

ELEC353 Class Test

Name: _____

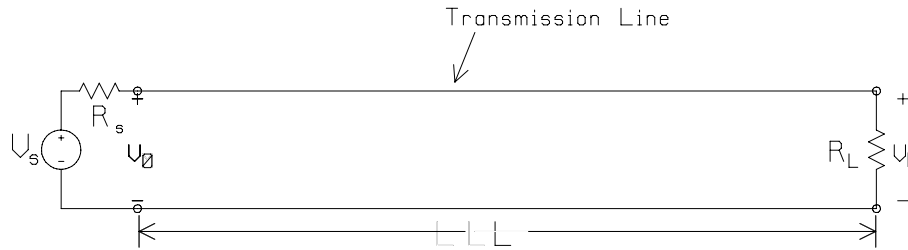
I.D. Number: _____

February 16, 2007

Closed book exam! No books or notes allowed!

Cell phones and other wireless devices are forbidden in examinations. You are permitted to use an electronic calculator.

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.



1. A transmission line of length $L = 2$ cm has characteristic resistance $R_c = 50$ ohms and speed of travel $u = 14$ cm/ns. The source generates a pulse of amplitude $V_s = 10$ volts and length 0.31 ns, starting at $t = 0$. The source resistance is $R_s = 20$ ohms. The load is a resistor of value $R_L = 900$ ohms.

1.1 What is the voltage V_L at the load at $t = 0.15$ ns?

(a) 13.53 volts	(b) 5.00 volts	(c) 4.08 volts	(d) 9.52 volts	(e) none of these
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1.2 What is the voltage V_0 at the generator terminals at $t = 0.30$ ns?

(a) 5.39 volts	(b) 10.26 volts	(c) 10.79 volts	(d) 8.50 volts	(e) none of these
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1.3 What is the voltage V_0 at $t = 0.33$ ns?

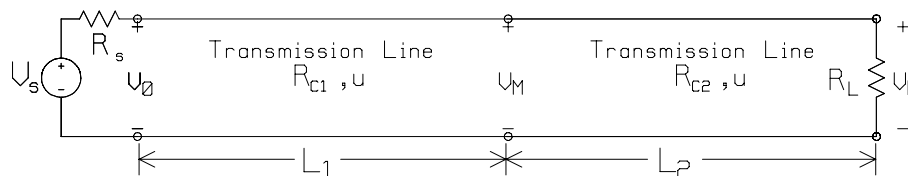
(a) 1.36 volts	(b) 3.65 volts	(c) 6.67 volts	(d) -1.75 volts	(e) none of these
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1.4 What is the voltage V_L at $t = 0.44$ ns?

(a) 8.25 volts	(b) 4.83 volts	(c) 5.00 volts	(d) -0.50 volts	(e) none of these
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1.5 What is the voltage V_L at $t = 0.46$ ns?

(a) 0.75 volts	(b) 5.00 volts	(c) -1.36 volts	(d) -5.19 volts	(e) none of these
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2. The transmission-line circuit shown above is driven by a step-function generator that switches on at $t = 0$, with $V_s = 5$ volts and $R_s = 1$ ohms. The two transmission lines have characteristic resistance $R_{c1} = 30$ ohms and $R_{c2} = 80$ ohms, and speed-of-travel $u = 20$ cm/ns. Line #1 has length $L_1 = 2$ cm and line #2 has $L_2 = 3$ cm. The circuit is terminated by a load resistor of value $R_L = 10$ ohms.

2.1 Find the voltage V_M across the junction at $t = 0.12$ ns.

(a) 3.87 volts	(b) 4.72 volts	(c) 7.04 volts	(d) 8.42 volts	(e) none of these
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2.2 Find the voltage V_L across the load at $t = 0.27$ ns.

(a) 2.58 volts	(b) 0.80 volts	(c) 6.57 volts	(d) 1.56 volts	(e) none of these
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2.3 Find the voltage V_M across the junction at $t = 0.32$ ns.

