Review for Exam3

TA:

Parisa and Yuan

Exam 3 info

- ECEB 2013 (for Section C)
- ECEB 2015 (for Section X)
- ECEB 2017 (for Section E)
- Wednesday 7- 8: 15 PM

- Wednesday 5: 30 – 6:45 PM (for Conflict)

- ONE 3 X 5 inch card of notes allowed

- The first page of Spring17 exam3 will be provided

Concept list

- Poynting Theorem (Lecture 20)
- Phasor form of Maxwell's equations (Lecture 21-22)
- Wave propagation inside different media (Lecture 23)
- Circular polarization (Lecture 24)
- Transmission line (Lecture 25-27)
- Bounce diagram (Lecture 28-29)
- Multi-line circuits (Lecture 30)

Summary

Lecture 20-21

- Poynting Theorem

$$\frac{\partial}{\partial t}\left(\frac{1}{2}\epsilon\mathbf{E}\cdot\mathbf{E}+\frac{1}{2}\mu\mathbf{H}\cdot\mathbf{H}\right)+\nabla\cdot(\mathbf{E}\times\mathbf{H})+\mathbf{J}\cdot\mathbf{E}=0.$$

- Phasor Representation

Field	Phasor	Comment
$\mathbf{E}=\cos(\omega t+\beta y)\,\hat{z}$	$\tilde{\mathbf{E}}=e^{j\beta y}\,\hat{z}$	z-polarized wave propagating in $-y$ direction
	$\tilde{\mathbf{H}}=-\frac{e^{j\beta y}}{\eta}\,\hat{x}$	magnetic phasor that accompanies $\tilde{\mathbf{E}}$ above
$\mathbf{H}=\sin(\omega t-\beta z)\,\hat{y}$	$\tilde{\mathbf{H}}=-je^{-j\beta z}\,\hat{y}$	wave propagating in $+z$ direction
$\mathbf{E}=\eta\sin(\omega t-\beta z)\,\hat{x}$	$\tilde{\mathbf{E}}=-j\eta e^{-j\beta z}\,\hat{x}$	electric field phasor of $\tilde{\mathbf{H}}$ above which is an x-polarized field (see the right column)

Summary

Lecture 22-23

- Wave propagation inside different media
  - Important concepts and definitions
  - Table (in Lectures 23) will be provided during exam

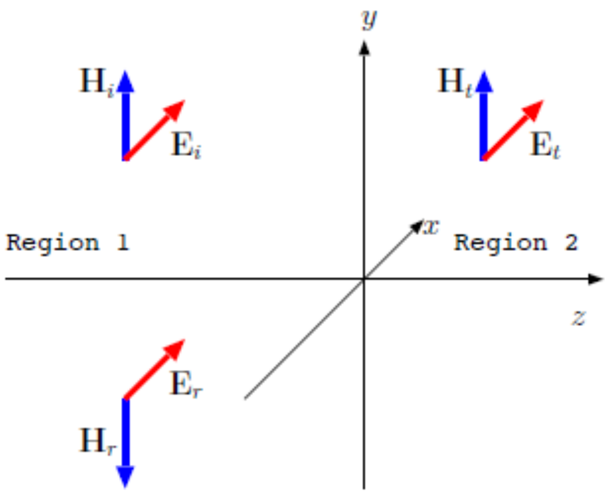
Lecture 24

- Polarization
  - Linear (one or two components, 0 or 180 degrees out-of phase)
  - Circular (two components, 90 degrees out-of phase)
  - Elliptical (two components, some degrees out-of phase not 0,90,180)

Summary

Lecture 25, 26

- Wave reflection and transmission
  - Different media with different properties →Discontinuity
    - Reflection and transmission
  - Standing wave



