111 (下)　　電磁學(二)　　共同作業 Part 1　　　　(共 9 題)P1-P9

作業說明:

(a) 共同作業為 take-home exam, 禁止互相討論及抄襲。

(b) 答案請**儘量多輔以文字寫出理由與解釋**，避免與他人高度雷同；只寫公式和代公式計算只會獲得低分。

Problem 1

A lossless 20-km long coaxial cable whose characteristic impedance is 45.5 Ω has the propagation velocity of $0.7c$ (c = speed of light) and $\mu_r = 1$. Calculate (a) the capacitance per unit length and the inductance per unit length, (b) the ratio of the outer radius over the inner radius of this coaxial cable, (c) the relative permittivity of the dielectric between the outer and inner conductors of the cable.

Answers:
(a) $L_u = \cdots$; $C_u = 1.0466\times10^{-10}$ (F/m) (0.1047 (nF/m)); (b) …; (c) $\varepsilon_r = \ldots$.

Problem 2

A two-wired high-power line in air (ε_0, μ_0, $\sigma = 5\times10^{-7}$ S/m) is composed of two parallel 20-mm diameter conductors (ε_0, μ_0, $\sigma_c = 5.7\times10^{5}$ S/m), separated by 1 m, and operates at 1.6 MHz. Calculate (a) the parameters of the transmission line equivalent model (R/L/G/C per unit length) and (b) the propagation constant and the characteristic impedance of the line. (c) To make it function as a distortionless transmission line, an additional series inductor (ΔL) per unit length is designed to inserted in series, calculate the value of ΔL.

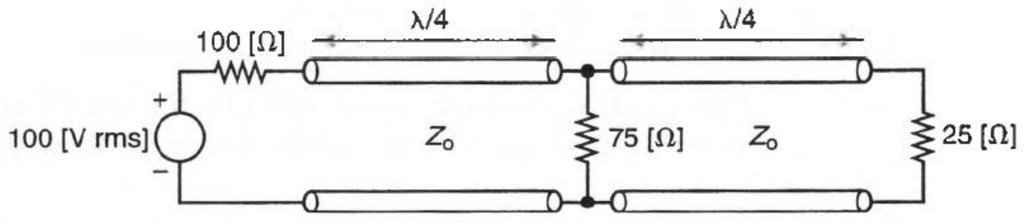
Answers:
(a) $R = 0.106$ Ω/m, …, $C = 6.032\times10^{-12}$ C/m. (b) propagation constant = …;
the characteristic impedance = $552.6 - j2.68\times10^{-2}$ Ω. (c) ΔL =…

Problem 3

A 50-Ω, 10-m transmission line (transmit time = 36 ns) is fed from a signal generator of 200 kHz, $50\angle 0°$ Vrms. Then, a second transmission line is connected. This 75-Ω, 2-m transmission line (transmit time = 8 ns) follows the first line to transmit signals to a load whose impedance is $120 - j200$ Ω. At the junction of the two transmission lines, calculate (a) the reflection and transmission coefficients, (b) the voltage standing-wave ratio (VSWR) of first line, and (c) the voltage and current.

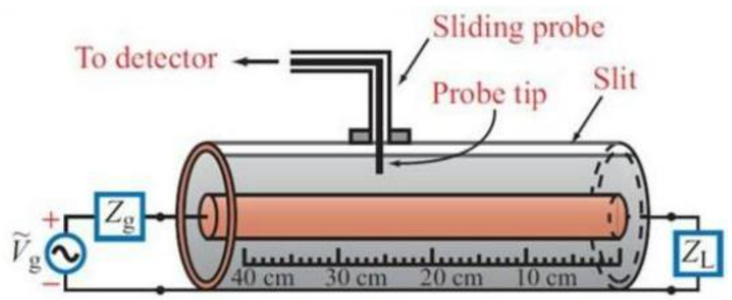
Answers:
(a) $\Gamma_{junction}$ = ⋯. $t_{junction}$ =1.7487 - j0.3 = 1.774∠-9.75°, (b) $VSWR_1$ = 9.348, (c) $V_{junction}$ = 50.4862 - j0.2557 (Vrms) = 50.487∠-0.29° (Vrms), current =….

Problem 4
The lengths of these two transmission lines are quarter wavelengths, operating at 200 MHz. Calculate the power consumptions of those three resistors in these two kinds of transmission lines: (a) Given a lossless transmission line (characteristic impedance $Z_0 = R_0$ Ω, $R_0 = 50$). (b) Given a **lossy** transmission line (characteristic impedance $Z_0 = R_0+jX_0$ Ω, $R_0 = 50$, $X_0 \approx 0$) which has a loss of 0.5 dB/m and the dielectric constant is $\varepsilon_r = 2.0$ and μ_r=1.



