Name: _____

GTID: _____

# ECE 3025: Electromagnetics

## TEST 1 (Fall 2005)

- Please read all instructions before continuing with the test.
- This is a **closed** notes, **closed** book, **closed** calculator, **closed** friend, **open** mind test. You should only have writing instruments on your desk when you take this test. If I find anything on your desk (excluding the test itself, writing instruments, and life-or-death medication) I will turn you in for an honor code violation. I am serious.
- Show all work. (It helps me give partial credit.) Work all problems in the spaces below the problem statement. If you need more room, use the back of the page. DO NOT use or attach extra sheets of paper for work.
- Work intelligently – read through the exam and do the easiest problems first. Save the hard ones for last.
- All necessary mathematical formulas are included either in the problem statements or the last few pages of this test.
- You have 50 minutes to complete this examination. When I announce a "last call" for examination papers, I will leave the room in 5 minutes. The fact that I do not have your examination in my possession will not stop me.
- I will not grade your examination if you fail to 1) put your name and GTID number in the upper left-hand blanks on this page or 2) sign the blank below acknowledging the terms of this test and the honor code policy.
- Have a nice day!

Pledge Signature: _____

*I acknowledge the above terms for taking this examination. I have neither given nor received unauthorized help on this test. I have followed the Georgia Tech honor code in preparing and submitting the test.*

(1) **Short Answer Section** (24 points)

(a) _____ (1) _____ (2)
The *Answer 1* and the *Answer 2* are two examples of transmission lines that have complete signal and field confinement.

(b) _____
True or False: A reverse crosstalk signal is the *derivative* of the original signal on the coupled transmission line.

(c) _____ _____ _____ _____
List 4 ways to terminate a transmission lines to minimize reflections.

(d) _____
The microstrip transmission line is made from a printed circuit board (PCB) with etched traces above the dielectric and a *Answer* on the bottom.

(e) _____
If a $Z_0$ lossless transmission line has $N$ transmission lines connected to it in series fan-out, the impedance of each fan-out line must be *Answer* to maintain a load-side match at the end of the primary line.

(f) _____
When a transmission line fans-out to 6 lines (in parallel) with identical input impedance, the forward-looking reflection coefficient at the end of the primary line is *Answer*.

(g) _____ (1) _____ (2)
Complete reflection occurs if the load is either a *Answer 1* circuit or an *Answer 2* circuit.

(2) **Descriptive Answer Section** (20 points)
Write a **concise** answer to each question in the spaces provided beneath each problem statement. **Note:** Correct answers that are extremely verbose will be penalized.

(a) **Microchip Interconnect:** Here is a recent news posting coming off the very non-technical news wire:

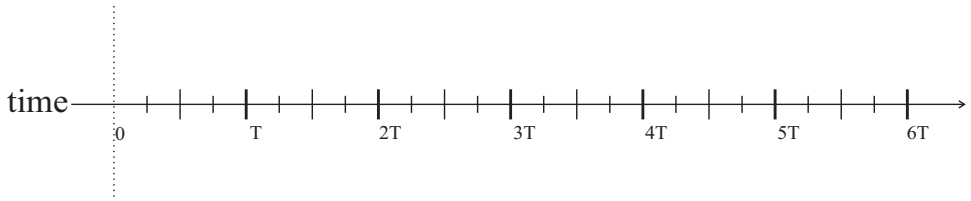
> New Sun Microsystems Chip May Unseat the Circuit Board
>
> September 22, 2003 By John Markoff
>
> MOUNTAIN VIEW, CA, September 19, 2003 – Written off lately by the computer industry as a has-been, Sun Microsystems may still have a few tricks up its engineers' shirt sleeves.
>
> On Tuesday, Sun researchers plan to report that they have discovered a way to transmit data inside a computer much more quickly than current techniques allow. By placing the edge of one chip directly in contact with its neighbor, it may be possible to move data 60 to 100 times as fast as the present top speeds.
>
> For the computer industry, the advance – if it can be repeated on the assembly line – would be truly revolutionary. It would make obsolete the traditional circuit board constructed of tiny bits of soldered wires between chips, familiar to hobbyists how hand-soldered connection when assembling Heathkit electronic projects.
>
> "It could represent the end of the printed circuit board," said Jim Mitchell, director of Sun Laboratories here. "It makes things way, way faster."
>
> Sun, an icon of Silicon Valley, has been losing market share and laying off thousands of workers as corporate computing customers turn increasingly to Microsoft and Intel for their software and hardware. Sun is in desperate need of a technical advance that can differentiate it from the others.

Using basic principles of transmission line theory, explain why it might be advantageous to connect chips in this fashion. (**10 points**)

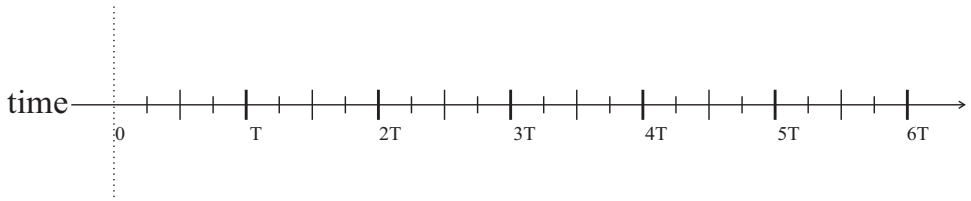
(b) **Signal Distortion on Transmission Lines:** List 5 detrimental signal effects that can result from propagation on a transmission line. (**10 points**)

