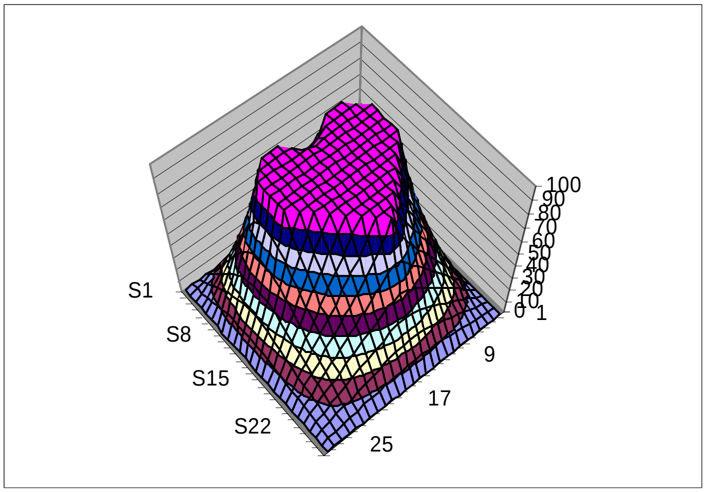
Quiz 1

TRANSMISSION LINES



Name ___________________________

Section ___________________________

Multiple Choice

1. (12 Pts) ____________

2. (5 Pts) ____________

3. (5 Pts) ____________

4. (10 Pts) ____________

5. (8 Pts) ____________

Regular Questions

6. (14 Pts) ____________

7. (16 Pts) ____________

8. (18 Pts) ____________

9. (12 Pts) ____________

Total ____________

Notes:
1. In the multiple choice questions, each question may have more than one correct answer; circle all of them.
2. For multiple choice questions, you may add some comments to justify your answer.
3. Make sure your calculator is set to perform trigonometric functions in radians & not degrees.

Some Useful Equations:

<u>Wavelength</u>

$\lambda f = u$ where u is the propagation velocity; $\beta = \dfrac{2\pi}{\lambda}$

<u>Low Loss Lines</u>

$$Z_o = \sqrt{\frac{r + j\omega l}{g + j\omega c}} \approx \sqrt{\frac{r + j\omega l}{j\omega c}} \approx \sqrt{\frac{j\omega l}{j\omega c}}\sqrt{1 + \frac{r}{j\omega l}} \approx \sqrt{\frac{l}{c}}\left(1 - j\frac{r}{2\omega l}\right)$$

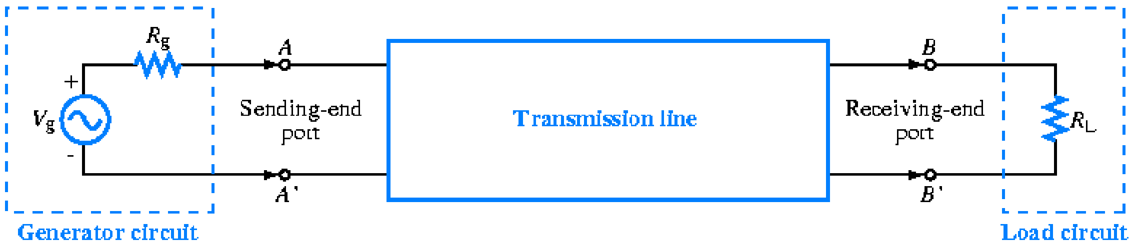
$$\gamma = \alpha + j\beta = \sqrt{(r + j\omega l)(g + j\omega c)} \approx \sqrt{(r + j\omega l)(j\omega c)} \approx \sqrt{(j\omega l)(j\omega c)}\sqrt{1 + \frac{r}{j\omega l}}$$

$$j\beta \approx j\omega\sqrt{lc} \text{ and } \alpha \approx \omega\sqrt{lc}\left(\frac{r}{2\omega l}\right) = \frac{r}{2Z_o}$$

MULTIPLE CHOICE AND SHORT ANSWER QUESTIONS

1. Specific Length Transmission Lines (12 points)

A lossless transmission line configuration with a characteristic impedance of Z_o and propagation velocity *u* is shown generically as:



Determine the input impedance Z_{in} for the following conditions:

a) Transmission line length equals $\lambda/2$

1. Load impedance $Z_L = Z_o$ ________

2. Load impedance $Z_L = 0$ ________

3. Load impedance $Z_L \to \infty$ ________

b) Transmission line length equals $\lambda/4$

1. Load impedance $Z_L = Z_o$ ________

2. Load impedance $Z_L = 0$ ________

3. Load impedance $Z_L \to \infty$ ________

2. Wave Equation (5 points)

A wave equation is given by the following expression:

$$\frac{\partial^2}{\partial z^2}G - a^2\frac{\partial^2}{\partial t^2}G = 0$$

The propagation velocity for this wave is

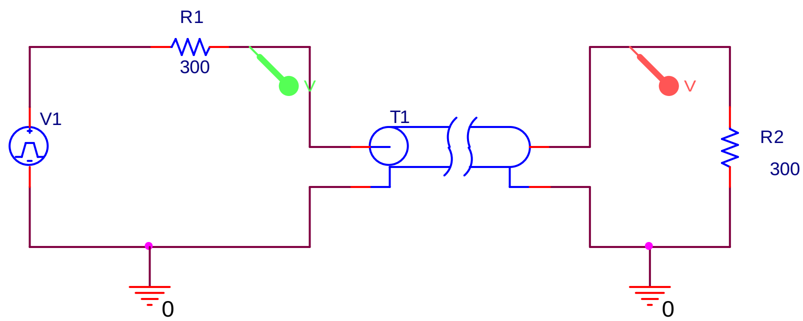
a. $\sqrt{a}$
b. a
c. a^2
d. $1/a^2$
e. $1/a$
f. $1/\sqrt{a}$

3. Low Loss Transmission Line (5 points)

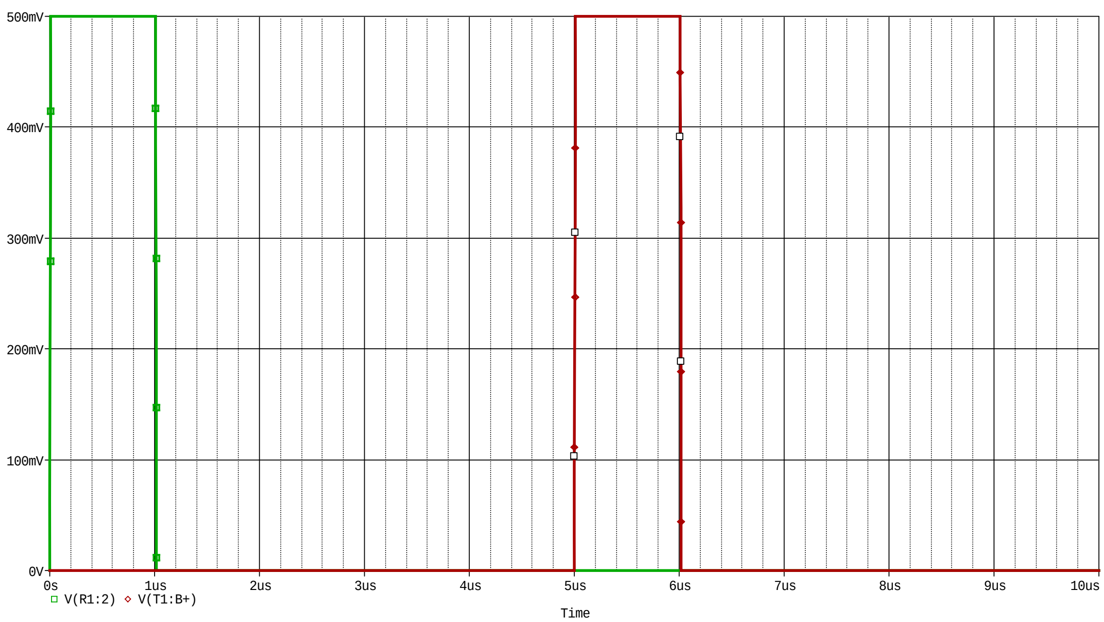
Someone tries to build a transmission line in salt water for which $\sigma = 5$ and $\varepsilon = 80\varepsilon_o$. The capacitance per unit length of the line is 100pF per meter. For which of the following frequencies can the line be considered to be low loss? Assume that all of the line loss is in the sea water and, thus, you can neglect the resistance per unit length of the lines *r*. Circle the correct answers.

a. 1 Hz
b. 10 Hz
c. 100 Hz
d. 1 kHz
e. 10 kHz
f. 100 kHz
g. 1 MHz
h. 10 MHz
i. 100 MHz
j. 1 GHz
k. 10 GHz
l. 100 GHz
m. 1 THz
n. 10 THz
o. 100 THz

4. Pulses on a Matched Transmission Lines (10 points)



Assume that a pulsed source is matched to its line and load. That is $R_g = R_L = Z_o = 300$ *Ohms*. The propagation velocity on the line is $u = 2x10^8$ *m/s*. A 1 microsecond voltage pulse is launched on the line. The following voltages are observed at the input and output of the line:



a. What is the length of the line?

b. What is the source voltage V1?

