Q1 Model answer EE312 2016/2017

[A] - $e^{-\alpha z} = 0.5$

$\alpha = \frac{\omega \epsilon''}{2\epsilon'} \sqrt{\mu \epsilon'} = 1.85 \times 10^{-4}$ NP/m

$z = 3.72$ km → (3)

[B] $\beta z = \frac{\pi}{2}$

$\beta = \omega \sqrt{\mu \epsilon'} = 3.717$ rad/m

$z = 0.4225$ m → (3)

[C] $\delta = \frac{1}{\alpha} = 5405.4$ m → (3)

(B)

(a) $\omega = \beta v_p = 3 \times 10^9$ rad/sec → (2)

(b) $\Gamma\big|_{z=0} = \frac{E^-}{E^+} = \frac{1}{3}\angle 20°$ → (2)

(c) $H_1^+ = \frac{1}{\eta}(a_N \times E^+) = \frac{1}{\eta_0}(\hat{a}_z \times E^+) = 0.398\, e^{-j10z}\, \hat{a}_y$ → (2)

$H_1^- = -\frac{1}{\eta}(a_N \times E^-) = -0.133\, e^{j10z}\, e^{j20}\, \hat{a}_y$ → (2)

(d) $\Gamma = \frac{\eta_2 - \eta_1}{\eta_2 + \eta_1} = \frac{1}{3}\angle 20$

$\eta_2 = 691.45 + j177.36 = 713.8 \angle 14.3$ → (2)

(e) $E_2^+ = \tau E_1^+ = (1 + \Gamma) E_1^+ = 197.73\, e^{j4.96°}\, e^{-(\alpha_2 + j\beta_2)z}\, \hat{a}_x$ → (2)

(f) $z_{max} = \frac{\phi + 2m\pi}{-2\beta_1} = \frac{\phi}{-2\beta_1}\Big|_{m=0} = -1.76$ cm → (1.5)

$z_{min} = \frac{\phi + (2m+1)\pi}{-2\beta_1} = \frac{-\phi - \pi}{2\beta_1}\Big|_{m=0} = -17.45$ cm → (1.5)

(g) $E_{max} = (1 + |\Gamma|) E_{x_0}^{+}$

$= \left(1 + \frac{1}{3}\right) \times 150 = 200 \ V/m \rightarrow$ (2)

$E_{min} = (1 - |\Gamma|) E_{x_0}^{+}$

$= 100 \ V/m \rightarrow$ (2)

Q 2

A - $E_s = 10(\hat{a}_y + j\hat{a}_z) e^{-j25x}$

(a) $f \Rightarrow \beta = 25 = \frac{\omega}{v_p} \Rightarrow f = 1.19 \ GHz \rightarrow$ (3)

(b) $H_s = \frac{1}{\eta_0}(\hat{a}_N \times E_s)$

$= \frac{10}{377}\left(\hat{a}_x \times (\hat{a}_y + j\hat{a}_z) e^{-j25x}\right)$

$= 0.026(\hat{a}_z - j\hat{a}_y) e^{-j25x}$ $\rightarrow$ (3)

(c) $P_{avg} = \frac{1}{2} Re(E \times H^*)$

$= \frac{1}{2\eta} |E|^2 \cos\theta_\eta$

$= 0.265 \hat{a}_x \rightarrow$ (3)

B $jk = 0.2 + j2$

(a) $\alpha = 0.2 \rightarrow$ (2)

$\beta = 2 \rightarrow$ (2)

$\gamma = 0.2 + j2 \rightarrow$ (1)

(b) $P_{av} = \frac{1}{2\eta} |E|^2 \cos\theta_\eta = 315.4 \ W/m^2 \rightarrow$ (3)

