February 9, 2007 Duration: 50 minutes	EE331 Midterm Exam. # 1 (Closed notes & book)	Spring 2007 School of EECS/ WSU
Name: Master Solution	ID #:	

- Answer all questions and budget your time.
- Closed books
- Closed notes (two pages of equations allowed)
- No crib notes
- No headphones, cell phones, or pagers. Make sure your cell phone is off, otherwise 20% will be taken of the exam grade.
- No hats
- No guests or visitors during exam.
- See attached equation sheets.
- Relax and take a deep breath !!

Signature: ____________________

	Possible Points	Grade point
1	25	
2	25	
3	25	
4	25	
	100	

Problem 1

The electric field traveling in a lossy nonmagnetic medium is given by:

$$\vec{E} = 0.5e^{-2x}\sin(\pi 10^9 t - 20x)\,\hat{a}_z \text{ V/m}$$

Determine the following:

1. Direction of propagation: (4) $+\hat{a}_x$

2. Frequency of the wave (4) $\omega = 2\pi f = \pi 10^9$
   $f = 5\times10^8$ Hz $= 0.5$ GHz

3. Phase velocity of the wave (4) $\beta = 20$
   $u_p = \frac{\omega}{\beta} = \frac{\pi\times10^9}{20} = 1.57\times10^8$ m/s

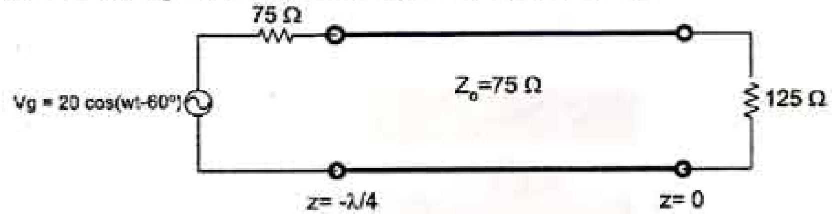
4. Relative dielectric constant of the medium (4) $u_p = \frac{c}{\sqrt{\epsilon_r}}$
   $\epsilon_r = \left(\frac{c}{u_p}\right)^2 = \left(\frac{3}{1.57}\right)^2 = 3.6$

5. Wavelength λ (4) $\beta = \frac{2\pi}{\lambda} = 20 \Rightarrow \lambda = \frac{2\pi}{20} = 0.314$ m

6. Phasor form of the electric field (5) $\sin\theta = \cos(\theta - \pi/2) = \cos(\pi/2 - \theta)$
   $\therefore \vec{E}(x,t) = 0.5e^{-2x}\cos(\pi 10^9 t - 20x - \pi/2)\,\hat{a}_z$ V/m
   $\vec{E}_s = 0.5e^{-2x}e^{-j(20x+\pi/2)}\hat{a}_z$

Problem 2

A signal generator has an impedance $Z_g = 25\ \Omega$ is connected to a lossless transmission line with characteristic impedance $Z_o = 75\ \Omega$ as shown in the figure below.



Determine the following:

(a) Phasor form of generator voltage signal (4)

$$V_{gs} = 20\, e^{-j60}\ V/m$$

(b) The load reflection coefficient Γ_L : (4)

$$\Gamma_L = \frac{125-75}{125+75} = 0.25$$

(c) The generator reflection coefficient Γg : (4)

$$\Gamma_g = \frac{75-75}{75+75} = 0$$

(d) Input impedance Z_{in} at a distance λ/4 away from the load? (4)

$$\beta \ell = \frac{2\pi}{\lambda} \cdot \frac{\lambda}{4} = \frac{\pi}{2} \qquad \tan\beta\ell = \infty$$

$$Z_{in} = Z_0 \left[\frac{Z_L + jZ_0 \tan\beta\ell}{Z_0 + jZ_L \tan\beta\ell} \right] = \frac{Z_0^2}{Z_L} = \frac{75 \times 75}{125} = 45\ \Omega$$

(e) The input voltage V_{in} at a distance λ/4 away from the load (4)

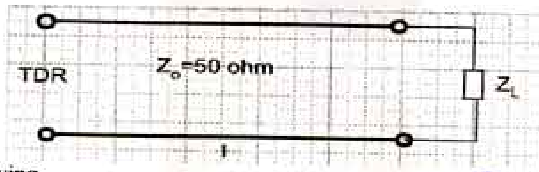
$$V_{in} = \frac{V_g Z_{in}}{Z_{in} + Z_g} = \frac{9\ 45}{45+125 \atop 9+25} * 20e^{-j60} = \frac{180}{34} e^{-j60} =$$

