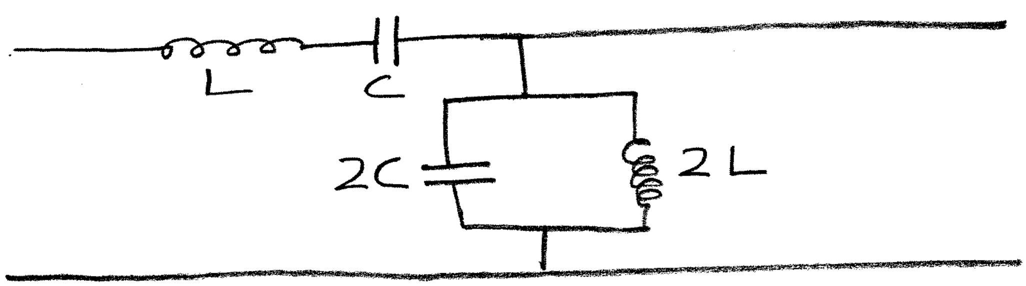
ENEE 381 Second Examination
Thursday, November 21, 2002, 12:30 - 1:45pm
ANSWER 3 QUESTIONS
If more than 3 are answered, best 3 will count

(1) A transmission line of characteristic impedance 50 ohm is terminated with a load Z_L. The line is being driven at a freqency of 100 MHz. The line is found to be matched by adding an inductance in parallel to the line at 0.1 λ from the load. The inductance needed is 79.58 nanoHenry. What is the value of the load? (7 points). What is the reflection magnitude and phase at the load when the line is unmatched? (2 pts.) What is the standing wave ratio when the line is unmatched? (1 pt.)

(2) For the generalized transmission line shown below draw the behavior of the attenuation constant (α) in the stop band and the propagation constant (β) in the pass bands(s). What are the cutoff frequencies?



For what frequency range is this a backward wave line? What are the phase and group velocities in this range?

(3)A plane wave linearly polarized perpendicular to the plane of incidence (an S-wave) is incident on the planar boundary between two lossless dielectrics at angle θ_1. By using the boundary contions at the interface Prove the following expression for the reflection coefficient at the boundary (6 pts.)

$$\rho = \frac{Z_2 \sec\theta_2 - Z_1 \sec\theta_1}{Z_2 \sec\theta_2 + Z_1 \sec\theta_1}$$

If θ_1=30°, and the dielectric constants of the first and second media are 2 and 4, repectively, what fraction of the incident wave Poynting vector is transmitted through the boundary? (4pts.)

(4) A plane wave is bouncing in a zig-zag pattern between two infinite, plane, perfect conductors with its electric vector in the plane of incidence (a TM wave). Derive expressions for the field components between the two conductors (7pts.). If the spacing between the conductor is 100mm and has ϵ_r=1 and the wave frequency is 10GHz, what is one possible reflection angle for the bouncing waves? (3pts.)

$$\epsilon_0 = 8.854 \times 10^{-12} \quad \text{F/m}$$
$$\mu_0 = 4\pi \times 10^{-7} \quad \text{Henry/m.}$$
$$c_0 = 2.998 \times 10^{8} \quad \text{m/s.}$$
$$Z_0 = 377 \text{ ohm.}$$