ⓒ

ⓐ SWR -

$$Z_{in} = Z_2 \frac{Z_3 + jZ_2 \tan \beta_2 L_2}{Z_2 + jZ_3 \tan \beta_2 L_2}$$

$$Z_2 = \frac{Z_0}{2} \quad \& \quad Z_3 = \frac{Z_0}{3}$$

$$\beta_2 = \omega \sqrt{\mu_2 \epsilon_2} = 10\pi$$

$$\beta_2 L_2 = 0.05 \times 10\pi = 0.5\pi \Rightarrow \tan \beta L = \infty$$

$$\text{so } Z_{in} = \frac{Z_2^2}{Z_3} = 90\pi \ \Omega \rightarrow (1)$$

$$\Gamma = \frac{Z_{in} - Z_1}{Z_{in} + Z_1} = -1/7 \longrightarrow (2)$$

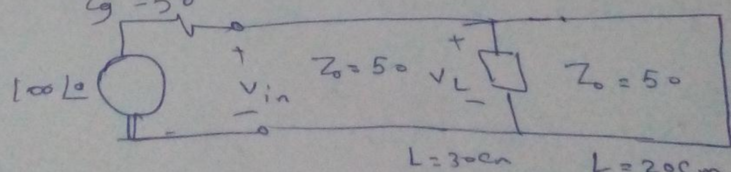
$$SWR = \frac{1 + |\Gamma|}{1 - |\Gamma|} = 1.33 \longrightarrow (2)$$

ⓑ $Z_{in} = Z_1$ and assuming $d_2 = \frac{\lambda}{4} \Rightarrow \beta_2 d_2 = \frac{\pi}{2}$

$$\text{so } Z_1 = \frac{Z_2^2}{Z_3} \Rightarrow Z_2 = \sqrt{Z_1 Z_3} \text{ so} \Rightarrow$$

$$Z_2 = Z_0/\sqrt{3} \longrightarrow (3)$$

Q 3



$$Z_0 = \sqrt{L/C} = 50\,\Omega \rightarrow (1)$$

$$\beta = \omega\sqrt{LC} = \frac{4}{5}\pi \longrightarrow (1)$$

$$Z_L = 0,\ L = 20\,Cm \Rightarrow Z_{in_1} = Z_0 \frac{Z_L + jZ_0 \tan\beta L}{Z_0 + jZ_L \tan\beta L} = jZ_0 \tan\beta L$$

$$Z_{in_1} = j27.48\ \Omega \longrightarrow (2)$$

$Z_{ineq} = Z_{in} \parallel (50 + j20)$

$= 7.94 + j19.9 \longrightarrow$ (1)

$\Gamma = \dfrac{Z_{ineq} - 50}{Z_{ineq} + 50} = 0.759 \angle 2.36\,rad \longrightarrow$ (2)

$SWR = \dfrac{1 + |\Gamma|}{1 - |\Gamma|} = 7.3 \longrightarrow$ (2)

$Z_{in}\Big|_{z=50cm} = 36.05 + j98.16 = 104.5 \angle 1.218\,rad$ (2)

$V_{in} = V_g \dfrac{Z_{in}}{Z_{in} + Z_g} = 80.1 \angle 0.367\,rad$

$V_{in}\Big|_{z=-50cm} = V^+ e^{j\beta L} + \Gamma V^+ e^{-j\beta L}$

$= V^+ e^{j(\frac{4}{5}\pi \times 0.5)} + 0.759 e^{j2.36} V^+ e^{-j(\frac{4}{5}\pi \times 0.5)}$

$\Rightarrow V^+ = 45.6 \angle -0.826\ V \longrightarrow$

so $V\Big|_{z=-20} = 45.65 e^{-j0.826} e^{+j(\frac{4}{5}\pi \times 0.2)} + 0.759 e^{j2.36} V^+ e^{-j(\frac{4}{5}\pi \times 0.2)}$

$V = 45.65 e^{-j0.323} + 34.65 e^{j1.038}$

$= 62.79 \angle 0.247\ V \longrightarrow$ (2)