5. Valentines (8 points)

Fill in the blanks or true-false (2 pts each).

a. Roses are red, violets are blue, if $\Gamma_L = \frac{1}{3}$, the *SWR* = ___*?*

b. From an Engineer's Valentine (Unknown Author)

I was alone and all was dark
Beneath me and above
My life was full of volts and amps
But not the spark of love

But now that you are here with me
My heart is overjoyed
You've turned the square of my heart
Into a __________?

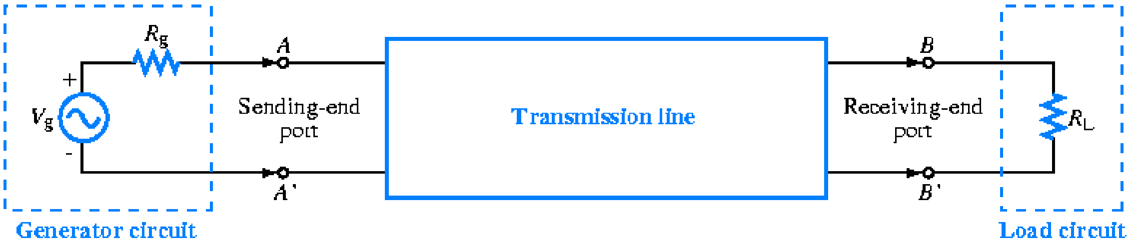
c. True or false: There are 10 types of people in the world, those who understand binary and those who don't.

d. True or false: I wish Valentine candy hearts looked like this: 

REGULAR QUESTIONS

6. Sinusoidal Voltages on a Matched Lossless Transmission Line (14 points)

A lossless transmission line is properly matched to its source and load, $R_g = R_L = Z_o = 50$ Ohms. The propagation velocity on the line is $u = 1.5x10^8 \, {}^{m}\!/_{s}$.



a. What is the reflection coefficient Γ_L at the load? (2 pts)

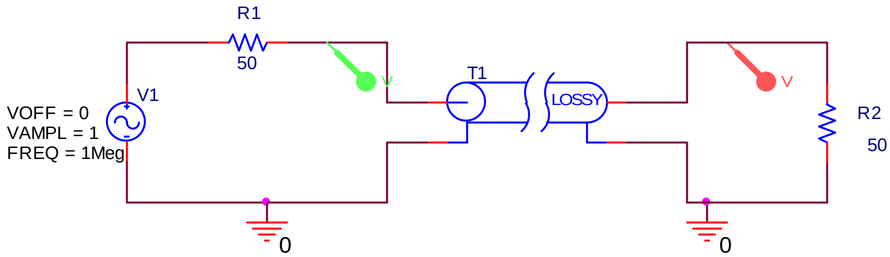
b. What is the standing wave ratio *SWR*? (2 pts)

c. For a frequency $f = 100x10^6 \, Hz$, what is the propagation constant β? (2 pts)

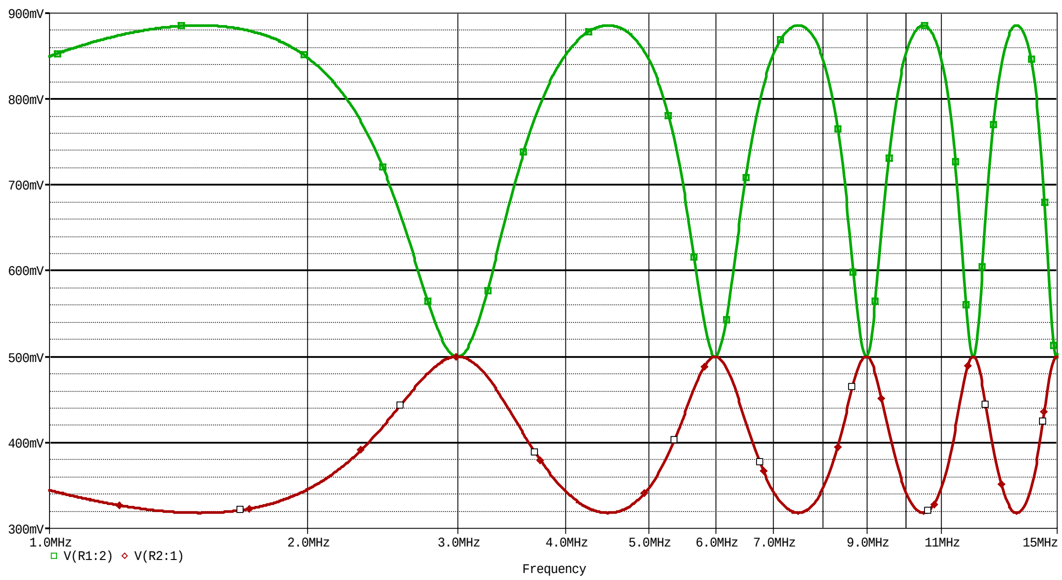
d. What is the wavelength λ? (2 pts)