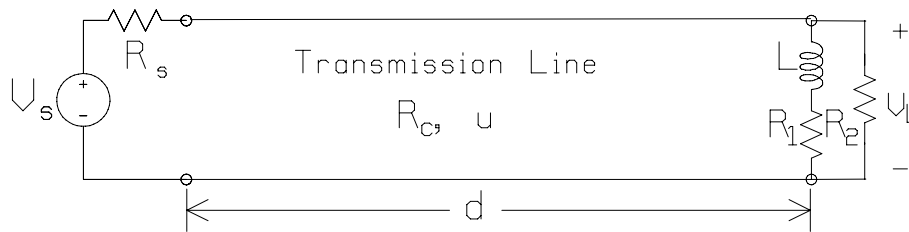
(a) 2.60 volts	(b) 4.60 volts	(c) 4.05 volts	(d) 1.87 volts	(e) none of these
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2.4 Find the voltage V_L across the load at $t = 0.47$ ns.

(a) 0.25 volts	(b) 0.90 volts	(c) 2.48 volts	(d) 3.06 volts	(e) none of these
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2.5 Find the voltage V_L across the load as $t \rightarrow \infty$.

(a) 7.24 volts	(b) 4.51 volts	(c) 5.00 volts	(d) 2.32 volts	(e) none of these
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3. A transmission line drives a load consisting of $L = 200$ nH with resistors $R_1 = 25$ ohms and $R_2 = 40$ ohms. The transmission line has characteristic impedance $R_c = 50$ ohms and speed-of-travel $u = 20$ cm/ns. The length of the transmission line is $d = 15$ cm. The source is a step-function voltage starting at $t = 0$, of amplitude $V_s = 12$ volts and internal resistance $R_s = 50$ ohms.

3.1 What is the time constant τ ?

(a) 1.27 ns	(b) 3.43 ns	(c) 6.00 ns	(d) 4.23 ns	(e) none of these
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3.2 What is the "final value" of the load voltage V_L as $t \rightarrow \infty$?

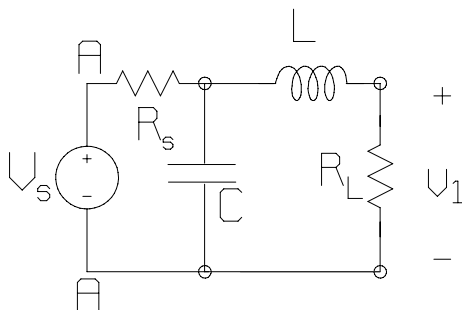
(a) 2.82 volts	(b) 1.50 volts	(c) 3.43 volts	(d) 12.00 volts	(e) none of these
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3.3 What is the value of the load voltage V_L just after the step voltage from the generator arrives, at $T = 0.75$ ns?

(a) 2.00 volts	(b) 12.00 volts	(c) 8.00 volts	(d) 5.33 volts	(e) none of these
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3.4 What is the value of the load voltage V_L at $t = 5.00$ ns?

(a) 4.75 volts	(b) 6.00 volts	(c) 3.74 volts	(d) 1.75 volts	(e) none of these
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In the circuit above, the generator voltage is $V_s(t) = 24\sqrt{2}\cos(\omega t)$ at frequency $\omega = 2\pi f$ with $f = 2450$ MHz. The source resistance is $R_s = 50$ ohms. The component values are $C = 1.2$ pF, $L = 2$ nH and $R_L = 80$ ohms.

4.1 What is the impedance of the inductance L ?

a) $j69.3$ ohms	b) $j30.8$ ohms	c) 30.8 ohms	d) $j117$ ohms	e) none of these
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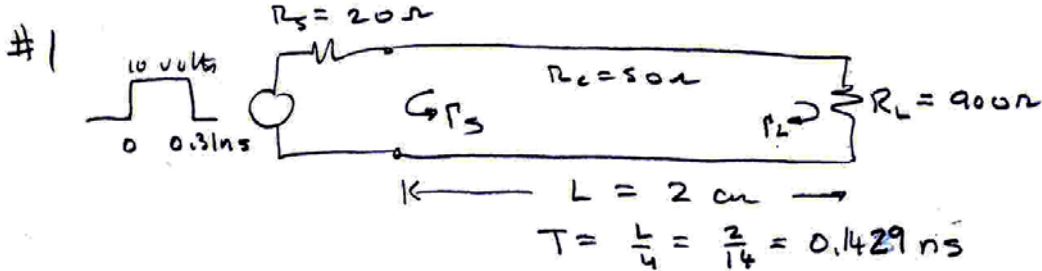
4.2 What is the input impedance across the generator terminals A-A?