$P_{av}\Big|_{Z_L} = P_{av}\Big|_{Z_{in}} = \frac{1}{2} |I_{in}|^2 R_e(Z_{in})$

$I_{in} = \dfrac{V_{in}}{Z_{in}} = \dfrac{80.1 \angle 0.367}{104.5 \angle 1.218} = 0.765 \angle -0.852\ A$

$P_{av} = 10.57$ watt $\longrightarrow$ (2)

Q4

A Γ

$Z_{L_n} = \frac{Z_L}{Z_0} = 1.2 + j0.6$

(a) $\Gamma = 0.28 \angle 56^\circ \rightarrow (3)$

(b) $SWR = 1.8 \rightarrow (2)$

(c) distance $= 0.5\lambda - 0.173\lambda = 0.327\lambda$

(d) $y_L = 0.667 - j0.33$

$y_{in_1} = 1 + j0.57$

T.L length =

$0.147\lambda - 0.423\lambda + 0.5\lambda$

$= 0.224\lambda \rightarrow (2.5)$

O.C. stub $-j0.57$

$= 0.417\lambda \rightarrow (2.5)$

S.C. stub $-j0.57$

$= 0.417\lambda - 0.25\lambda$

$= 0.167\lambda$

$\rightarrow (2.5)$

$y_{in_1} = 1 - j0.57$

T.L. length =

$0.352\lambda - 0.423\lambda + 0.5\lambda$

$= 0.429\lambda \rightarrow (2.5)$

O.C. stub $j0.57$

$= 0.083\lambda$

S.C. stub $j0.57$

$= 0.083\lambda + 0.25\lambda$

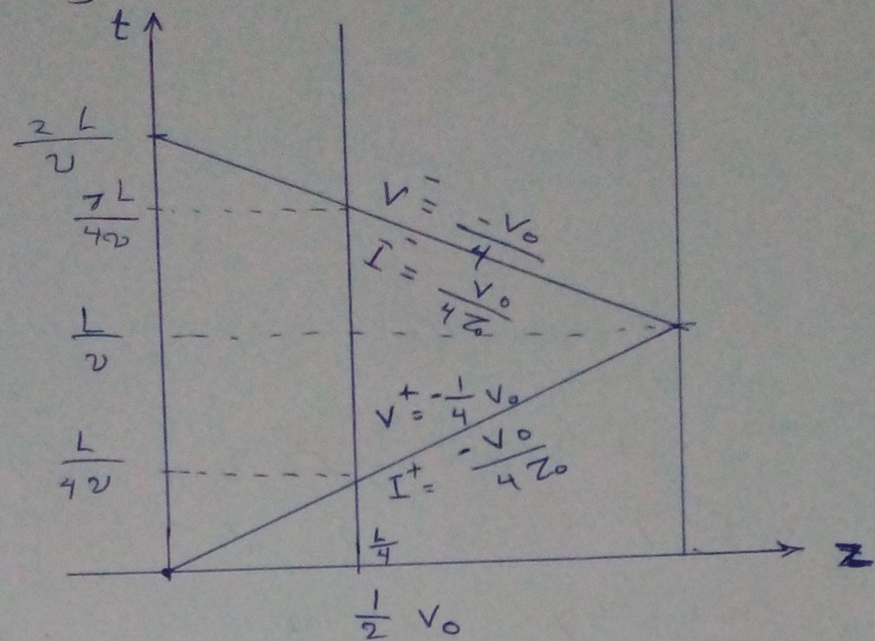
$= 0.333\lambda$

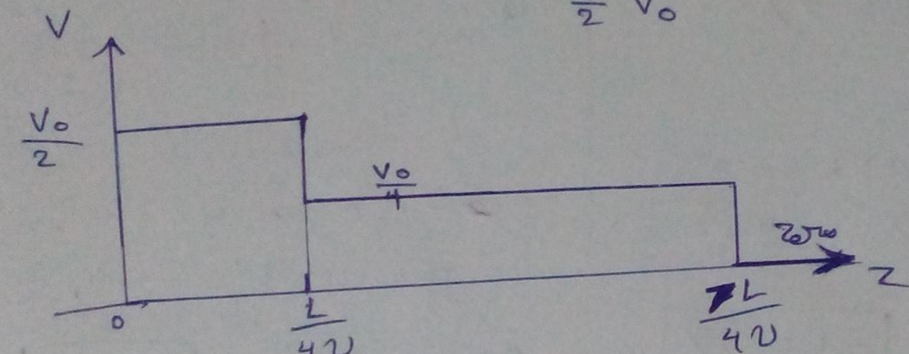
B $R_g = Z_0$, $V_{in} = \frac{1}{2} V_0$

$\Gamma_L = \frac{R_L - Z_0}{R_L + Z_0} = 1 \rightarrow (1)$

$\Gamma_g = \frac{R_g - Z_0}{R_g + Z_0} = 0 \rightarrow (1)$

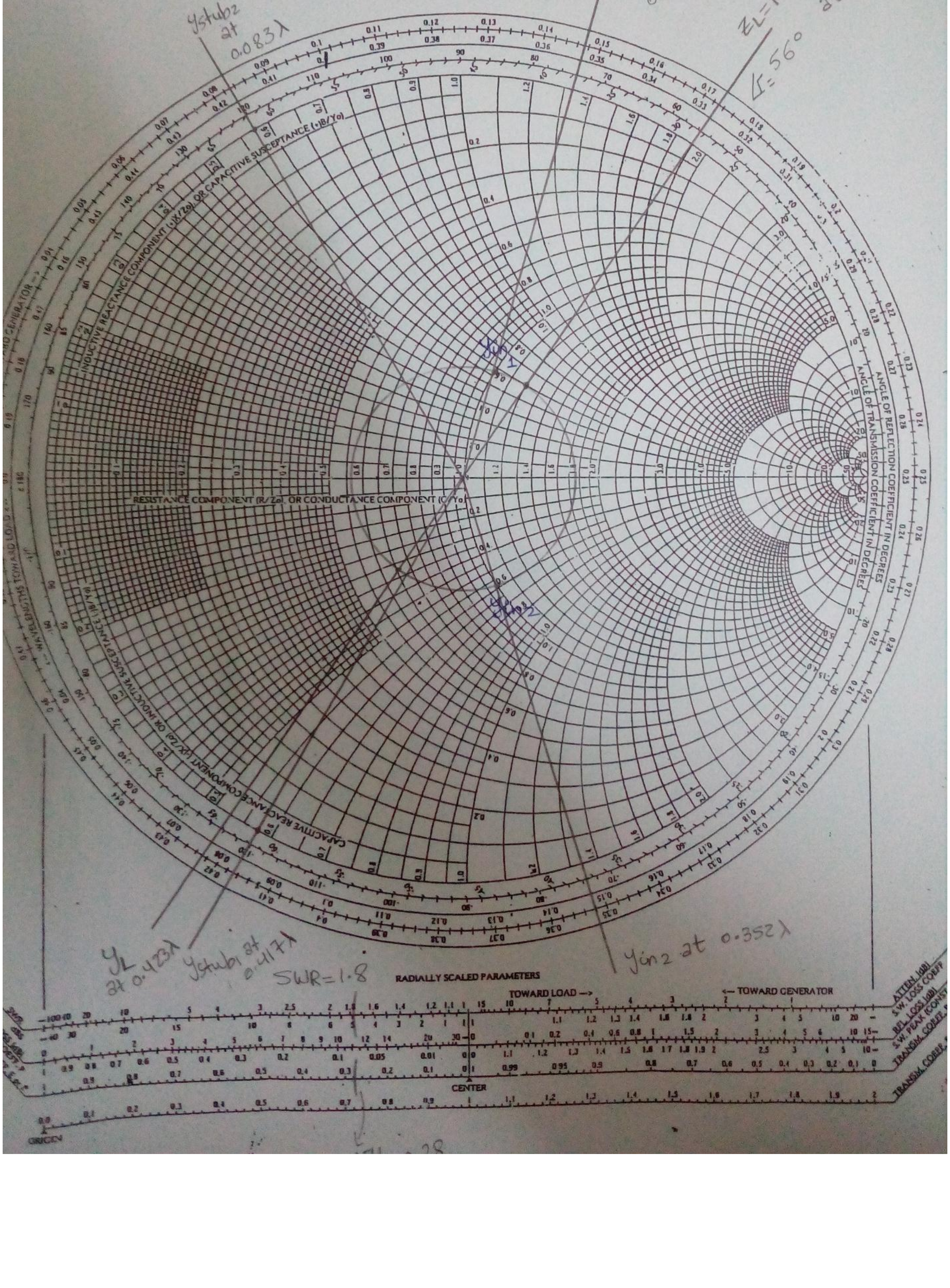
$$V^{+} = -\frac{Z_0}{Z_0 + R_g} \qquad V_{in} = -\frac{V_0}{4}$$





