Math err -1

EE 469/569 Advanced Digital System Design – Final Name: ____________________

You have 2 hours to work this test. This test is open book, open notes, but no sharing of books or notes during the test is permitted.

1. Consider a 10-mil-wide circuit trace located 5 mils over a ground plane with FR-4 dielectric ($\varepsilon_r = 4.2$). The trace is routed microstrip, with open air on top of the trace. The trace is 5 inches long and is carrying a signal with a 200 ps rise time.

   4.5 a. What is the speed of propagation of a signal on the trace, in ps/in?

   $\sqrt{4.2} * 84.7$ ps/in $= 174$ ps/in

   $1/\sqrt{4.2}$: -2
   weird calc -3
   85 ps/in: -3

   4.5 b. For a signal with a 200 ps rise time, how long must the trace be in order to be considered distributed?

   200ps/6 = 33 ps = 0.19"

   did not ÷6: -2
   weird calc -3

   4.5 c. What is the Z_0 of the trace?

   $t = 17\mu m = 0.017 mm = 0.67$ mils

   $= \frac{87}{\sqrt{5.61}} \ln\left(\frac{5.98 \cdot 5}{0.8 \cdot 10 + 0.67}\right) = 45.5\ \Omega$

   wrong formula: -3
   wrong t: -2

   4.5 d. What are the T_p and T_0 of the trace?

   138.6 ps/in To = 693 ps
   (or 5*174 = 870 ps

   wrong e -3
   ~~did not × inches~~

   4.5 e. What is the rise time adder due to dielectric loss?

   5 ×

   weird calc: -4

   4.5 f. Consider a 5 pF load. What is the rise time adder due to the Z_0 and the load?

   270 × .02 × $\sqrt{4.2}$ = 11.1 ps/in
   × 5" = 55ps

   2.2 × 45.5 × 5p = 500ps

   $1.1 Z_0 C$: -0
   wrong Z_0: -2
   $Z_0 C$: -2
   did $\sqrt{T}$ formula -2
   calc'ed C_L of line -3
   $\sqrt{t_1^2 + t_2^2}$ -4

   4.5 g. For a signal source with a 200 ps rise time, and considering the two additional rise times you computed in f and g, what is the rise time at the load?

   541 ps

   Left out source: -2
   RC: -2
   both: -4
   Did X+Y+Z calc: -4

before	after
85.9	86.8
3.62	3.76
17/18	20/5

2. Consider a trace with a 50-ohm Z_0 and a source impedance of 12 ohms and a load impedance of 2 Megohms. The source is a rising edge from 0V to 1V with a 500 ps rise time. The trace has a T_0 of 2 ns.

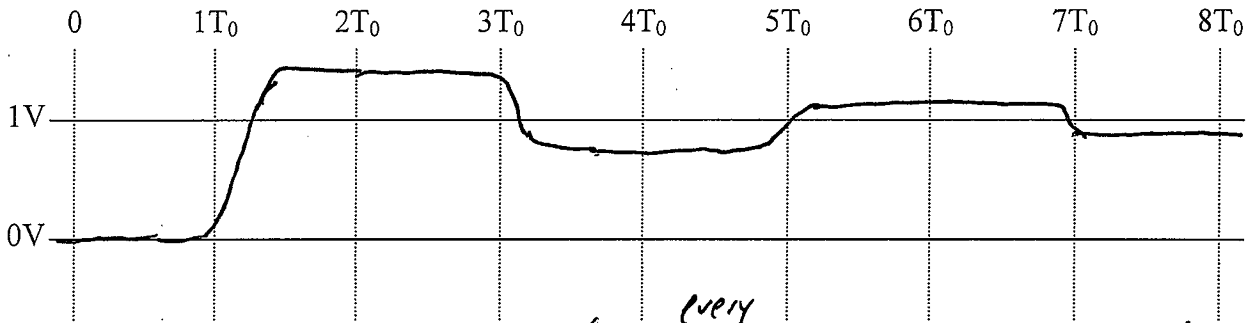
a. Find the reflection and transmission coefficients at the source and the load.