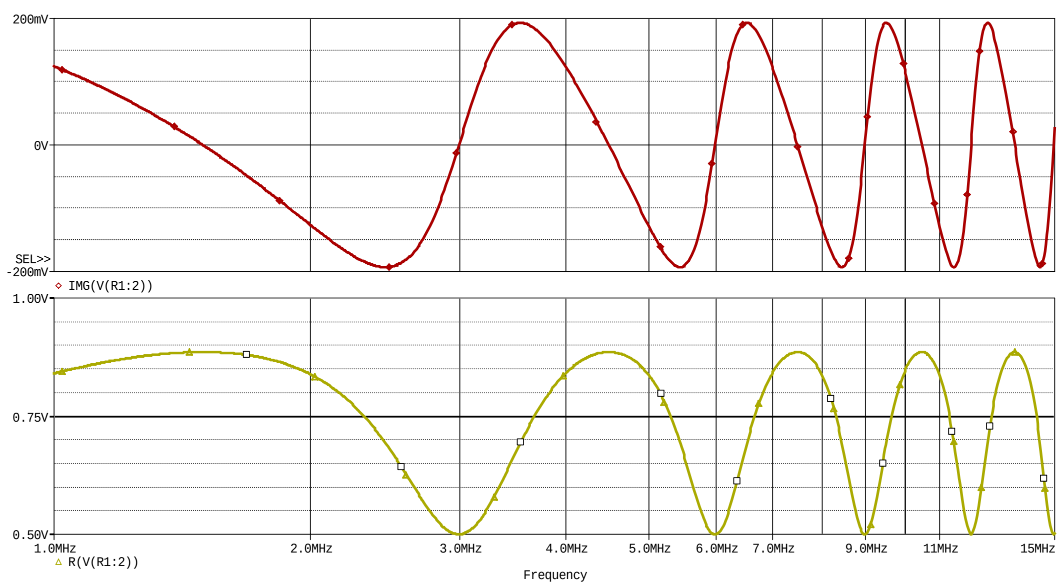
e. Assuming that position $z = 0m$ at the load, write the voltage and current as a function of position on the line in phasor form. (6 pts)