The Complete Smith Chart

Black Magic Design



Benha University
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Department: Electric
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<u>*Answer All Questions*</u>

<u>*Question ①*</u> (*28 marks*)

A- A 150 MHz uniform plane wave having amplitude E_o and propagated in +ve z direction within a lossy dielectric having $\epsilon_r = 1.4$, $\mu_r = 1$ and $\frac{\sigma}{\omega\epsilon} = 10^{-4}$. How many meters can the wave travel in the dielectric before :

(a) Its $|E(z)| = 0.5 * E_o$ (3)
(b) Phase shifted by 90^o related to z = 0 position (3)
(c) Depth of penetration (3)

B- Region z < 0, is characterized by $\epsilon_r' = \mu_r = 1$ and $\epsilon_r'' = 0$. The total E field here is given as two components, $\boldsymbol{E_1^+} = 150\, e^{-j10z} a_x$ and $\boldsymbol{E_1^-} = 50\, e^{j10z} e^{j20} a_x$ V/m.

Find a) ω (2)
b) Reflection coefficient (Γ) amplitude and phase (2)
b) $\boldsymbol{H_1^+}$ and $\boldsymbol{H_1^-}$ (4)
c) Intrinsic impedance for region z > 0 that provides the appropriate reflected wave. (2)
d) The transmitted wave $\boldsymbol{E_2^+}$ (2)
e) Positions of first maximum and minimum at region z < 0 (3)
f) Maximum and minimum values of electric field at region z < 0 (4)

<u>*Question ② (25 marks)*</u>

A- The electric field of a uniform plane wave in free space is given by $E_s = 10\,(a_y + j\,a_z)\,e^{-j25x}$

(a) Determine the frequency, *f* (3)
(b) Find the magnetic field phasor, H_s (3)
(c) Calculate the average power. (3)

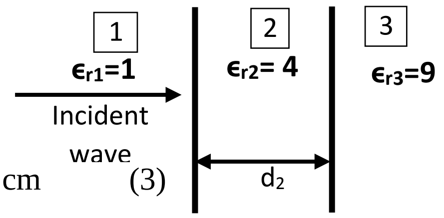
B- Let $jk = 0.2 + j2$ m^{-1} and $\eta = 250 + j30$ Ω for a uniform plane propagating in the +ve a_z direction within a dielectric material having some finite conductivity. If $|E_s| = 400$ V/m at z = 0.

