

ELEC351 Class Test

Name: _____
 I.D. Number: _____

October 10, 2008

Closed book exam! No books or notes allowed!

You are permitted to use an ENCS-approved electronic calculator, either the Sharp EL 531 and the Casio FX-300 MS. No other calculator is permitted.

Cell phones and other wireless devices are forbidden in examinations. You are not permitted to have a cell phone in your possession, even if it is turned off.

Circle the correct answer directly on the examination paper. The exam booklet is for rough work only and will not be evaluated. If your answer is within 3% of one of the given answers, then choose that answer.

Problem 1



A time-domain reflectometer drives a transmission line with a step-function generator, which steps up from 0 volts to $V_s = 1$ volt at $t = 0$. The internal resistance is $R_s = 50\Omega$. The speed-of-propagation on the transmission line is $u = 20$ cm/ns and the characteristic impedance is $Z_0 = 71\Omega$. The transmission line is $L = 14.4$ cm in length. The load resistor is $R_L = 10\Omega$.

1.1 What is the voltage at the generator terminals, V_{in} , at $t = 0.5$ ns?

(a) 1.00 volts	(b) 0.215 volts	(c) 0.587 volts	(d) 0.500 volts	(e) none of these
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1.2 What is the reflection coefficient at the load, Γ_L ?

(a) 0.867	(b) -0.972	(c) 0.170	(d) -0.753	(e) none of these
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1.3 What is the voltage at the load terminals, V_L , at $t = 0.8$ ns?

(a) 0.016 volts	(b) 0.686 volts	(c) 0.145 volts	(d) 1.10 volts	(e) none of these
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1.4 What is the voltage at the generator terminals, V_{in} , at $t = 1.6$ ns?

(a) 0.222 volts	(b) 0.669 volts	(c) 0.115 volts	(d) 1.01 volts	(e) none of these
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1.5 What is the value of the input voltage V_{in} as $t \rightarrow \infty$?

(a) 0.952 volts	(b) 0.167 volts	(c) 0.020 volts	(d) 0.667 volts	(e) none of these
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Problem 2



A sinusoidal generator at 5.5 GHz drives has an RMS value of 10 volts. The internal resistance is $R_s = 50 \Omega$. The line length is $L = 3.3 \text{ cm}$, and the transmission line has a characteristic impedance of $Z_0 = 300 \Omega$, speed of propagation $u = 14 \text{ cm/ns}$, and is lossless. The load is an antenna of input impedance $Z_L = 300 - j100 \Omega$.

2.1 What is the value of the phase constant β on the transmission line?

(a) 312 deg/cm	(b) 141 deg/cm	(c) 3.64 deg/cm	(d) 5.46 deg/cm	(e) none of these
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2.2 What is the input impedance of the transmission line, Z_{in} ?

(a) $0.329 + j3.11 \Omega$	(b) $34.5 + j38.1 \Omega$	(c) $327 + j101 \Omega$	(d) $8.41 + j17.4 \Omega$	(e) none of these
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2.3 What is the RMS value of the voltage at the generator terminals, V_{in} ?

(a) 3.17 volts	(b) 5.54 volts	(c) 0.620 volts	(d) 8.78 volts	(e) none of these
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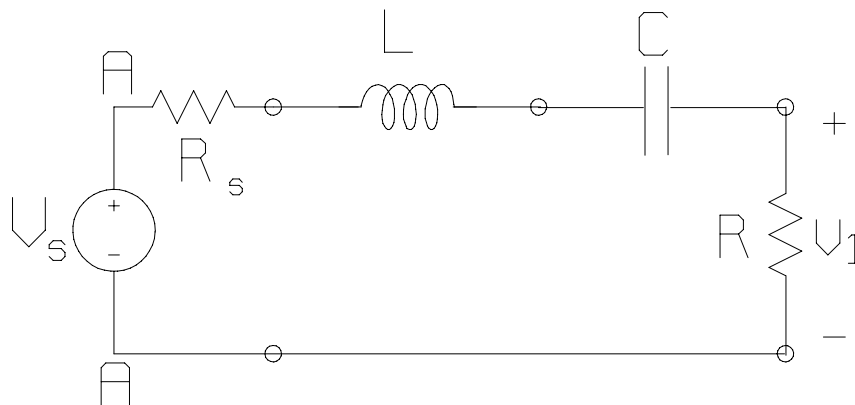
2.4 The voltage on the transmission line is given by $V(z) = V^+ e^{-j\beta z} + V^- e^{j\beta z}$. What is the RMS value of V^+ ?

(a) 1.07 volts	(b) 7.54 volts	(c) 8.14 volts	(d) 5.00 volts	(e) none of these
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2.5 What is the RMS value of the voltage at the load terminals, V_L ?

(a) 8.98 volts	(b) 11.6 volts	(c) 2.07 volts	(d) 8.46 volts	(e) none of these
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Problem 3



Soft Skill: Self-Learning

An A.C. generator at 850 MHz has an open-circuit voltage of 10 volts amplitude, and internal resistance $R_s = 10 \Omega$. It drives a series RLC circuit, with $L = 1 \text{ nanoHenry}$, $C = 10 \text{ picoFarads}$ and $R = 5 \Omega$.