(f) The voltage standing wave ratio: VSWR (5)

$$VSWR = \frac{1+|\Gamma_L|}{1-|\Gamma_L|} = \frac{1.25}{0.75} = \frac{5}{3} = 1.67$$

Problem 3

A long coaxial lossless transmission line uses a dielectric material with $\varepsilon_r = 4$ and has a characteristic impedance $Z_o = 50\ \Omega$. The TL is connected to a time domain reflectometer (TDR) that is matched to the TL. The TDR applies 2 volt step signal to the TL with different load impedances at the far end. The TDR display plots are shown in figures (A), (B) and (C)



Determine the following

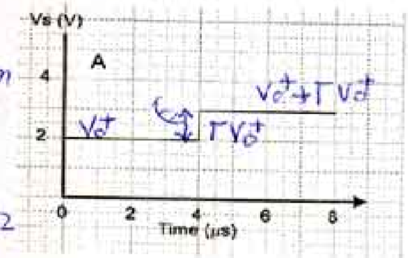
(I) The phase velocity u_p (4) $u_p = \frac{c}{\sqrt{\epsilon_r}} = \frac{3\times10^8 m/s}{2} = 1.5\times10^8 m/s$

(A) (9)

(a) Length of the transmission line.
$2t = 4 \Rightarrow t = 2\,\mu s$
$\ell = u_p t = 2\times10^{-6}\times1.5\times10^8 = 300 m$

(b) Reflection coefficient $\Gamma V_o^+ = 1,\ V_o^+ = 2$
$\Gamma = 0.5$

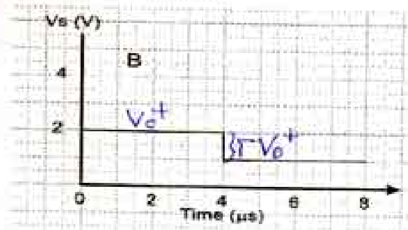
(c) Load impedance
$Z_L = \frac{1+\Gamma}{1-\Gamma} Z_o = \frac{1.5}{0.5} \times 50 = 150\ \Omega$



(B) (6)

(d) Reflection coefficient $\Gamma V_o^+ = -1$
$\Gamma = -0.5$

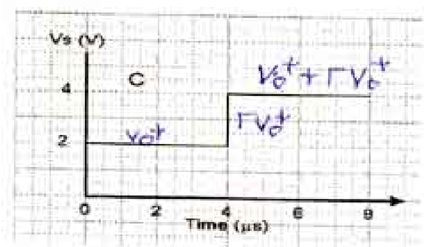
(e) Load Impedance
$Z_L = \frac{1-0.5}{1+0.5} Z_o = \frac{50}{3}\ \Omega$



(C) (6)

(i) Reflection Coefficient: $V_o^+ \Gamma = 2$
$\Gamma = 1$

(ii) Load Impedance:
$Z_L = \frac{1+1}{1-1} = \infty$
Open circuit.



Problem 4

The voltage and current phasors on a lossless transmission line are given by

$$V_s(z) = 100\, e^{-j\beta z} + 50\, e^{j\beta z} \quad V/m$$
$$I_s(z) = 2e^{-j\beta z} - e^{j\beta z} \quad A$$

Determine the following:

(a) Reflection Coefficient Γ (4) $\quad V_0^+ = 100 \; V/m \,,\; \Gamma V_0^+ = 50\; V$

$$\Gamma = \frac{50}{100} = 0.5$$

(b) Characteristic impedance Z_o (4) $\quad I_0^+ = 2 = \frac{V_0^+}{Z_0} A, \quad V_0^+ = 100\, V$

$$Z_0 = \frac{100}{2} = 50\,\Omega$$

(c) The incident-voltage wave in time domain $v^i(t)$ (4)

$$V_i(z,t) = 100 \cos(\omega t - \beta z)$$

(d) The incident-current wave in time domain $i^i(t)$ (4)

$$i(z,t) = 2\cos(\omega t - \beta z)$$

(e) The instantaneous power carried by incident wave $P^i(t)$ (4)

$$P^i(t) = V_i(t) \cdot i_i(t) = 200 \cos^2(\omega t - \beta z)$$

(f) The net average power delivered to load P_{av} (5)

$$P_{av} = \frac{|V_0^+|^2}{2Z_0}(1 - |\Gamma|^2) = \frac{100^2}{100}(1 - 0.25) = \underline{75}\, W$$