$$\Gamma_{12} = \frac{\eta_2 - \eta_1}{\eta_2 + \eta_1}$$

$$\tau_{12} = 1 + \Gamma_{12} = \frac{2\eta_2}{\eta_2 + \eta_1}$$

perfect conductor

$$\Gamma = -1 \quad \text{and} \quad \tau = 0.$$

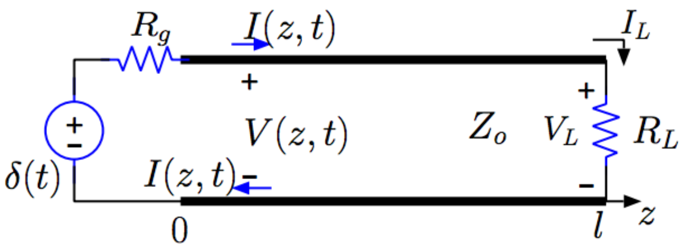
matched impedance

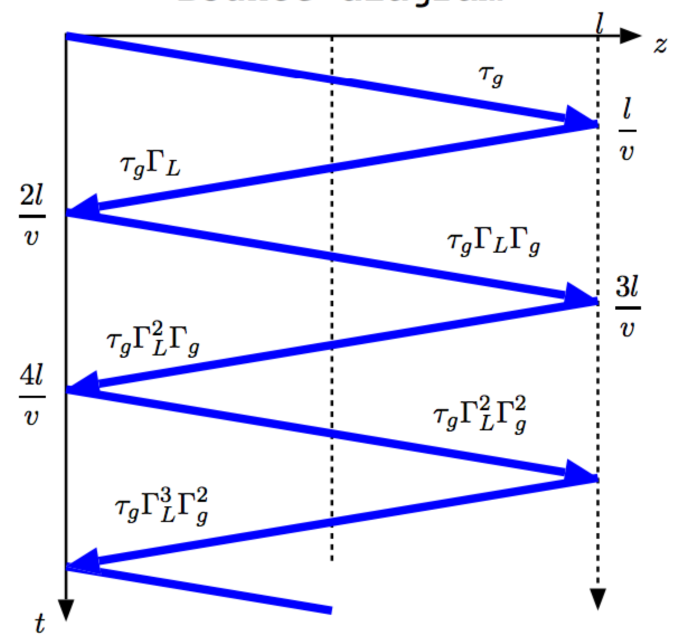
$$\Gamma = 0 \quad \text{and} \quad \tau = 1.$$

Summary

Lecture 27- 30

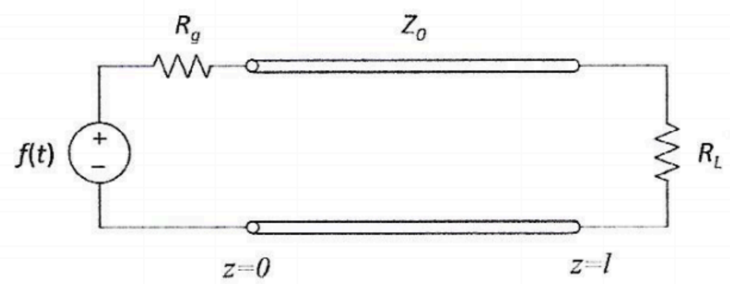
- Transmission lines
- Transmission and reflection coefficients
- Bounce diagram
- Multi-line circuits





Example

4. (25 points) Consider a transmission line circuit below where $Z_0 = 100\Omega$, $v = 200$ m/μs, $l = 800$ m, $R_g = 50\Omega$, and $R_L = 200\Omega$.



a) (6 points) Find the injection coefficient τ_g , the reflection coefficient Γ_g at the source and the reflection coefficient Γ_L at the load , respectively.

$$\tau_g = \frac{Z_0}{Z_0 + R_g} = \frac{100}{100+50} = \frac{2}{3}, \quad \Gamma_g = \frac{R_g - Z_0}{R_g + Z_0} = \frac{50-100}{50+100} = -\frac{1}{3}$$

$$\Gamma_L = \frac{R_L - Z_0}{R_L + Z_0} = \frac{200-100}{200+100} = \frac{1}{3}$$

Your Answer (include appropriate units):