4.5 $\rho_s = \frac{12-50}{12+50} = -0.613$ $T_s = 0.387$

$\rho_L = \frac{2M-50}{2M+50} = 1$ $T_L = 2$

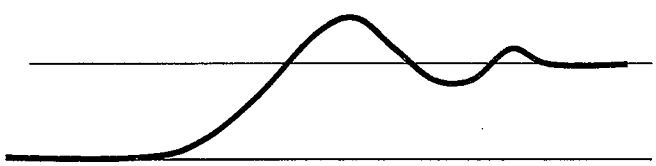
weird calc: -3

b. Draw a rough sketch of the voltage you expect to see at the load over time. (The rising edge begins at t=0.)
4.5



every T_0 instead of every 2 T_0 : -3 no refl'ns: -3
falling ~~rising~~ instead of ~~falling~~ rising : -1

3. An engineer observes the following waveform on an oscilloscope and asks for your help.



a. What are three possible physical explanations for the waveform? (Hint: Consider that you did not see the engineer making the measurement.)
4.5
Bad probing
Ringing
Reflections
} 1 ea

"ground bounce" -2

b. For each of the three possible explanations, how might you fix the problem?
4.5
Better probing
Series R
Better termination

c. How would you decide which of the three possible explanations is correct?
4.5
- observe probing methods
- observe length of trace

"by what works" -3

4. You are doing the layout for the new high-speed XYZ bus. The bus is a low-voltage differential signal (LVDS) bus that runs at 5 Gbps (5 gigabits per second). (That is, it is a serial link running at 5 gigabits per second.)
   a. Assuming that the rising or falling edge is allowed to be 20% of the time of one bit, what is the rise/fall time of the signal?

4.5

$1 \text{ bit} = \frac{1}{5GHz} = 200ps$

$t_r = 40ps$

Math err: −1
1 bit = 5E9 ... : −3
no/weird calc + wrong answ : −4

   b. What is the knee frequency of the signal?

4.5

$\frac{1}{2t_r} = 12.5 GHz$

   c. The XYZ bus is supposed to be routed with a differential impedance of 100 ohms. What is the Z_0 of each of the two differential traces?

4.5

50Ω

200Ω : −3

   d. Consider the rise/fall time you computed in part a and consider the fact that FR-4 has a risetime adder of about 10.8 ps per inch due to dielectric losses. At what trace length does the risetime adder of the dielectric loss equal the risetime of the original signal?

4.5

$40ps / 10.8 = 3.7''$

weird calc: −3

5. When a certain signal switches, you notice that another quiet signal coming from the same chip has a glitch.
   a. What are two possible causes for the glitch?

4.5

Ground bounce
Crosstalk

"Mutual L+C" + nothing else −2
Missing either gnd bounce or xtalk: −2
Missing both: −4

   b. If the two signals are not routed near each other, what is the likeliest possible cause?

4.5

Ground bounce

chose xtalk: −4
chose new answ not in 'a' −4

   c. What could be done *to the switching signal* to reduce the size of the glitch on the quiet signal?

4.5

Slower rise time ⇒ Series R

weird −3

6. A set-top box is designed to receive software updates. First, the software people notice that doing a software update causes the PCI Express bus not to work. Second, the hardware people discover that disabling the LED display (which flashes rapidly and changes often during a software download) lets the PCI Express bus work correctly during a download.

   a. Clearly rapidly changing the LED display on the front causes the PCI Express bus not to work correctly. What possible explanations are there for this failure?

      4.5

      Ground Bounce
      Cross talk

      no gnd bounce: -2
      software expl'n: -4

      no gnd bounce or xtalk plus weird expl'n: -4

   b. It is discovered that the PCI Express bus was routed in the middle of the LED control lines. What is a likely explanation for the PCI Express bus failure?

      4.5

      Cross talk

      "cabling" -4
      "ESD"

   c. How could the design be fixed? (That is, how could you fix it so that you can update the LED's rapidly and do a download at the same time?)

      4.5

      re-layout w/ guard traces

      only s/w fix: -2
      "cabling" -2