7. Determining Unknown Transmission Line Properties (16 points)

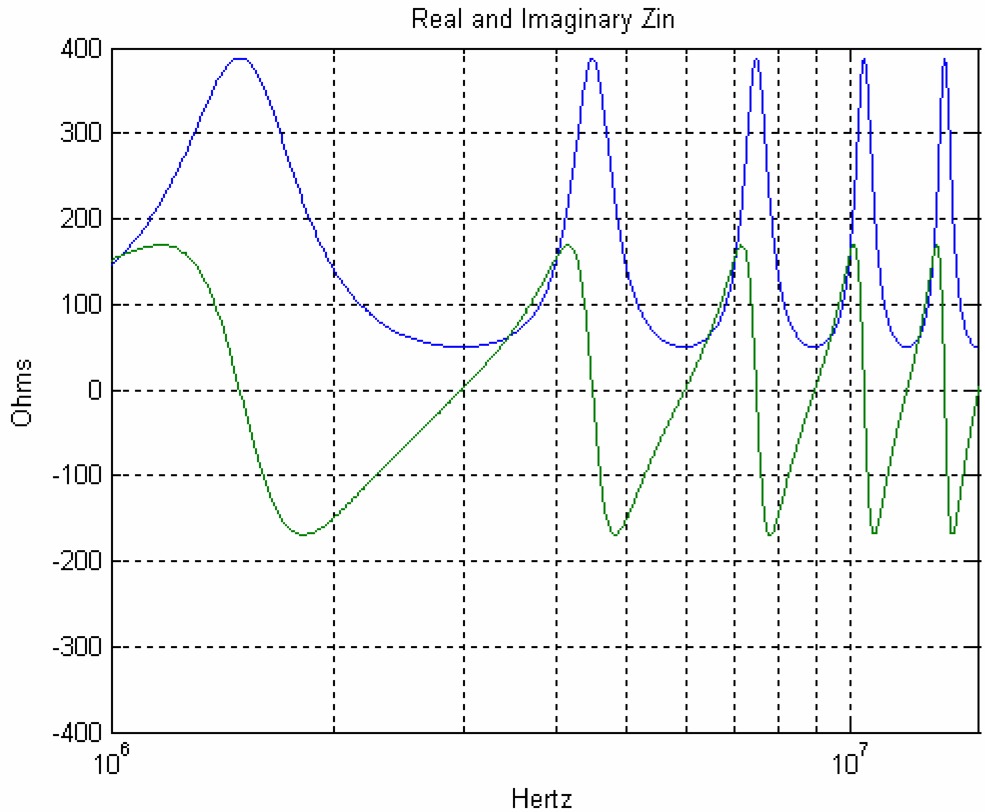


Assume we have a transmission line for which we know nothing, except its length (24 meters). We set up the standard configuration shown above and find the following voltages at the input and output ends as a function of frequency:





We also use a network analyzer to determine the real and imaginary parts of the input impedance Z_{in} as a function of frequency for the same range.



From this information, determine the characteristic impedance Z_o, the propagation velocity u, the capacitance per unit length c and the inductance per unit length l.

Z_o ___________

u ___________

l ___________

c ___________

8. Standing Waves (18 points)

A lossless transmission line is driven by a sinusoidal voltage source with a frequency of 50MHz. Four different loads are connected to the line and the standing wave pattern is determined (maybe by miracle, since this is hard to do) as shown on the next two pages. The loads are a short circuit, 25 Ohms, 400 Ohms and an open circuit.

a. First, indicate which plot corresponds to each load impedance. (4 pts)

1. Z_L= 2. Z_L= 3. Z_L= 4. Z_L=

b. Next, determine the wavelength on the line λ. (2 pts)

c. Determine the propagation constant β. (2 pts)

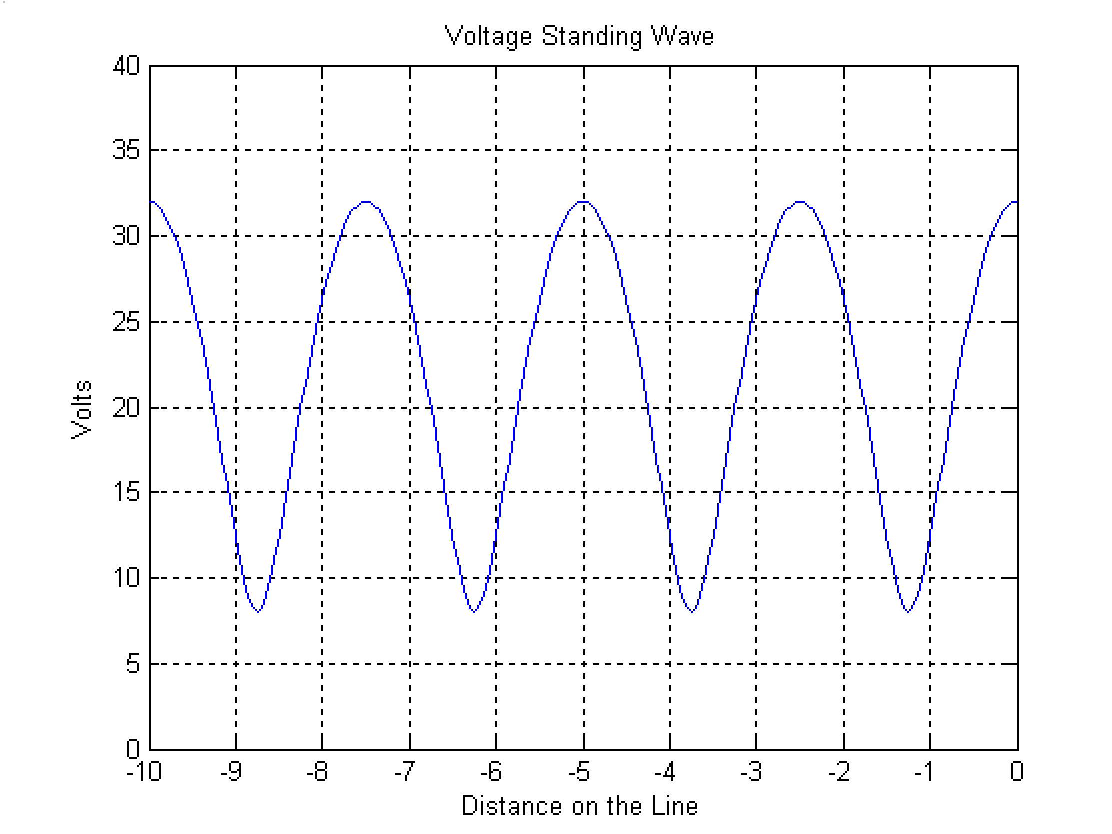
d. Determine the propagation velocity u. (2 pts)