ENEE 381 SECOND EXAMINATION SOLUTIONS

(1) $Z_0 := 50$ Characteristic impedance of line

$Y_0 := \frac{1}{Z_0}$ Characteristic admittance

$\nu := 10^8$ Frequency

$\omega := 2 \cdot \pi \cdot \nu$

$L := 79.58 \cdot 10^{-9}$ Inductance

$Y := \frac{1}{i \cdot \omega \cdot L}$

$\frac{Y}{Y_0} = -i$ Normalized admittance of inductance

Consequently at 0.1 lambda from load

$y_i := 1 + i$

From the Smith Chart the normalized load is 1.4-j1.09 so

$Z_l := 70 - i \cdot 54.5$

$\rho := \frac{Z_l - Z_0}{Z_l + Z_0}$

$\rho = 0.309 - 0.314i$

$|\rho| = 0.44$

$\frac{\arg(\rho)}{\deg} = -45.422$

$S := \frac{1 + |\rho|}{1 - |\rho|}$

$S = 2.575$

(2) $i := 1,2..1000$

$$Z = i\cdot\omega\cdot L + \frac{1}{i\cdot\omega\cdot C}$$

$$Y = i\cdot\omega\cdot 2\cdot C + \frac{1}{i\cdot\omega\cdot 2\cdot L}$$

$$\gamma = \sqrt{\left(i\cdot\omega\cdot L + \frac{1}{i\cdot\omega\cdot C}\right)\cdot\left(i\cdot\omega\cdot 2\cdot C + \frac{1}{i\cdot\omega\cdot 2\cdot L}\right)}$$

$$\gamma = \frac{1}{2}\cdot\left[-\left(2\cdot\omega^2\cdot C\cdot L - 2\right)\cdot\frac{\left(4\cdot\omega^2\cdot C\cdot L - 1\right)}{\left(\omega^2\cdot C\cdot L\right)}\right]^{\left(\frac{1}{2}\right)}$$

Note that cutoff frequencies are

$$\omega_1 = \frac{1}{\sqrt{L\cdot C}} \qquad \omega_2 = \frac{1}{2\cdot\sqrt{C\cdot L}}$$

To plot curves give C and L some values

$$C := 10^{-9} \qquad L := 10^{-9}$$

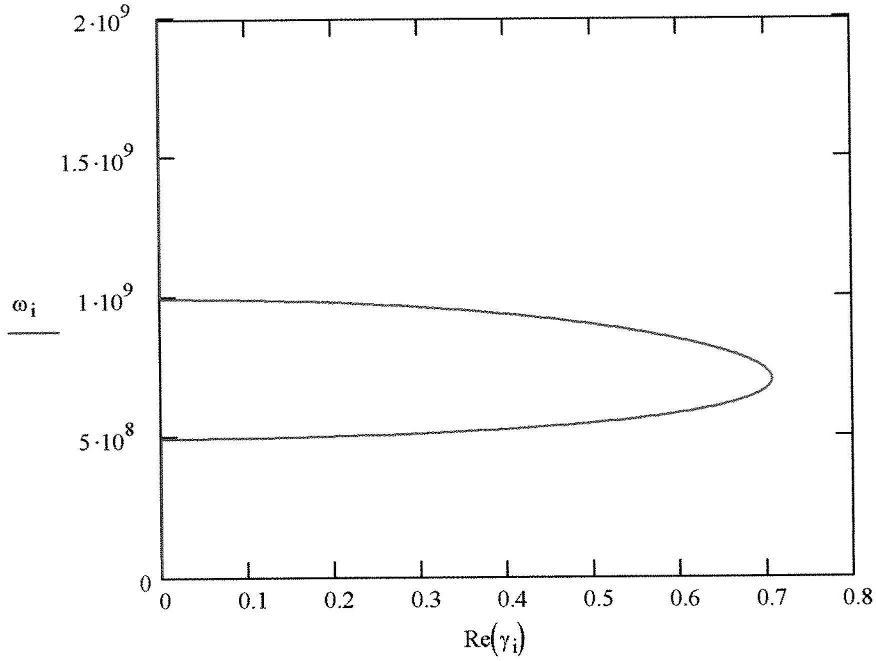
$$\omega_1 := \frac{1}{\sqrt{L\cdot C}} \qquad \omega_2 := \frac{1}{2\cdot\sqrt{L\cdot C}}$$

