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：0226，節次：2

※ 考生請注意：本試題可使用計算機，並限「考選部核定之國家考試電子計算器」機型

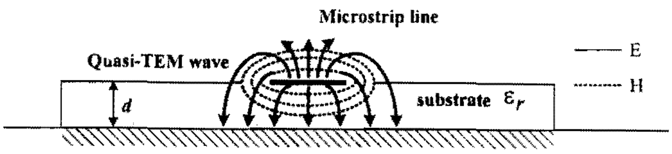
* $\varepsilon_0 = 10^{-9}/36\pi$; $\mu_0 = 4\pi \times 10^{-7}$; $\eta_0 = 120\pi$

1. (a) Briefly explain why the *microstrip line* **can not support pure TEM-wave.** (5%)

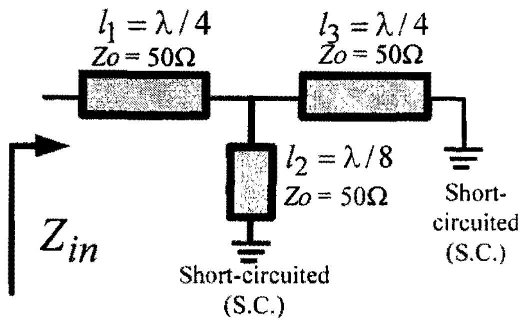
   (b) For **50-Ω** microstrip line is on a substrate with $\varepsilon_r = 4$ and $d = 8$ $\mu$m at $f = 60$ GHz, use the **quasi-TEM-wave approximation**, determine the guided wavelength $\lambda_{eff}$ and wave velocity $v_p$ in the microstrip line. (10%)

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\frac{1}{\sqrt{1+12(d/W)}}$$

* Use the **pure TEM-wave approximation** to the required line width $W$




2. As shown in the following, determine the input impedance $Z_{in}$ of the transmission network (10%)




$$Z_i = Z_0 \frac{Z_L + jZ_0 \tan(\beta l)}{Z_0 + jZ_L \tan(\beta l)}$$

3. The **propagation constant** of a **lossy transmission line** is

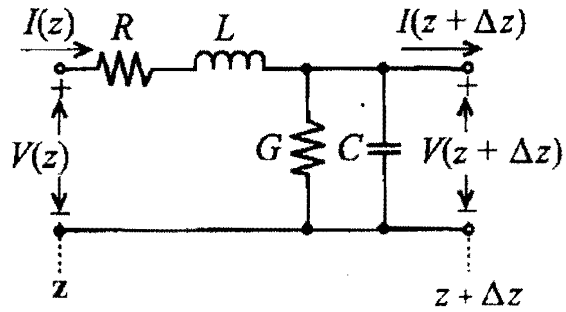
$$\gamma(=\alpha + j\beta) = \sqrt{(R + j\omega L)(G + j\omega C)}$$

It is called the **distortionless line when**

$$R/L = G/C$$

(a) Determine $\alpha$, $\beta$, and phase velocity $v_p$ of a **distortionless line.** (10%)

(b) From $\beta$, explain the advantage of a **distortionless line.** (5%)




(背面仍有題目,請繼續作答)