e. Determine the characteristic impedance of the line Z_o. (4 pts)

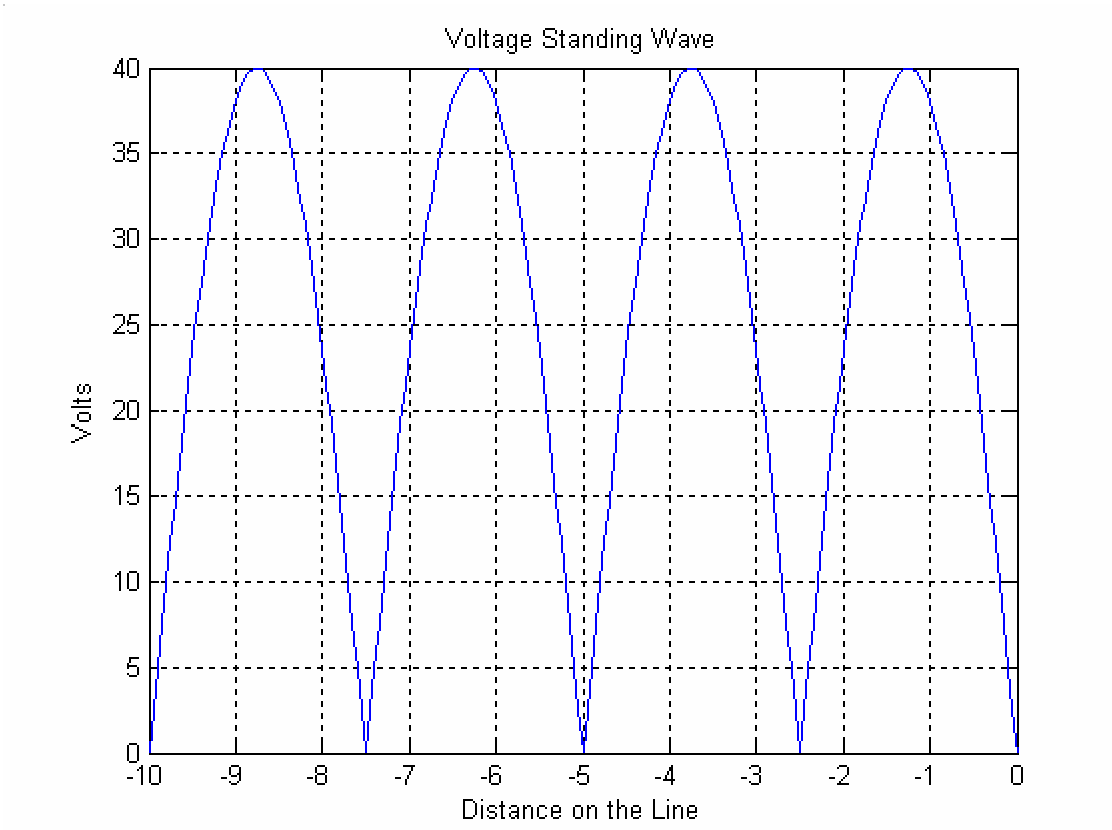
f. Finally, if the current standing wave patterns were displayed instead of voltage standing wave patterns, indicated which plot would correspond to each load. (4 pts)