Answers:
(a) (For lossless line) $P_{100\Omega}$ = 39.889 W, $P_{75\Omega}$ = …, $P_{25\Omega}$ = 9.972 W..
(b) (For lossy line) $P_{100\Omega}$ = …, $P_{75\Omega}$ = 12.783 W, $P_{25\Omega}$ = ….

Problem 5
A 50-Ω lossless slotted transmission line with a sliding probe is terminated in an unknown load Z_L. The distance between neighboring minimum points is 4 cm. The movable probe slides away from the load, and it is observed that the nearest V_{min} comes first (before the occurrence of V_{max}) and locates at 1.11 cm, and $|V_{max}| = 3.65|V_{min}|$. Find (a) the reflection coefficient at the load, (b) the position of the current minimum nearest the load, and (c) the value of the unknown load impedance.



Answers:
(a) Γ_L = …; (b) at 3.11 (cm), and (c) Z_L = … -j49.734 Ω

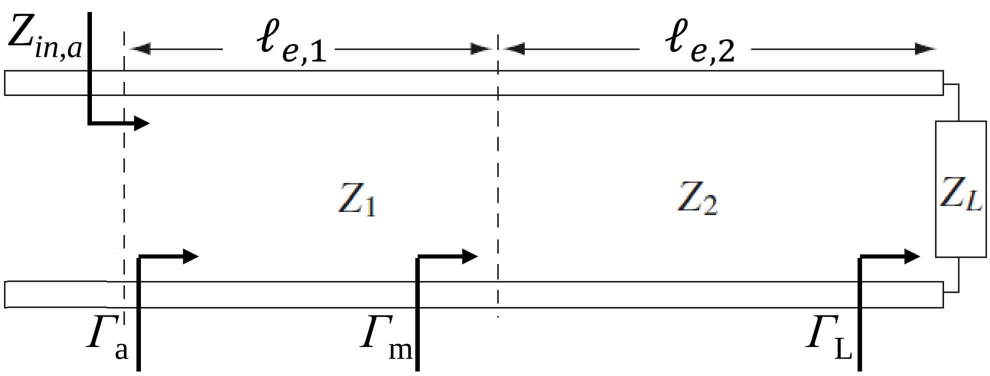
Problem 6

[Using Smith chart] Given a series RC load with an impedance $Z_L = 200 - j100\ \Omega$ and to a 75-Ω, 0.7λ transmission line at a frequency of 500 MHz. "Use Smith chart" to evaluate (describe all the steps in details): (a) VSWR and the reflection coefficient at input of the line, (b) the input impedance Z_{in} looking into this line and its corresponding Y_{in} at the input, (c) the distance of first voltage minimum from the load. (d) inserted a shunt short-circuited stub at the load to make a 'real' reflection coefficient (no imaginary part), find the minimum required length of the stub section and (e) the corresponding VSWR.

Answers:
(a) VSWR = 3.42; Γ_{IN} =… (b) Z_{IN} =… - j10.4 Ω ; Y_{IN} = …;
(c) 0.224λ; (d) …; (e) VSWR = 10/3

Problem 7

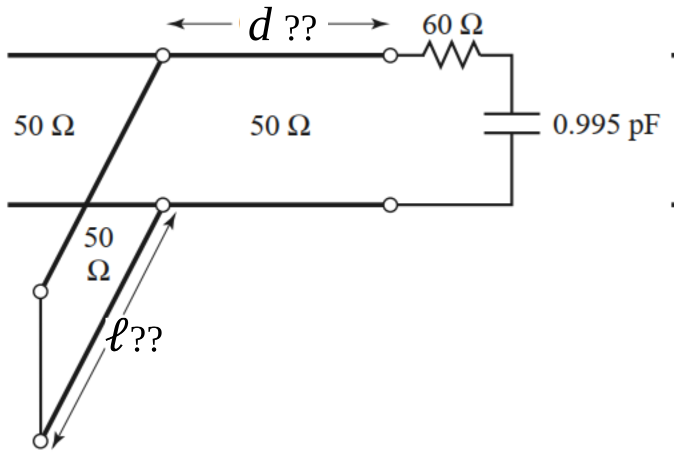
Use Smith chart to find the generalized reflection coefficient and the line impedance at discontinuity. The impedances and electrical lengths of these two cascaded transmission lines are line 1: $(Z_1,\ \ell_{e,1}) = (200, 130°)$ and line 2: $(Z_2,\ \ell_{e,1}) = (75, 75°)$ where $\ell_{e,i}$ represents the electrical length of line 1 and line 2. Assume the generator is matched to the line but the load is not ($Z_L = 150 - j60\ \Omega$). Calculate (a) those reflection coefficients (Γ_a, Γ_m, Γ_L), where Γ_a is the reflection coefficient at a distance $\ell_{e,1}$ (electrical length) away from the discontinuity and Γ_m is the reflection coefficient at the discontinuity in line 1, (b) VSWRs in line 1 and line 2, and (c) input impedance looking into line 1.