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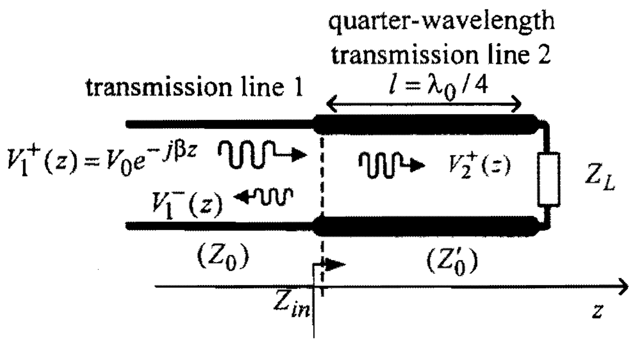
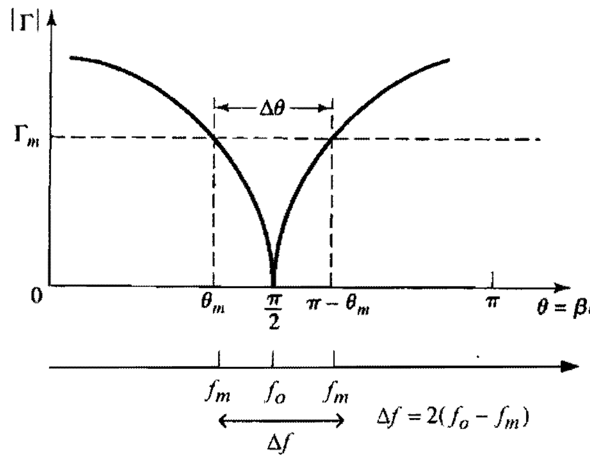
4. For a quarter-wavelength line transformer with a real lad impedance ($Z_L$), the following curve shows an approximate response of the reflection coefficient $\Gamma$ near the central frequency ($f_o$). If $\Delta\theta << \pi/2$ and $\Delta f << f_0$. $\Gamma_m$ can be derived as

$$\Gamma_m^{-2} = 1 + \left[\frac{2\sqrt{Z_0 Z_L}\sec\theta}{(Z_L - Z_0)}\right]^2$$

(a) Prove that $\dfrac{\Delta f}{f_o} = 2 - \dfrac{4}{\pi}\cos^{-1}\left[\dfrac{\Gamma_m}{\sqrt{1-\Gamma_m^2}}\dfrac{2\sqrt{Z_0 Z_L}}{|Z_L - Z_0|}\right]$ (5%)

(b) For $\Gamma_m = 0.5$ and $Z_L = 4Z_0$, determine $\Delta f$ and **reflected & transmitted voltage** (to the load), $V_1^-(z)$ & $V_2^+(z)$, at $f = f_m$. (10%)




5. An **automotive tunnel (汽車隧道)** with a rectangular cross section (*width* $a$ = 15m & *height* $b$ = 6 m) has **aluminum metallic walls** ($\sigma_c = 4\times10^8$). If this tunnel is treated as a **waveguide** :

(a) Determine the **lowest frequency** of the radio wave that will propagate through this tunnel and write down the mode ($TE_{mn}$ or $TM_{mn}$) of this wave. **(5%)**

(b) Let the **tunnel length is 100 m** and a **12-MHz radio wave** propagating into this tunnel. Find the **total attenuation** (dB) of this radio wave through this tunnel. **(5%)**

(c) Determine the VSWR of the radio wave at the end of the tunnel-waveguide (like having a free-space load). **(5%)**

**Note:** *Waveguide wavelength and $TE_{10}$-mode impedance*

$$\lambda_g = \lambda\Big/\sqrt{1-(f_c/f)^2} \quad \& \quad Z_{TE} = \eta_0\Big/\sqrt{1-(f_c/f)^2}$$

*Waveguide $TE_{10}$ mode attenuation constant* :

$$\alpha_{c_{TE10}} = \frac{\lambda}{b\lambda_g}\sqrt{\frac{\pi}{\lambda\eta_0\sigma_c}}\left[1+(\lambda_g/\lambda_c)^2\left(1+2\frac{b}{a}\right)\right]$$