Find:

(a) α , β and γ (5)

(b) P_{av} (average power) at z = 0 (3)

C- The given three regions are all lossless and nonmagnetic, where the incident wave frequency is 750 MHz.
(a) Find the standing-wave ratio for wave in the region 1 when d_2 = 5 cm. (5)
(b) Suggest a matching technique for layer 2 (ϵ_{r2} unknown) where the wave has no reflection in region 1. Assume d2=5 cm (3)



<u>*Question ③ (13 marks)*</u>

In Fig. Q.3, a **lossless transmission line** is 50 cm in length and operating at a frequency of 100 MHz. The line parameters are L = 0.2 μH/m and C = 80 pF/m. The line is terminated by a short circuit at z = 0, and there is a load, Z_L =50+j20 Ω across the line at location z = −20 cm. What is the reflection, VSWR (standing wave ratio), voltage at Z_L (incident and reflected) (amplitude and phase) and the average delivered power to Z_L if the source has an input voltage 100 $\angle 0^o$ V with Zg = 50 Ω?

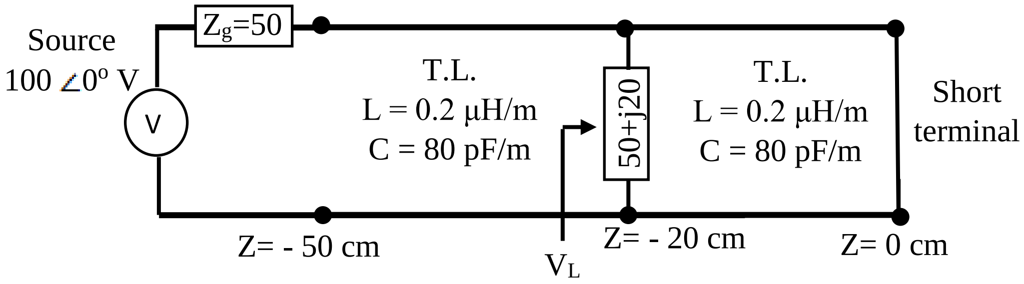


Fig. Q.3

Question ④ (24 marks)

A- A lossless 50 Ω transmission line operates with velocity 0.8*C* where *C* = 3 × 10^8 m/s and *f* = 300 MHz and terminated by a load Z_L= 60 + j 30 Ω located at z = 0.

Use smith chart to find:

(a) Amplitude and angle of reflection coefficient. (3)

(b) SWR (2)

(c) The distance from the load to the nearest voltage minimum (per wavelength). (2)

(d) The lengths of transmission line and open-circuit stubs (shortest length) for matching load with transmission line. (5)

(e) The lengths of transmission line and short-circuit stubs (shortest length) for matching load with transmission line. (5)

B- In Fig. Q.4B, there is ½ V_o initial voltage stored in transmission line before switch is on. The transmission line has an open terminated end, i.e., $R_L = \infty$ while $R_g = Z_o$. The line has Z_o = 50 Ω. For the time period $0 < t < 2L/v$, plot

a) Voltage and current reflection diagram as function of V_o. (3)

b) The line voltage at *L*/4 as function of V_o. (4)

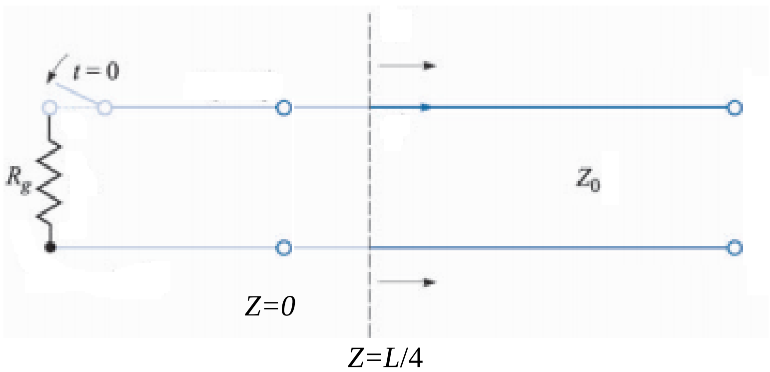


Fig. Q.4B

My Wishes for all,