Answers:
(a) Γ_L = …; Γ_m = -0.73 - j0.025i = 0.73∠-178°; Γ_a = …; (b) $VSWR_1$ = …, $VSWR_2$ = 2.4; (c) $Z_{in,a}$ = 76 – j…. Ω.

Problem 8

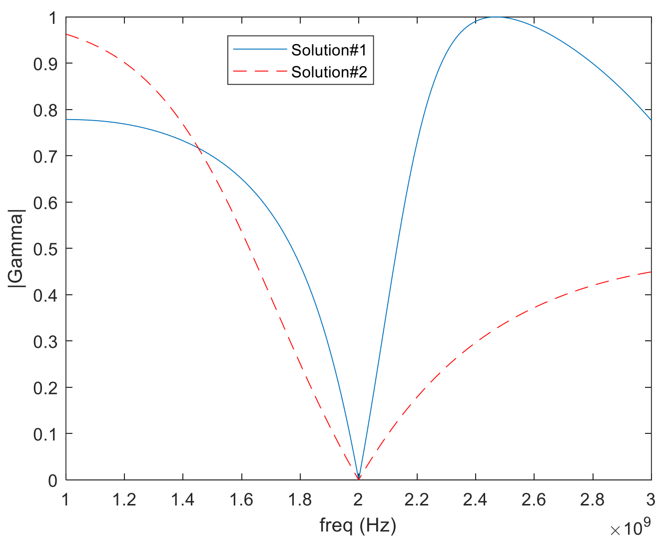
(a) Design a L-section impedance matching network (two solutions) for a load impedance of series RC (R = 60 Ω, C = 0.9947 pF). Using single-stub (short circuit) shunt tuning networks to match this load to a 50-Ω line at 2 GHz. (b) Plot reflection coefficient magnitudes versus frequency chart for the design matching circuits (use mathematic or numerical to calculate $|\Gamma(f)|$). (c) Calculate the fractional bandwidth for $|\Gamma(f)|<0.2$.



Answers:

(a) 2 possible solutions: #1) d_1 = …, ℓ_1= 0.405λ; #2) d_2 = 0.11λ, ℓ_2= …

(b)



(c) Solution#1 freq ranges 1.934 ~ 2.054 GHz; (6%); Solution 2: ….

Problem 9

A time-domain reflectometer is performed, and the voltage waveform in response to a step voltage (shown in Figure 9) is observed at the sending end of a shorted transmission line ($Z_0 = 50\ \Omega$ and $\varepsilon_r = 4$, $\mu_r = 1$). Find V_g, R_g, and the line length.

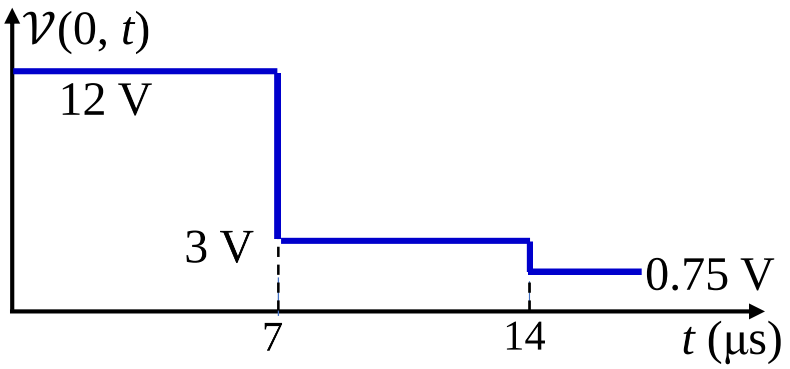


Figure 9

Answers:

$V_g = \ldots$, $R_g = \ldots$, the line length = 525 m.