University of Portland  
School of Engineering

EE 301 - Electromagnetic Fields-3 cr. hrs.  
Spring 2005

SOLUTIONS TO  
Midterm Exam #1  
(Prepared by Professor A. S. Inan)

(Wednesday, March 2, 2005)  
(Closed Book Exam; 1 Formula Sheet Allowed)  
(Total Time: 55 mins.)

Name:  

Signature:  

"Honesty is the best policy."
Aesop (~ 620B.C. –?)

"An honest mind possesses a kingdom."
Lucius Annaeus Seneca (4B.C.–65A.D.)

"Honest people are the true winners of the universe."
Anonymous

"Honesty is not for sale."
A. Inan

Inan has been sick lately...
(1) (15 mins., 30 points) **Pulse excitation of a lossless transmission line.**

For the transmission line circuit shown, sketch the voltages $V_S$, $V_{\text{center}}$, and $V_L$ as a function of time between $t = 0$ and $t = 1^+ \text{ ns}$. Provide all the relevant values on your sketches. Also provide a bounce diagram for your solution.

\[ V_1^+ = \frac{Z_0}{R_S + Z_0} \quad V_0 = \frac{60}{15 + 60} (3 \text{ V}) = 2.4 \text{ V} \]

\[ \Gamma_L = \frac{R_L - Z_0}{R_L + Z_0} = \frac{660 - 60}{660 + 60} = \frac{600}{720} = \frac{5}{6} \]

\[ \Gamma_S = \frac{R_S - Z_0}{R_S + Z_0} = \frac{15 - 60}{15 + 60} = -\frac{45}{75} = -\frac{3}{5} = -0.6 \]

Please see the bounce diagram and the voltage sketches on the next page.
(2) (20 mins., 40 points) **Lumped inductive element between two lossless transmission lines.** For the transmission line circuit shown, find and sketch the source-end and load-end voltages as a function of time. Show your work and provide all the appropriate values on your sketches.

\begin{align*}
V_1^+ &= \frac{Z_{01}}{R_s + Z_{01}} V_0 = \frac{250}{250 + 250} (3V) = 1.5V \\
V_1^- &= \frac{Z_{02} - Z_{01}}{Z_{02} + Z_{01}} V_1^+ = \frac{50 - 250}{50 + 250} (1.5V) = -1V.
\end{align*}

Since the inductor will at first act like an open circuit, we have \( V_1^- (Z_{01}^{-}, t_{dl}) = V_1^+ = 1.5V. \) However, when the inductor reaches steady state, it acts like a short circuit and as a result, we have \( V_1^- (Z_{01}^{-}, \infty) = \frac{Z_{02} - Z_{01}}{Z_{02} + Z_{01}} V_1^+ = \frac{50 - 250}{50 + 250} (1.5V) = -1V. \) The time constant of the circuit can be found as

\[ t_c = \frac{L}{Z_{01} + Z_{02}} = \frac{15\text{ nH}}{(250 + 50) \Omega} = 50 \text{ ps} \]
The mathematical expressions for the source-end and load-end voltages can be written as follows:

\[ V_s(t) = 1.5 \left[ u(t) - u(t-0.2n) \right] \]
\[ + \left[ 3e^{-2 \times 10^{-10} (t-0.2n)} + 0.5 \left( 1 - e^{-2 \times 10^{-10} (t-0.2n)} \right) \right] u(t-0.2n) \]  
\[ (V) \]

\[ V_L(t) = 0.5 \left( 1 - e^{-2 \times 10^{-10} (t-0.3n)} \right) u(t-0.3n) \]  
\[ (V) \]

Anyway, I hope Inan will get well soon.
(3) (15 mins., 30 points) **Load reflection coefficient, standing wave ratio and input impedance.** Consider the transmission line circuit shown. Assuming sinusoidal steady-state condition, find (a) the load reflection coefficient; (b) the standing wave ratio on the line; and (c) the input impedance of the line. Show your work and provide all your results in their simplest form.

\[ Z_{in} = \ ? \]

\[ d = 0.75 \lambda \]

\[ Z_0 = 50 \Omega \]

\[ Z_L = 25 - j75 \Omega \]

(a) \[ \Gamma_L = \frac{Z_L - Z_0}{Z_L + Z_0} = \frac{25 - j75 - 50}{25 - j75 + 50} = \frac{-25 - j75}{75 - j75} \]

\[ = \frac{-1 - j3}{3 - j3} \cdot \frac{(3 + j3)}{(3 + j3)} = \frac{6 - j12}{18} = \frac{1}{3} - \frac{j2}{3} \]

\[ = \sqrt{5} \cdot e^{j \tan^{-1}(-2)} = 0.745 e^{-j 63.4^\circ} \]

(b) \[ S = \frac{1 + |\Gamma_L|}{1 - |\Gamma_L|} = \frac{1 + \frac{\sqrt{5}}{3}}{1 - \frac{\sqrt{5}}{3}} = \frac{3 + \sqrt{5}}{3 - \sqrt{5}} = 6.85 \]

(c) \[ Z_{in} = \frac{Z_0^2}{Z_L} = \frac{50^2}{25 - j75} = \frac{100}{1 - j3} \cdot \frac{(1 + j3)}{(1 + j3)} = 10(1 + j3) \]

\[ = (10 + j30) \Omega \]

And be humorous and funny again... Get well soon Iran!