a) $35.8 + 2.39j$ Ω	b) $72.6 - 71.9j$ Ω	c) $83.8 - 44.3j$ Ω	d) $67.2 - j12.8$ Ω	e) none of these
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4.3 What is the RMS value and phase angle of the voltage V_1 across the load?

a) $13.1 \angle -46^\circ$ v.	b) $5.32 \angle 132^\circ$ v.	c) $10.0 \angle -83^\circ$ v.	d) $12.2 \angle -65^\circ$ v.	e) none of these
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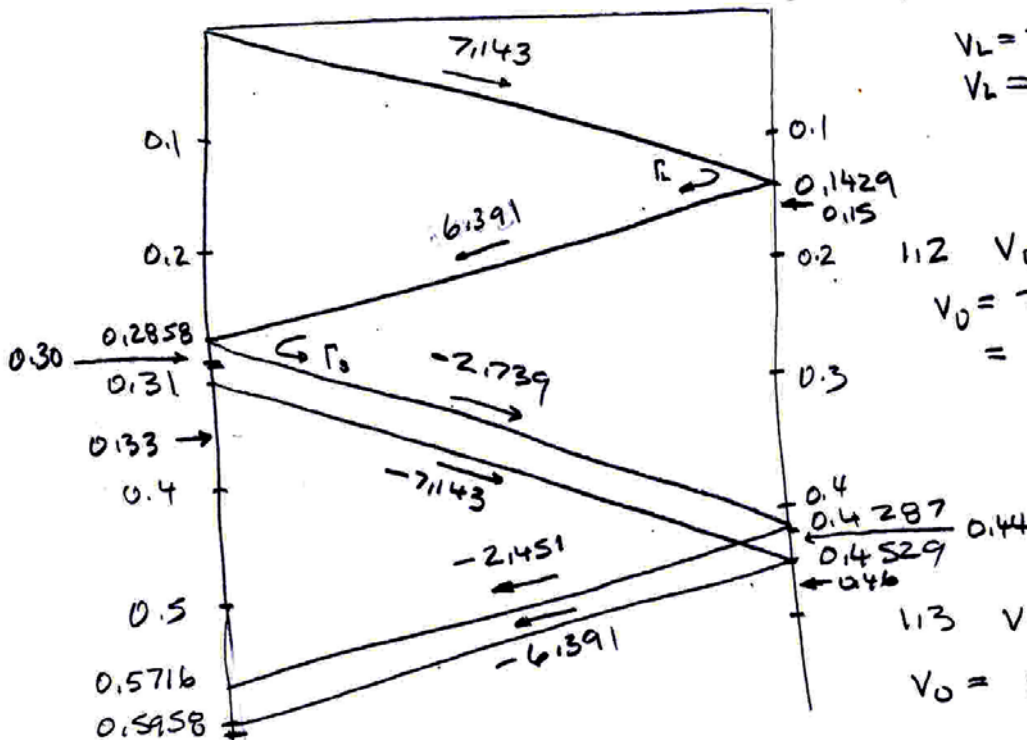
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$$\Gamma_s = \frac{R_s - R_c}{R_s + R_c} = \frac{20 - 50}{20 + 50} = -0.4286$$

$$\Gamma_L = \frac{R_L - R_c}{R_L + R_c} = \frac{900 - 50}{900 + 50} = \frac{850}{950} = 0.8947 \text{ ns}$$