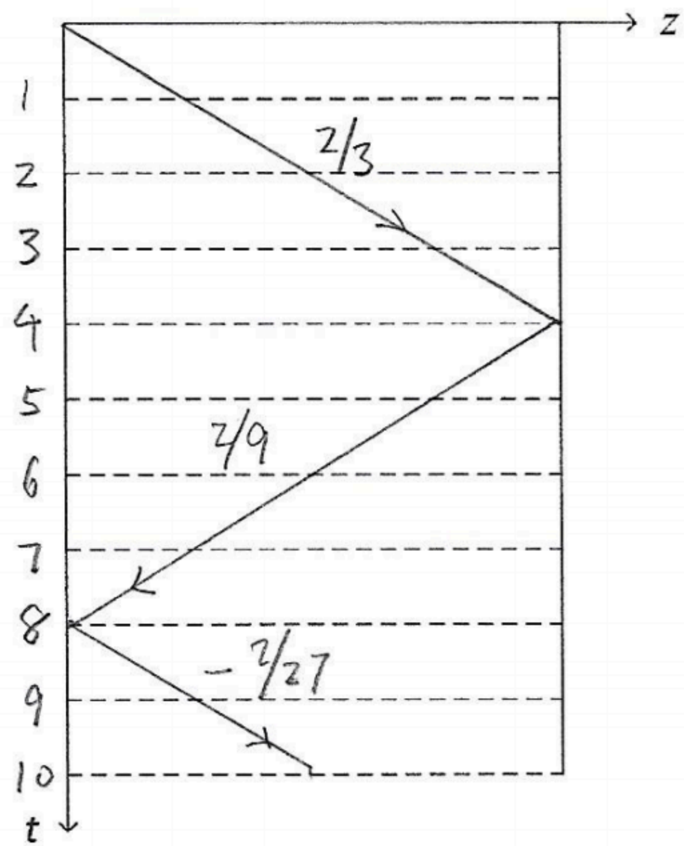
$\tau_g = 2/3$

$\Gamma_g = -1/3$

$\Gamma_L = 1/3$

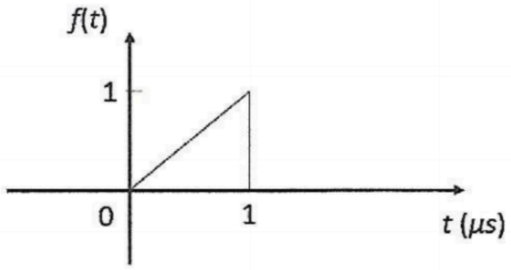
Example

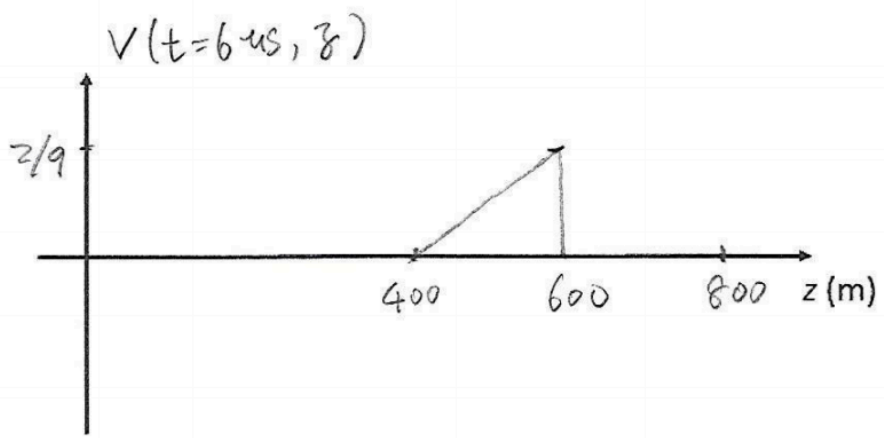
b) (6 points) Construct the voltage bounce diagram for the transmission line circuit for $0 < z < L$ and $0 < t < 10us$.



Example

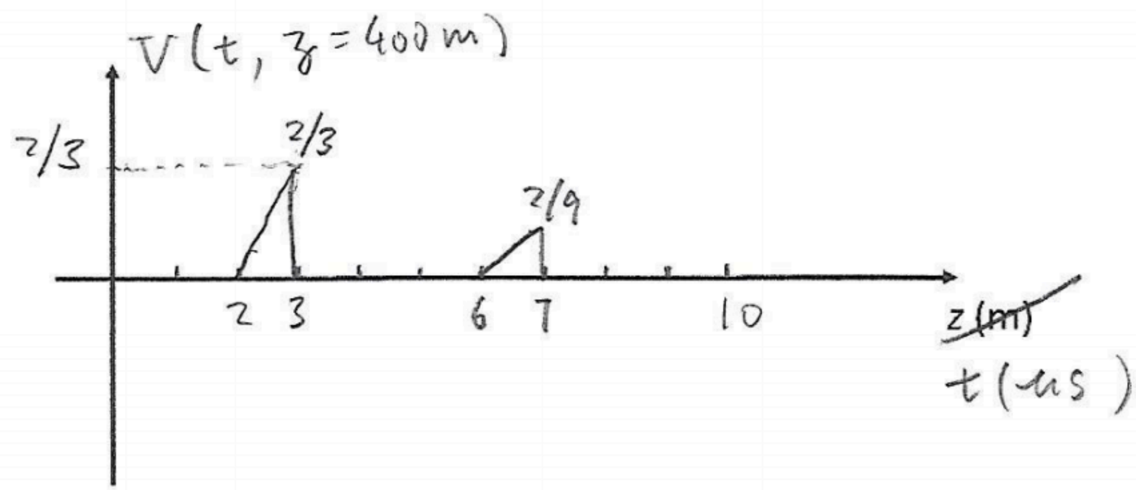
c) (7 points) If the voltage source $f(t)$ is given as below, plot the voltage $V(t = 6\mu s, z)$ vs. z for $0 < z < 800$m.