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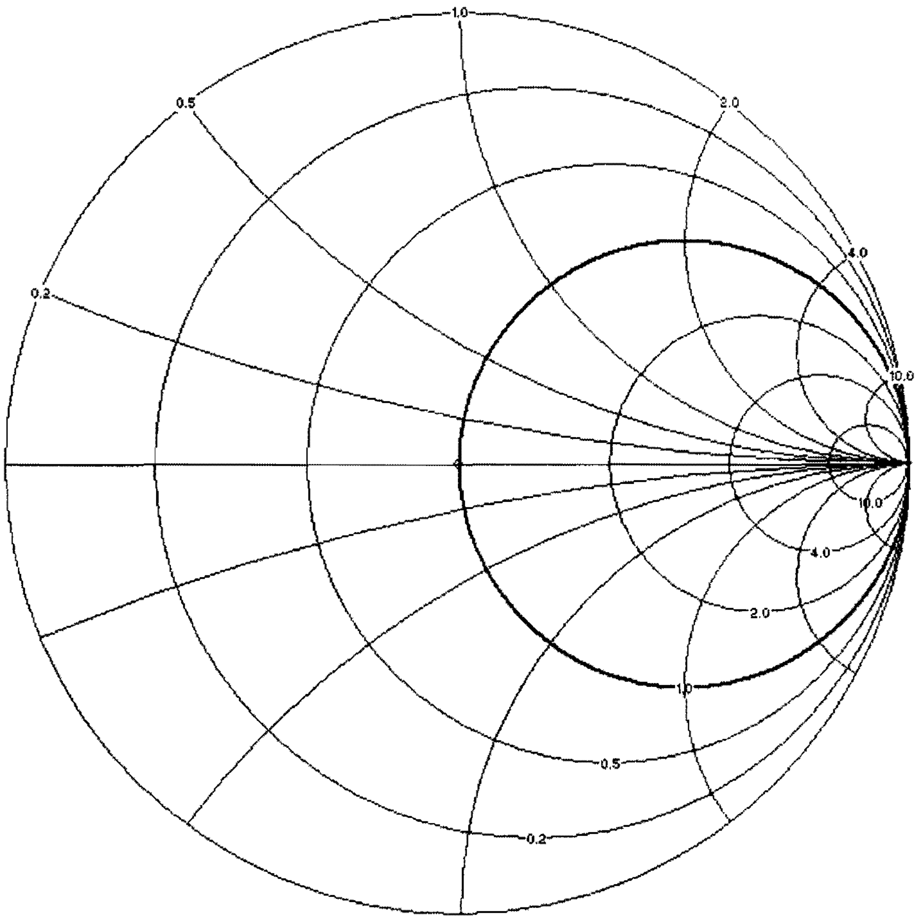
**6.** Plot the **normalized impedance point** (to 50 Ω) in the Smith Chart and the corresponding **SWR circles** (also calculate the **SWR value**). (10%)

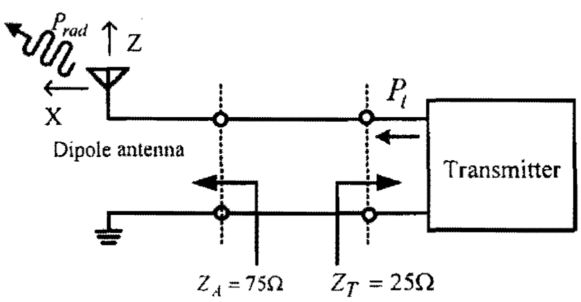
(a) $Z_L = 50\ \Omega$; (b) $Z_L = 75 - j25\ \Omega$; (c) $Z_L = 0\ \Omega$; (d) $\Gamma_L = 0.5\angle 45^0$

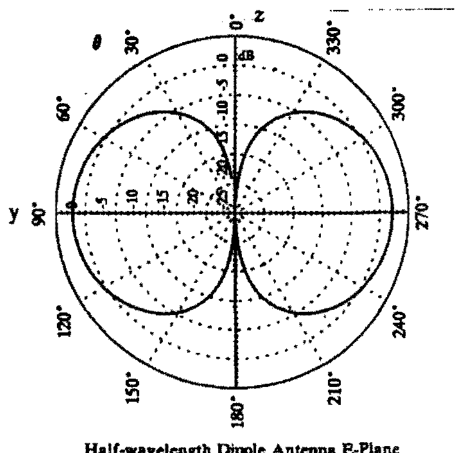



7. Let the transmitter output power is $P_t$ = 1 W and the dipole-antenna input and transmitter output impedance are shown in the figure ($f$ = 10 GHz).

(a) Calculate the relected power (to the transmitter) and dipole-antenna radiation power $P_{rad}$ (dBm) (if the antenna **radiation efficiency** $\eta_{rad}$=0.8). (10%)

(b) From the antenna directive gain pattern (in dB) shown in the figure, calculate the **radiation power density** (**$p_{av}$**) and ***E*-filed strength** in the direction of $\theta$ = $60^0$ and distance $r$ = 1 m. (10%)




Half-wavelength Dipole Antenna E-Plane Directive Gain Pattern