$$V(0) = \frac{R_c V_s}{R_c + R_s} = \frac{50 \times 10}{50 + 20} = 7.143$$



1.1 V_L at 0.15 ns

$$V_L = 7.143 + 1.391$$

$$V_L = 13.53 \text{ v.} \quad \textcircled{a}$$

1.2 V_0 at 0.30

$$V_0 = 7.143 + 6.391 + 2.739$$

$$= 10.79 \text{ v.} \quad \textcircled{c}$$

1.3 V_0 at 0.33

$$V_0 = 10.79 - 7.143$$

$$= 3.648 \text{ v.} \quad \textcircled{b}$$

1.4 V_L at 0.44

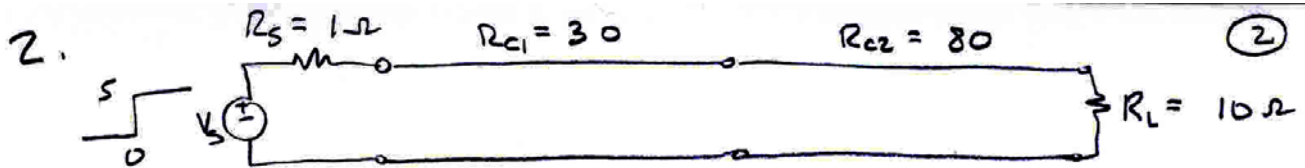
$$V_L = 13.53 - 2.739 - 2.451$$

$$= 8.34 \text{ v.} \quad \textcircled{d}$$

1.5 V_L at 0.46 ns

$$V_L = 8.34 - 7.143 - 6.391$$

$$= -5.194 \quad \textcircled{a}$$



$$T_1 = \frac{2}{20} = 0.10 \text{ ns} \quad T_2 = \frac{3}{20} = 0.15 \text{ ns}$$

$$V(0) = \frac{R_{c1} V_s}{R_{c1} + R_s} = \frac{30 \times 5}{30 + 1} = 4.838 \text{ volts}$$

$$\Gamma_3 = \frac{R_s - R_{c1}}{R_s + R_{c1}} = \frac{1 - 30}{1 + 30} = -0.9355$$

$$\Gamma_L = \frac{R_L - R_{c2}}{R_L + R_{c2}} = \frac{10 - 80}{10 + 80} = -0.7778$$