Example

d) (7 points) For the same $f(t)$ as in part c) plot the voltage $V(t,\ z = 400m)$ vs.t for $0 < t < 10\mu s$.



Example

3. (27 points) In conducting media, plane TEM wave parameters γ and η satisfy

$$\gamma\eta = j\omega\mu \text{ and } \frac{\gamma}{\eta} = \sigma + j\omega\epsilon$$

The electric field of such a plane wave propagating in a non-magnetic material ($\mu = \mu_0$) is given by:

$$\mathbf{E} = 3e^{-3x}\cos(8\pi 10^6 t - 4x + 60°)\hat{z} \text{ V/m}$$

Noting physical constants given on page 2 and that $\tan^{-1}(\frac{4}{3}) = 53°$, determine the following quantities:

a) (3 pts) The wave's attenuation constant α, wave number β, and propagation constant γ

Your Answer (include appropriate units):

$\alpha =$ 3 Np/m $\quad \beta =$ 4 rad/m $\quad \gamma =$ $3 + 4j$ rad/m

b) (4 pts) The amplitude and phase of the propagation constant γ

$|\gamma| = \sqrt{\alpha^2 + \beta^2} = \sqrt{3^2 + 4^2} = 5 \qquad \angle\gamma = \tan^{-1}\left(\frac{4}{3}\right) = 53°$

Your Answer (include appropriate units):

$|\gamma| =$ 5 $\quad$ *angle*$(\gamma) =$ 53°

c) (6 pts) The wavelength λ, linear frequency f, and phase velocity v_p of the wave

$\lambda = \frac{2\pi}{\beta} = \frac{\pi}{2} \qquad \omega = 8\pi\cdot 10^6 = 2\pi f \Rightarrow f = 4\cdot 10^6 \qquad v = \frac{\omega}{\beta} = \frac{8\pi\cdot 10^6}{4} = 2\pi\cdot 10^6$

Your Answer (include appropriate units):

$\lambda =$ $\pi/2$ m $\quad f =$ 4 MHz $\quad v_p =$ $2\pi\cdot 10^6$ m/s

Example

d) (6 pts) The amplitude and phase of the intrisic impedance η of the medium

Because $\eta\gamma = j\omega\mu$, $\angle\eta + \angle\gamma = \angle j = 90^\circ$

$$\eta = \frac{j\omega\mu}{\gamma} \Rightarrow |\eta| = \left|\frac{\omega\mu}{\gamma}\right| = \frac{8\pi\cdot10^6 \cdot 4\pi\cdot10^{-7}}{5} = \frac{32\pi^2}{50}$$

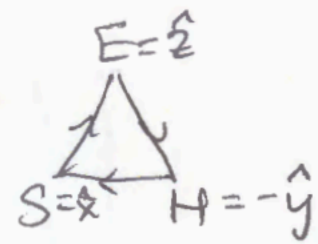
$\angle\eta + \angle\gamma = 90^\circ$

$\Rightarrow \tau = 90 - 53 = 37^\circ$

Your Answer (include appropriate units):

$|\eta| = \frac{32\pi^2}{50}$ or $\frac{64\pi^2}{100}$ or $0.64\pi^2\ \Omega$ $\quad \tau = angle(\eta) = 37^\circ$

e) (8 pts) The associated magnetic field **H**.



Your Answer (include vector direction and appropriate units):

$$\mathbf{H} = \frac{3}{|\eta|} e^{-3x} \cos(8\pi\cdot10^6 t - 4x + \underbrace{60^\circ - 37^\circ}_{23^\circ})(-\hat{y})\ A/m$$