93學年度國立成功大學研究所招生考試 電腦與通信工程研究所 丙組 電磁學及電磁波 試題 共 2 頁 第 1 頁

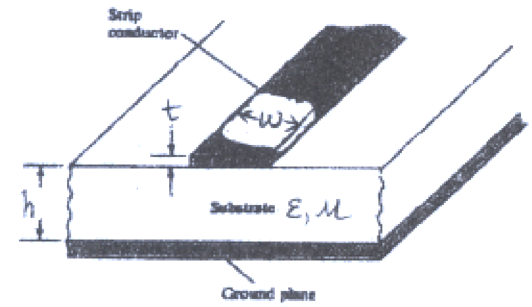
* **Useful constants :** $\varepsilon_0 = 10^{-9}/(36\pi)$ **(F/m);** $\mu_0 = 4\pi \times 10^{-7}$ **(H/m);** $C = 3 \times 10^8$ **(m/s)**

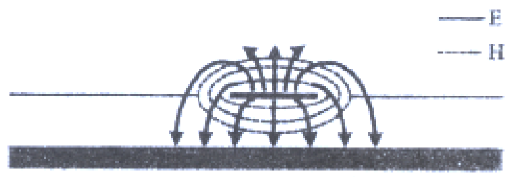
1. (a) Write down the formula of the ***displacement current density*** and the generalized **Ampere's law** (with the ***displacement current density***) in the Maxwell's equations. (5%)
   (b) Explain what is the difference between the **displacement current** and the **free current**? (5%)

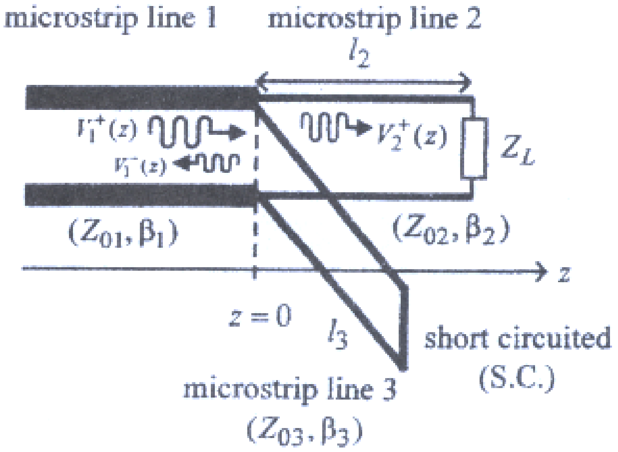
2. Determine the **attenuation ratio (dB)** and the **phase velocity** u_p of a **plane wave** (f = 100MHz) at a distance of 100m below the surafce of the sea water (ε_r= 80, $\sigma = 5(S/m)@f = 100$**MHz**). (10%)

Note that the complex propagation constant in a good conductor is $\gamma \approx \frac{(1+j)}{\sqrt{2}}\sqrt{\omega\mu_0\sigma}$

3. The illustration of the microstrip (transmission) line are shown in the following figures. The microstrip-line 1 (Z_{01}=50Ω) is connected to a parallel connection (at z = 0) of the microstrip-line 2 (Z_{02} = 100Ω, l_2 = 0.25 λ) with a load Z_L and the the microstrip-line 3 (Z_{03} =100Ω, l_3= 0.25 λ) with a short-circuited (S.C.) load. (f = 1 GHz)
   (a) Explain why the microstrip line can not support **a pure TEM wave.** (5%)
   (b) Determine the line width (W) and length (l) of the microstrip line 2 (substrate ε_r = 4 and h = 1mm). * Use the simple parallel-plate formula with TEM wave approximation. (10%)
   (c) If Z_L = 250Ω and the incident voltage (signal wave) is $V_1^+(z) = V_0 e^{-j\beta_1 z}$ in the microstrip line 1, determine the **reflection coffecient** (Γ) and the **SWR** at the point of z = 0 and write down the reflected voltage (wave), $V_1^-(z)$, in the microstrip line 1. (15%)
   (d) If the microstrip-line 1 is a lossless transmission line and the distributed parameter L = 1.25 nH/m, determine the **distributed parameter** C (pF/m) and the **propagation constant** β_l at f = 1GHz. (10%) (β_1)