3.1 What is the impedance across the generator terminals A-A?

(a) $15 - j13.4 \text{ ohms}$	(b) $15 - j8.04 \text{ ohms}$	(c) $15 - j2.70 \text{ ohms}$	(d) $15 + j115 \text{ ohms}$	(e) none of these
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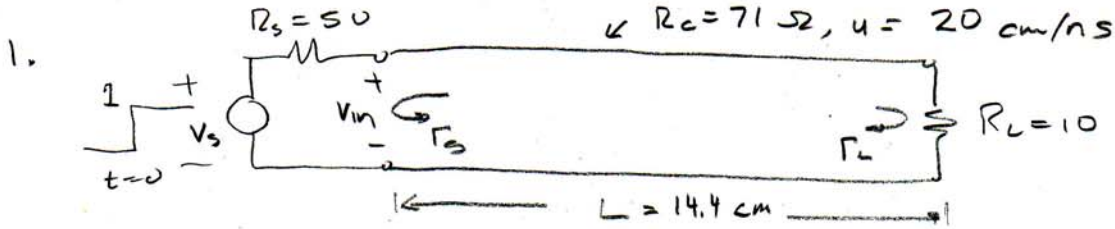
3.2 What is the amplitude of the voltage V_1 across the load?

(a) 4.15 volts	(b) 2.49 volts	(c) 4.63 volts	(d) 0.611 volts	(e) none of these
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3.3 What is the power delivered to the load resistor R ?

(a) 18.7 mW	(b) 863 mW	(c) 1076 mW	(d) 619 mW	(e) none of these
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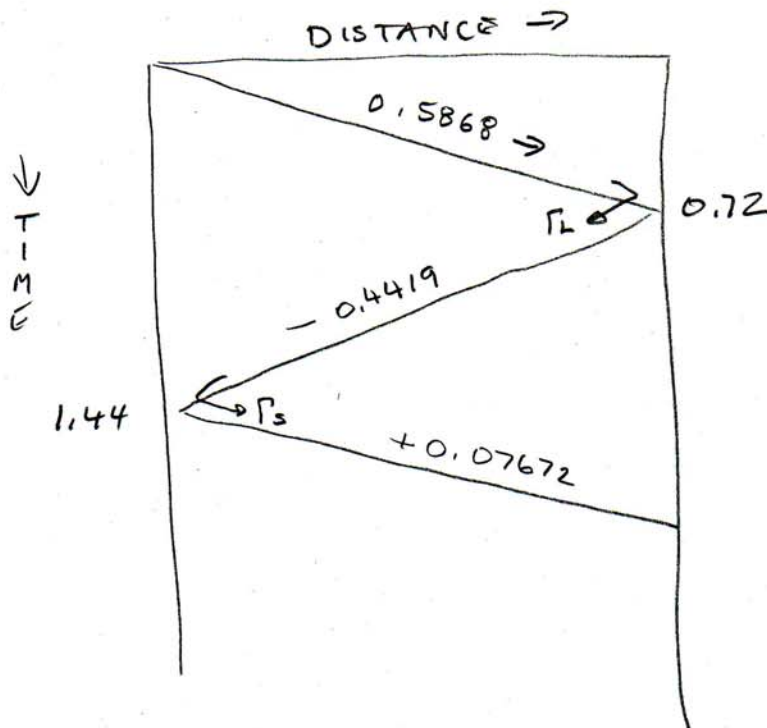


$$T = \frac{L}{u} = \frac{14.4}{20} = 0.72 \text{ ns}$$

$$V_{in}(0) = \frac{R_L V_s}{R_L + R_s} = \frac{71 \times 1}{71 + 50} = 0.5868 \text{ V}$$

$$\Gamma_L = \frac{R_L - R_c}{R_L + R_c} = \frac{10 - 71}{10 + 71} = -0.7531$$

$$\Gamma_s = \frac{R_s - R_c}{R_s + R_c} = \frac{50 - 71}{50 + 71} = -0.1736$$



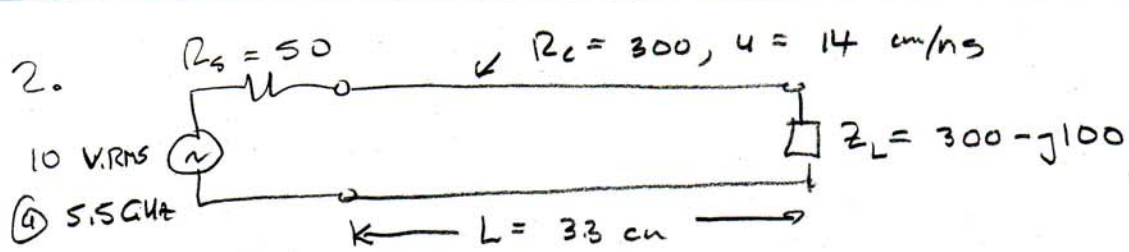
1.1 $V_{in} = 0.5868$ (c)

1.2 $\Gamma_L = -0.7531$ (d)