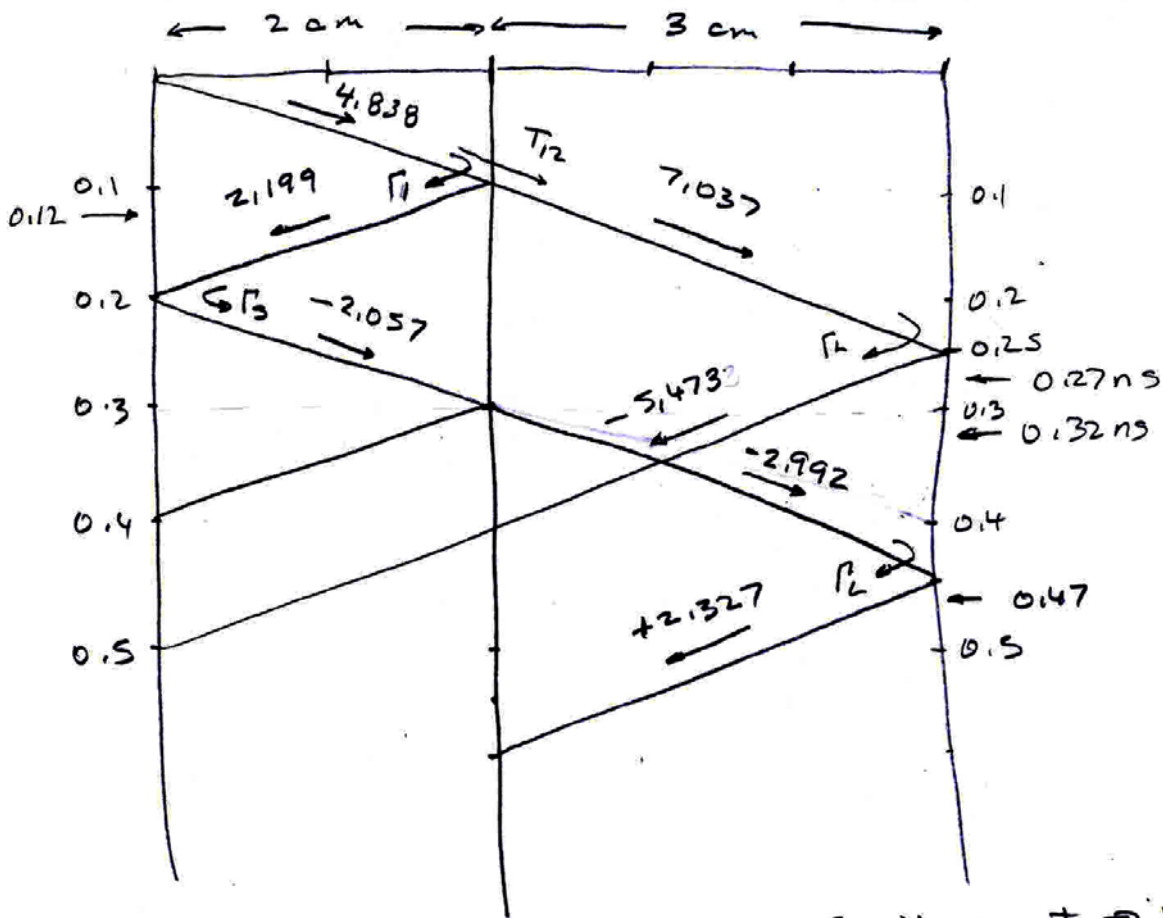


$$T_{12} = \frac{R_{c2} - R_{c1}}{R_{c2} + R_{c1}} = \frac{80 - 30}{80 + 30} = 0.4545$$

$$\Gamma_2 = \frac{R_{c1} - R_{c2}}{R_{c1} + R_{c2}} = \frac{30 - 80}{30 + 80} = -0.4545$$

$$T_{21} = \frac{2 \times R_{c2}}{R_{c1} + R_{c2}} = \frac{2 \times 80}{30 + 80} = 1.4545$$

$$T_{21} = \frac{2 \times R_{c1}}{R_{c1} + R_{c2}} = \frac{2 \times 30}{30 + 80} = 0.5454$$



2.1 V_A at 0.12 ns

$$V_A = 7.037 \text{ v. } \textcircled{c}$$

2.2 V_L at 0.27 ns

$$V_L = 7.037 - 5.473 = 1.563 \text{ } \textcircled{d}$$

2.3 V_M at 0.32 ns

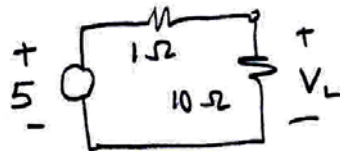
$$V_M = 7.037 - 2.992 = 4.045 \text{ volts } \textcircled{c}$$