1. Z_L= 2. Z_L= 3. Z_L= 4. Z_L=

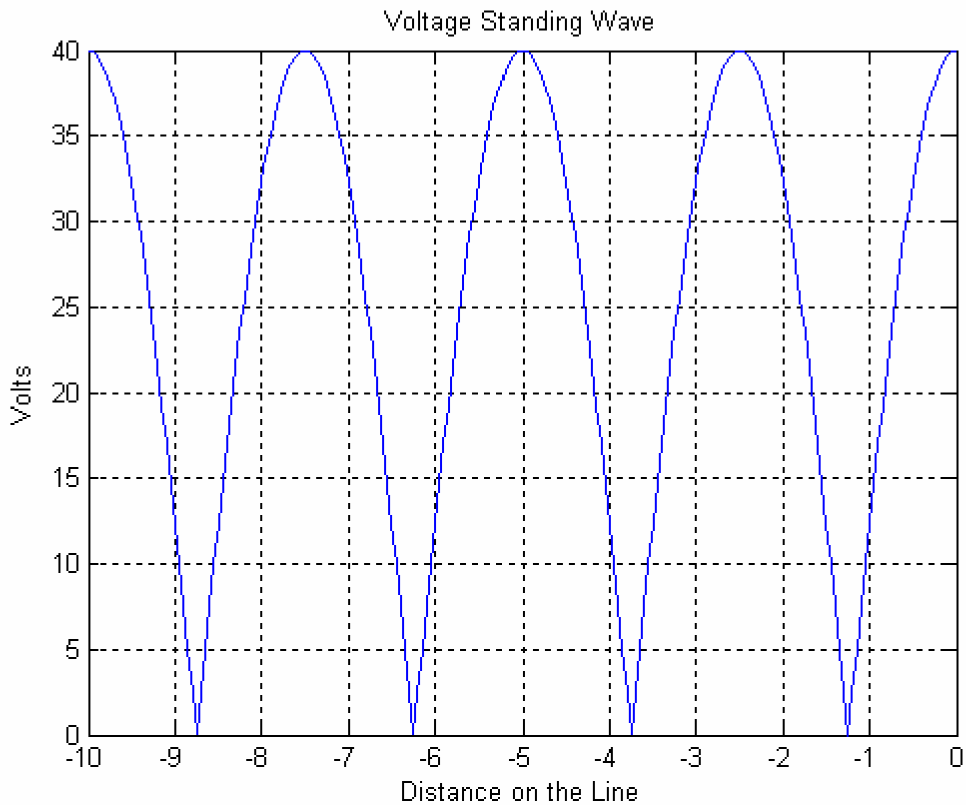
Quiz 1


Voltage Standing Wave
Volts
40
35
30
25
20
15
10
5
0
-10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0
Distance on the Line

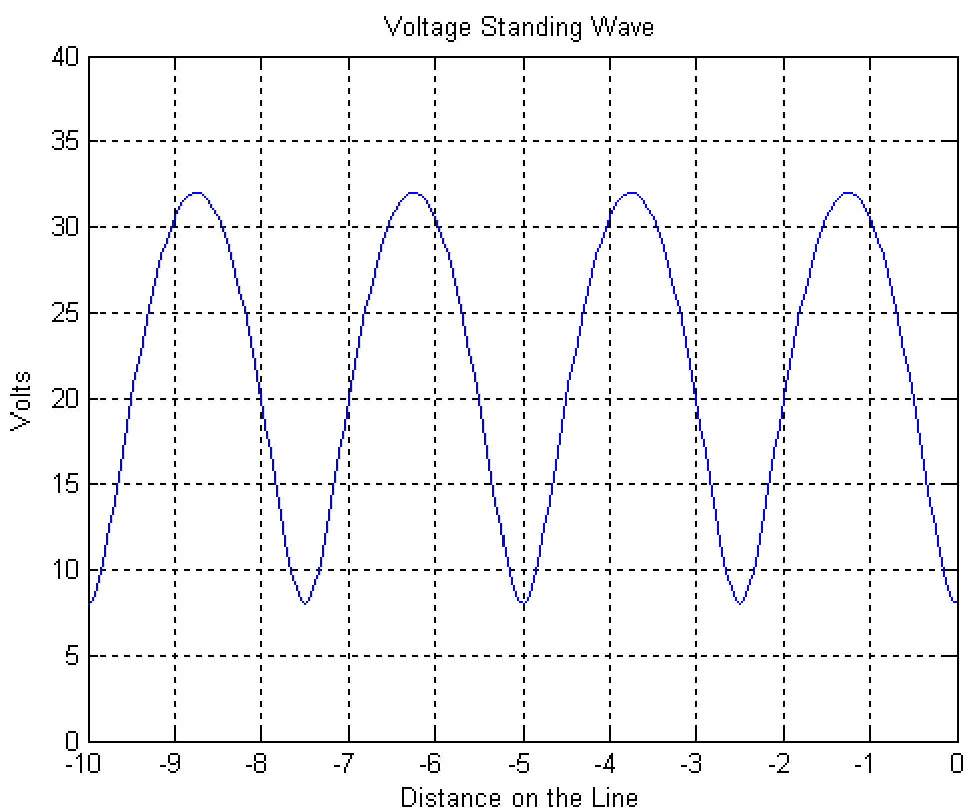
1.