$$\omega_1 = 1\times 10^9 \qquad \omega_2 = 5\times 10^8$$

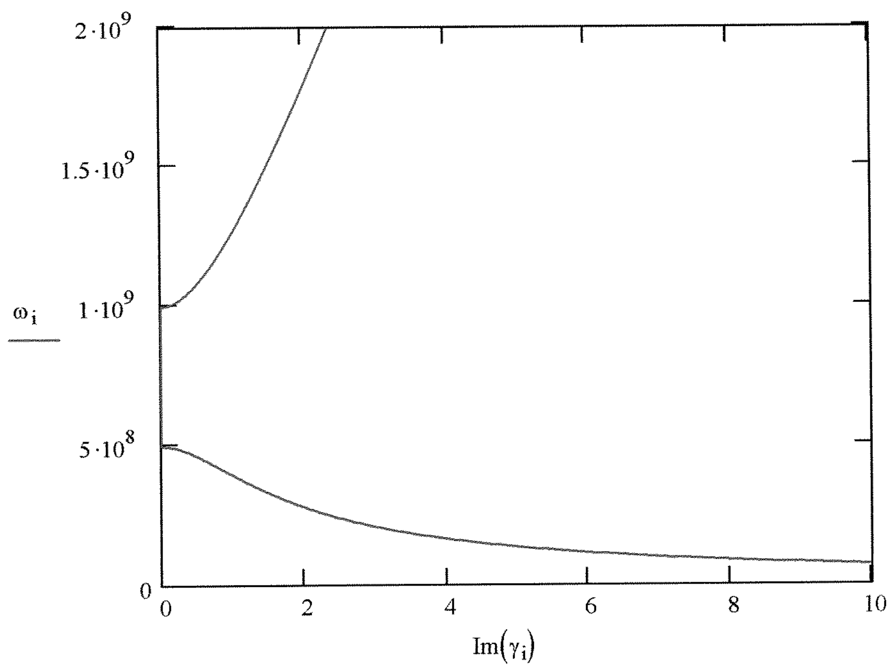
$$\omega_i := i\cdot\frac{2\cdot 10^9}{1000}$$

$$\gamma_i := \frac{1}{2}\cdot\left[-\left[2\cdot\left(\omega_i\right)^2\cdot C\cdot L - 2\right]\cdot\frac{\left[4\cdot\left(\omega_i\right)^2\cdot C\cdot L - 1\right]}{\left[\left(\omega_i\right)^2\cdot C\cdot L\right]}\right]^{\left(\frac{1}{2}\right)}$$

alpha in the stop band



Beta in the pass bands



(3) $\theta_1 := 30 \cdot deg$ $\quad n_1 := \sqrt{2}$ $\quad n_2 := \sqrt{4}$ $\quad Z_0 := 376.6$

$$\theta_2 := \operatorname{asin}\left(\frac{n_1 \cdot \sin(\theta_1)}{n_2}\right)$$

$$\frac{\theta_2}{deg} = 20.705$$

$$Z_2 := \frac{Z_0}{n_2} \qquad Z_1 := \frac{Z_0}{n_1}$$

$$Z_2 = 188.3 \qquad Z_1 = 266.296$$

$$\rho := \frac{Z_2 \cdot \sec(\theta_2) - Z_1 \cdot \sec(\theta_1)}{Z_2 \cdot \sec(\theta_2) + Z_1 \cdot \sec(\theta_1)}$$

$$\rho = -0.209$$

$$T := 1 - (|\rho|)^2$$

$$T = 0.956$$

(4) $\nu := 10 \cdot 10^9$

$d := 0.1$ **Meters**

$$c_0 := 2.998 \cdot 10^8$$

$$\lambda := \frac{c_0}{\nu}$$

$$\lambda = 0.03$$

$$d = \frac{\lambda}{2 \cdot \cos(\theta)}$$

$$\theta := \operatorname{acos}\left(\frac{\lambda}{2 \cdot d}\right)$$

$$\frac{\theta}{deg} = 81.379$$

$$k := \frac{2 \cdot \pi}{\lambda}$$

$$k \cdot \cos(\theta) \cdot d = 3.142$$