2.4 V_L at 0.47 ns

$$V_L = 1.563 - 2.992 + 2.327 = 0.898 \text{ } \textcircled{b}$$

2.5 V_L

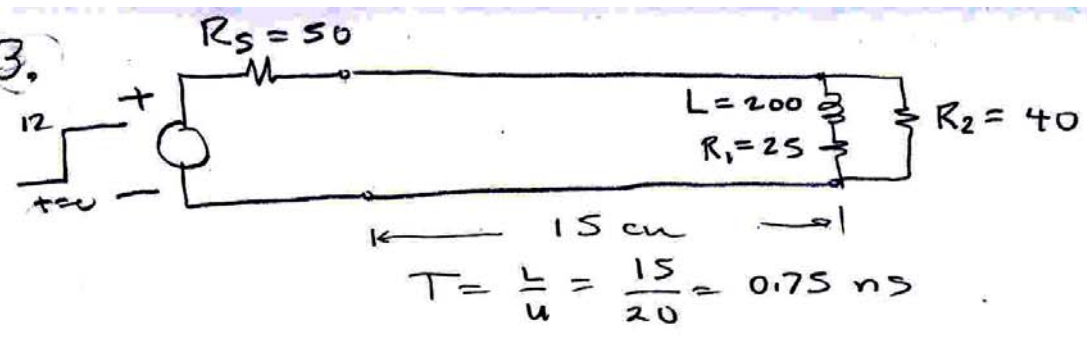
2.5 V_L as $t \rightarrow \infty$



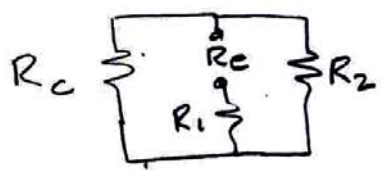
$$V_L = \frac{5 \times 10}{1 + 10} = \frac{50}{11} = 4.55 \text{ v. } \textcircled{b}$$

3.

4



3.1



$$R_e = R_1 + R_c \parallel R_2$$

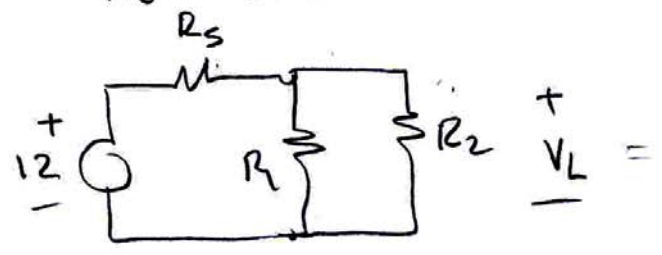
$$= 25 + \frac{50 \times 40}{50 + 40}$$

$$= 47.22 \Omega$$

$$T = \frac{L}{R_e} = \frac{200}{47.22} = 4.235 \text{ ns}$$

d

3.2

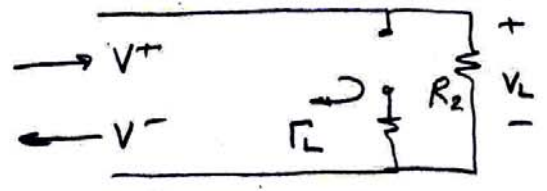


$$R_1 \parallel R_2 = \frac{25 \times 40}{25 + 40} = 15.38 \Omega$$

$$V_L = \frac{15.38 \times 12}{15.38 + 50} = 2.823 \text{ volts}$$

a

3.3 When the step arrives, L is an open circuit



$$\Gamma_L = \frac{R_2 - R_c}{R_2 + R_c} = \frac{40 - 50}{40 + 50} = \frac{-10}{90} = -0.1111$$

$$V^+ = \frac{R_c V_s}{R_c + R_s} = \frac{50 \times 12}{50 + 50} = 6 \text{ volts}$$

$$V_L = V^+ + V^- = V^+ + \Gamma_L V^+ = 6 + 6 \times -0.1111 = 5.333 \text{ volts}$$

d

3.4 V_L at $t = 5.00$ ns ?

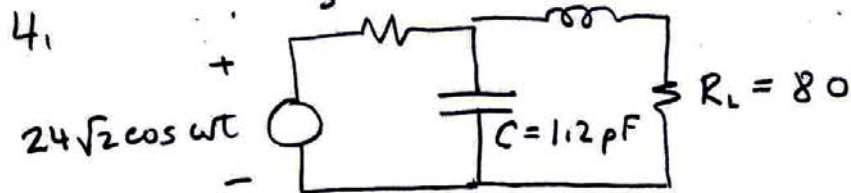
$$V_L(t) = V_{\text{final}} + (V_{\text{initial}} - V_{\text{final}}) e^{-\frac{t-T}{\tau}} \quad (5)$$

$$= 2.823 + (5.333 - 2.823) e^{-\frac{t - 0.75}{4.235}}$$

$$V_L(5) = 2.823 + 2.510 e^{-\frac{5 - 0.75}{4.235}}$$

$$= 3.743 \text{ volts} \quad (c)$$

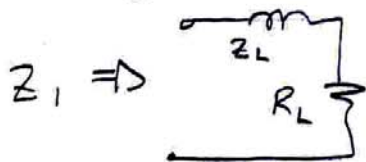
$$R_s = 50 \Omega \quad L = 2 \text{ nH}$$