(3) **Reflection Sketches:** There is an uncharged transmission line with transit time $T$, length $D$, and reflection coefficients $\Gamma_G = \frac{1}{2}$ and $\Gamma_L = -\frac{1}{2}$. At $t = 0$ an **ideal impulse**, $f(t) = 16\delta(t)$, enters the source-side of the line. Sketch the following functions of time in the space provided below. Please label the amplitudes of your pulses and show the appropriate modulus (sign) and relative increasing/decreasing behavior of amplitudes. (**21 points**)

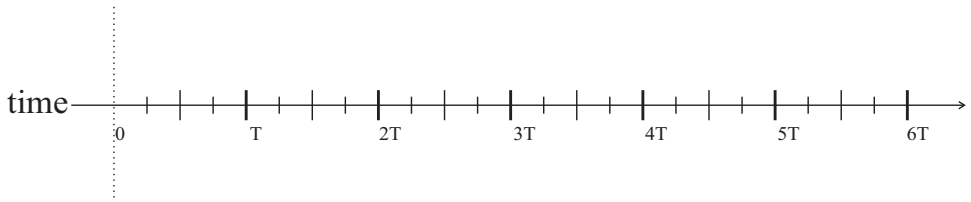
a. The voltage observed at the load side of the transmission line:




b. The voltage observed at the source side of the transmission line:

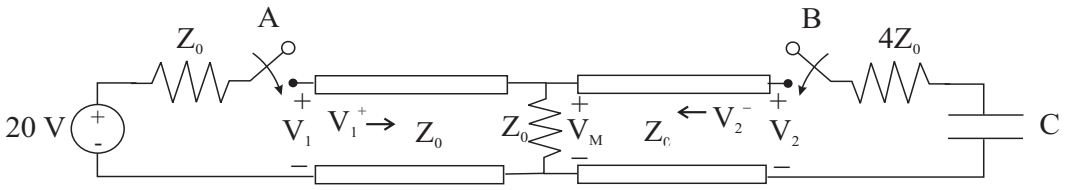



c. The voltage observed exactly **one-quarter** ($z = \frac{D}{4}$) down the transmission line:



(4) **Switching Network:** The circuit below represents a high-speed digital interconnect that is switched according to the following states:

- State 0: Both switches are open and both lines are uncharged.
- State 1: Immediately after switch A is closed.
- State 2: Switch A has been closed for a while.
- State 3: Immediately after switch B is closed.
- State 4: Switch B has been closed for a while.




Fill out the following table according to these switching states. Assume all backwards propagating waves are measured from the right-most side of the transmission line. Assume all forward propagating waves are measured from the left-most side of the transmission line. (**35 points**):

| | $V_1$ | $V_M$ | $V_2$ | $V_1^+$ | $V_2^-$ |
|---|---|---|---|---|---|
| State 0 | 0 | 0 | 0 | 0 | 0 |
| State 1 | | 0 | 0 | | 0 |
| State 2 | | | | | |
| State 3 | | | | | |
| State 4 | | | | | |

# Formula Sheet

$$\frac{\partial^2 v(z,t)}{\partial z^2} = LC\frac{\partial^2 v(z,t)}{\partial t^2} \qquad \frac{\partial^2 i(z,t)}{\partial z^2} = LC\frac{\partial^2 i(z,t)}{\partial t^2} \qquad Z_0 = \sqrt{\frac{L}{C}} \qquad v_p = \frac{1}{\sqrt{LC}}$$

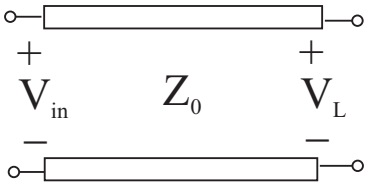
$$\lambda f = v_p \qquad \omega = 2\pi f \qquad \beta = \frac{2\pi}{\lambda} \qquad D = Tv_p$$

$$\text{Reflection: } \Gamma_{L,G} = \frac{R_{L,G} - Z_0}{R_{L,G} + Z_0} \qquad \text{Transmission: } 1 + \Gamma_{L,G}$$

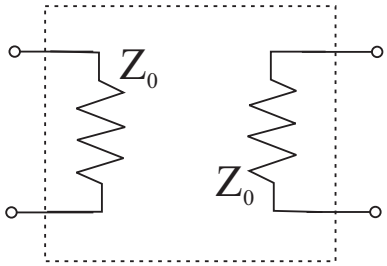
$$\text{General I/O: } V_L(t) = (1 + \Gamma_L)\sum_{n=0}^{\infty}(\Gamma_G\Gamma_L)^n f\left(t - [2n+1]T\right)$$

$$V^+ = \frac{V_L + I_L Z_0}{2} \qquad V^- = \frac{V_L - I_L Z_0}{2}$$

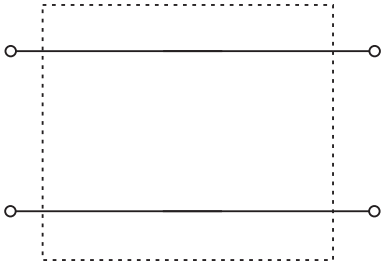
## Useful Equivalent Circuits for T-lines



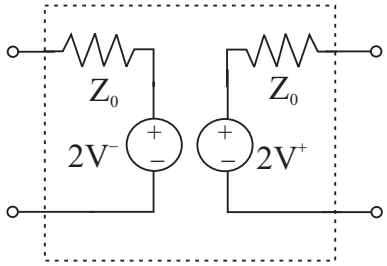

Completely Discharged Line




Charged to a DC Steady State



General Equivalent Circuit




$$\mu = \mu_r\mu_0 \qquad \mu_0 = 4\pi \times 10^{-7}\ \text{H/m} \qquad \epsilon = \epsilon_r\epsilon_0 \qquad \epsilon_0 = 8.854 \times 10^{-12}\ \text{F/m}$$