1.3 $V_L = +0.5868 - 0.4419 = 0.1449$ (c)

1.4 $V_{in} = +0.5868 - 0.4419 + 0.0767 = 0.2216$ (a)

1.5 $V_{in}(\infty) = \frac{R_L V_s}{R_L + R_s} = \frac{10 \times 1}{10 + 50} = 0.1667$ (b)



$$\lambda = \frac{u}{f} = \frac{14}{5.5} = 2.545 \text{ cm}$$

$$2.1 \quad \beta = \frac{2\pi}{\lambda} = 2.468 \frac{\text{rad}}{\text{cm}} \times \frac{360 \text{ deg}}{2\pi \text{ rad}} = 141.4 \frac{\text{deg}}{\text{cm}}$$

$$\beta L = 141.4 \times 3.3 = 466.7^\circ$$

$$\tan \beta L = -3.330$$

$$2.2 \quad Z_{in} = R_c \frac{Z_L + jR_c \tan \beta L}{R_c + jZ_L \tan \beta L}$$

$$= 300 \frac{300 - j100 + j300(-3.330)}{300 + j(300 - j100)(-3.330)}$$

$$= 300 \frac{300 - j1099}{-33 - j999}$$

$$= 326.7 + j100.9 \quad (c)$$

$$2.3 \quad V_{in} = \frac{Z_{in} V_s}{Z_{in} + R_s} = \frac{(326.7 + j100.9) \times 10}{326.7 + j100.9 + 50}$$

$$= 8.762 + j0.3317$$

$$= 8.769 \angle 2.20^\circ \rightarrow 8.77 \text{ VRMS} \quad (d)$$

$$2.4 \quad V^+ = \frac{V_{in}}{1 + \Gamma_L e^{-2j\beta L}}$$

$$\Gamma_L = \frac{Z_L - R_c}{Z_L + R_c} = \frac{300 - j100 - 300}{300 - j100 + 300} \quad (3)$$

$$= 0.02703 - j0.1622$$

$$V^+ = \frac{(8.762 + j0.3317)}{1 + (0.02703 - j0.1622)(14 - (466.7 \times 2))}$$

$$= 8.097 - j0.8296$$

$$= 8.140 \angle -5.9^\circ \quad (c)$$

$$2.5 \quad V^- = \Gamma_L e^{-2j\beta L} V^+$$

$$= (0.02703 - j0.1622)(14 - 933.4^\circ) \cdot (8.097 - j0.8296)$$

$$= 0.6649 + j1.162 = 1.338 \angle 60.2^\circ$$

$$V(z) = (8.140 \angle -5.9^\circ) e^{-j\beta z} + (1.338 \angle 60.2^\circ) e^{j\beta z}$$

$$\beta L = 466.7^\circ$$

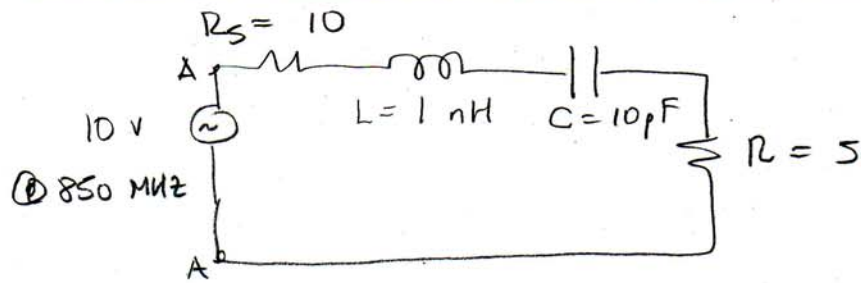
$$V(L) = (8.140 \angle -5.9^\circ)(14 - 466.7)$$

$$+ (1.338 \angle 60.2^\circ)(14 + 466.7)$$

$$= -4.431 - j7.212$$

$$= 8.464 \angle -121.6^\circ \rightarrow 8.46 \text{ VRMS} \quad (d)$$

3.



$$Z_L = j\omega L = j 2\pi \times 850 \times 10^6 \times 1 \times 10^{-9} = j 5.341 \Omega$$

$$Z_C = \frac{1}{j\omega C} = \frac{1}{j 2\pi \times 850 \times 10^6 \times 10 \times 10^{-12}} = -j 18.72 \Omega$$

$$\begin{aligned} 3.1 \quad Z_{AA} &= 10 + j 5.341 - j 18.72 + 5 \\ &= 15 - j 13.38 \Omega \end{aligned} \quad (a)$$

$$3.2 \quad V_1 = \frac{5 \times 10}{15 - j 13.38} = 2.488 \angle 41.7^\circ \quad (b)$$

$$3.3 \quad I = \frac{10}{15 - j 13.38} = 0.4975 \angle 41.7^\circ$$

$$\begin{aligned} P_{av} &= \frac{1}{2} \operatorname{Re}(V_1 I^*) \\ &= \frac{1}{2} \operatorname{Re}((2.488 \angle 41.7^\circ)(0.4975 \angle -41.7^\circ)) \\ &= 619 \text{ mW} \end{aligned} \quad (d)$$