Voltage Standing Wave
Volts
40
35
30
25
20
15
10
5
0
-10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0
Distance on the Line

2.

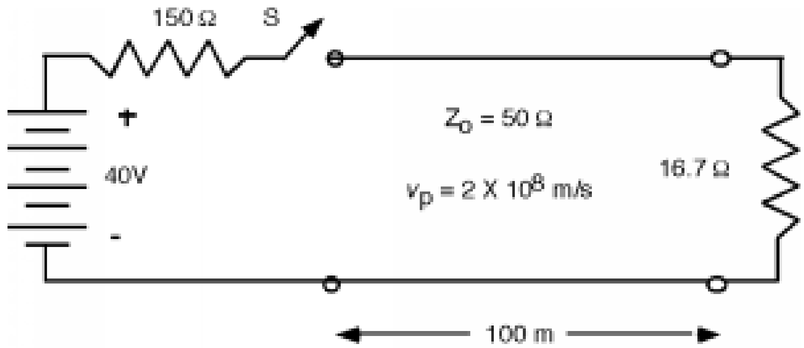

Voltage Standing Wave
Volts
Distance on the Line
40
35
30
25
20
15
10
5
0
-10
-9
-8
-7
-6
-5
-4
-3
-2
-1
0

3.


Voltage Standing Wave
Volts
Distance on the Line
40
35
30
25
20
15
10
5
0
-10
-9
-8
-7
-6
-5
-4
-3
-2
-1
0

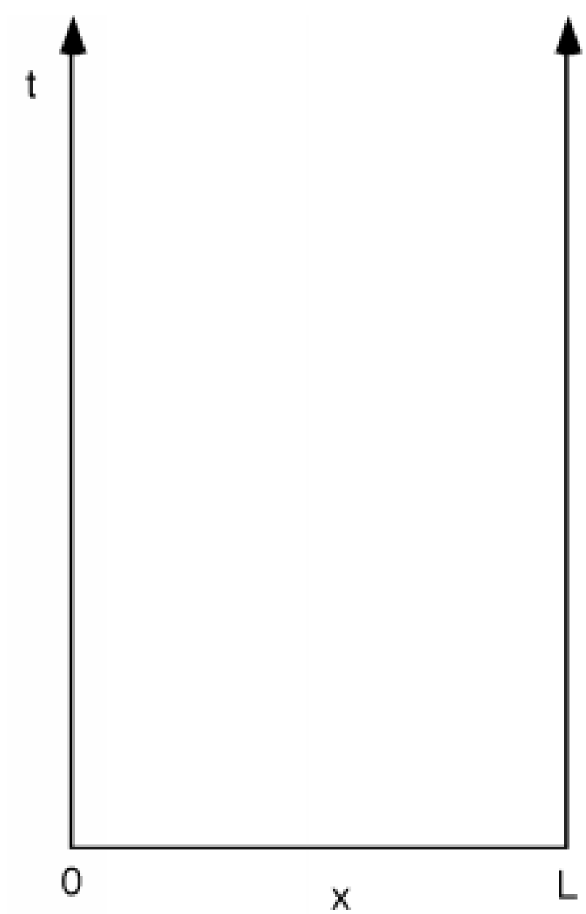
4.

9. Transients on Transmission Lines (12 points)



A 40V DC source with a 150 Ohm internal impedance is connected to a 50 Ohm transmission line with a 16.7 Ohm load. The length of the line is 100 meters and the propagation speed is $2x10^8$ m/s.

a. Generate the bounce diagram for this configuration.



$$\Gamma_{vs} = \frac{R_s - Z_o}{R_s + Z_o} \qquad \Gamma_{vL} = \frac{R_L - Z_o}{R_L + Z_o}$$

b. Determine and plot the voltage observed at the load as a function of time. Indicate the value the voltage will eventually reach if we wait long enough (time goes to infinity).