers in the answer sheets to get full credits.] **(10%)**

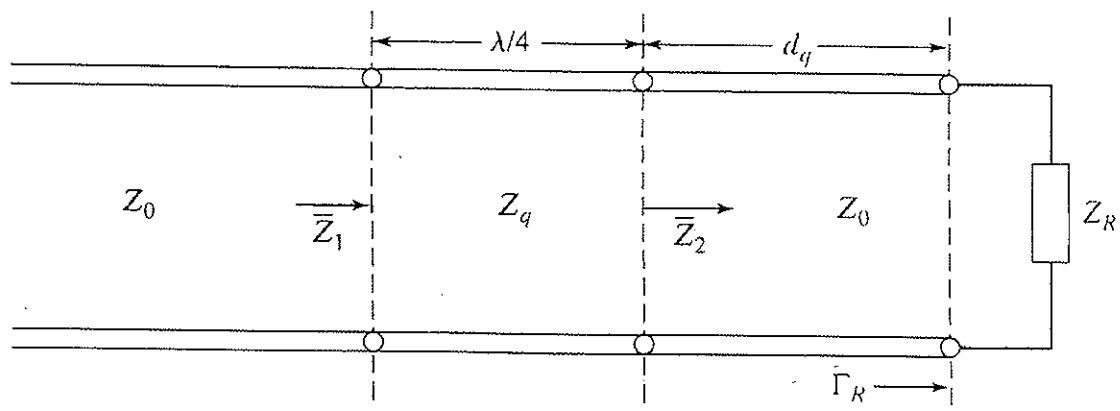


**Fig. 4**

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**本頁僅提供答題操作使用，如使用 Smith Chart 求解，請於答案卷上簡述操作過程。**

## The Complete Smith Chart

Black Magic Design