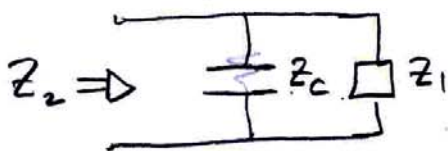
$$f = 2450 \text{ MHz} \quad \text{so } \omega = 2\pi f = 1.539 \times 10^{10} \text{ r/s}$$

$$4.1 \quad Z_L = j\omega L = j \times 1.539 \times 10^{10} \times 2 \times 10^{-9} = j 30.79 \quad (b)$$

$$4.2 \quad Z_C = \frac{1}{j\omega C} = \frac{-j}{1.539 \times 10^{10} \times 1.2 \times 10^{-12}} = -j 54.15$$



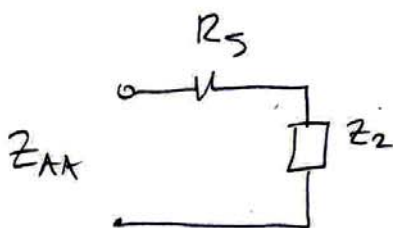
$$Z_1 = Z_L + R_L = 80 + j 30.79 \Omega$$



$$Z_2 = Z_1 \parallel Z_C$$

$$= \frac{(80 + j 30.79)(-j 54.15)}{80 + j 30.79 - j 54.15}$$

$$= 33.77 - j 44.29 \Omega$$



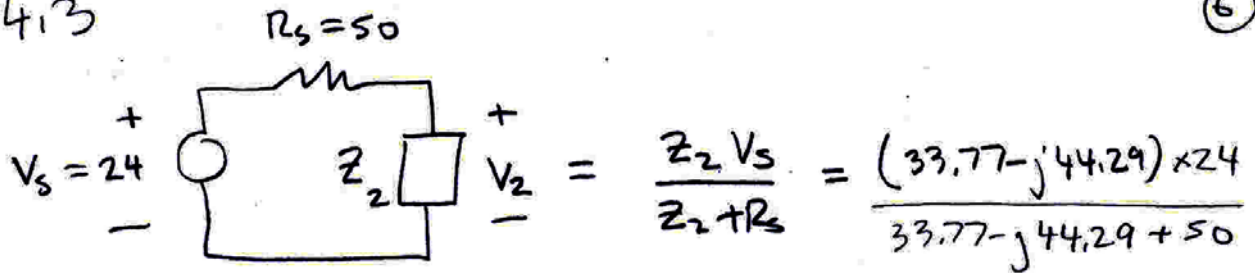
$$Z_{AA} = R_s + Z_2$$

$$= 50 + 33.77 - j 44.29$$

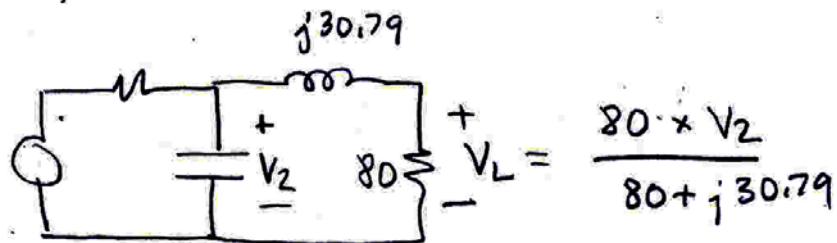
$$= 83.77 - j 44.29 \Omega \quad (c)$$

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(6)



$$V_2 = 12.80 - j5.92$$



$$V_L = \frac{80 \times (12.80 - j5.92)}{80 + j30.79}$$

$$= 9.17 - j9.45$$

$$= 13.17 \angle -45.9^\circ$$

(9)