(背面仍有題目,請繼續作答)

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4. **Waveguide Problem**

An **automotive tunnel (汽車隧道)** with a rectangular cross section (*width* a = 15m & *height* b = 6 m) is with **metal walls**. If we treat this tunnel 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%)**

(d) Let the **length of the tunnel** is **100 m** and a **12-MHz radio wave** propagating into this tunnel (assuming the tunnel wall made of aluminum 鋁 $\sigma_c = 4\times10^8$). Find the **total attenuation** (dB) of this radio wave through this tunnel. **(10%)**

(f) Dtermine the VSWR of the radio wave at the other side of the tunnel-waveguide (like having a free-space load). **(5%)**

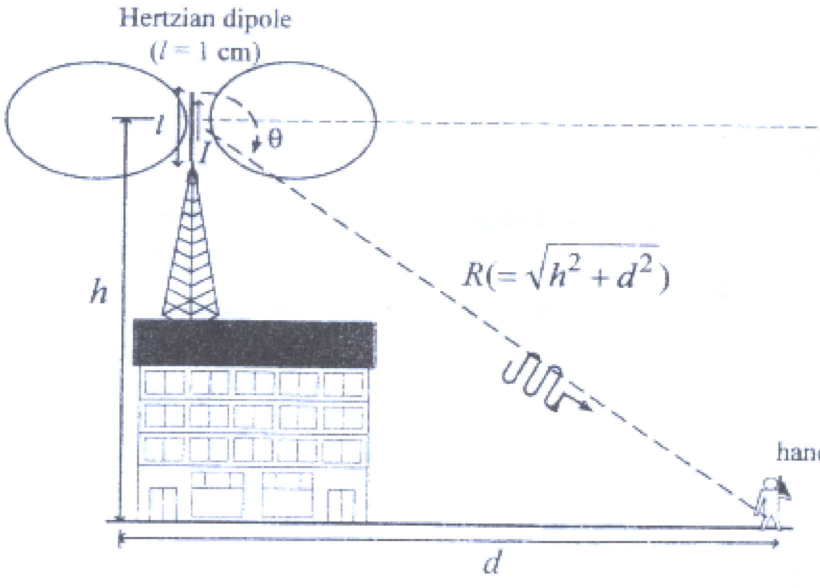
> **Note: Waveguide wavelength & TE_{10}-mode impedance**
>
> $$\lambda_g = \lambda\Big/\sqrt{1-(f_c/f)^2} \quad \& \quad Z_{TE} = \eta_0\Big/\sqrt{1-(f_c/f)^2}$$
>
> **Waveguide TE_{10} mode attenuation constant** :
>
> $$\alpha_{cTE10} = \frac{\lambda}{b\lambda_g}\sqrt{\frac{\pi}{\lambda\eta_0\sigma_c}}\left[1+(\lambda_g/\lambda_c)^2\left(1+2\frac{b}{a}\right)\right]$$

5. As shown in the following figure, let the **input power P_t** to a Hertzian dipole antenna (with an unifrom current distribution I) is **P_t = 1 W** and f = 1 GHz, h = 10 m.

(a) What kind of polarization of the far-zone radiated wave from this Hertzian dipole. (5%)

(b) Determine the **radiation power density** p_{av} (or S) (W/m^2) from the Hertzian dipole antenna at a cellular phone **handset** for a distance of ***d* = *100m*** . (15%)

> *Note: The **current** of the Hertzian dipole antenna can be determined from the **antenna input power P_t** which is equal to the **radiation power** $P_{rad} = \eta_0(klI)^2/12\pi$



Hertzian dipole far-zone radiation fields

$$\begin{cases} \vec{E} = \hat{\theta}\, j\eta k I l \dfrac{e^{-jkr}}{4\pi r}\sin\theta \\ \vec{H} = \hat{\phi}\, jkIl \dfrac{e^{-jkr}}{4\pi r}\sin\theta \end{cases}$$