ECE 733
Final Spring 2009

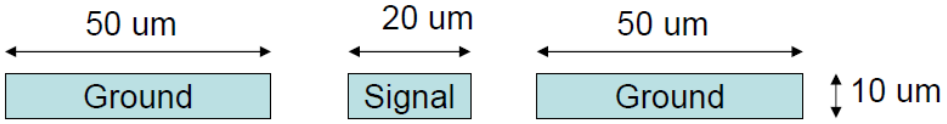
Name:

Student ID:

This test is open book, open notes. Computers, PDAs and cell phones are NOT allowed (calculators are). You have 90 minutes. Turn in answers in the space provided. [18 points total]

Question 1

Consider a Coplanar line that is 0.5 m long. It has the following dimensions:



For the calculations below, please use the following parameters:

- Dielectric constant = 4.3. Loss tangent tan δ = 0.03.
- Copper resistivity = 1.7E-8 Ohm.m
- Magnetic permeability = 4π E-7
- Speed of light in a vacuum = 3E8 m/s
- Z_0=50 Ω

Please answer the following questions:
(a) What is the DC resistance per unit length of the transmission line? [2 points]

85 Ohm/m. If you included the return path resistance, that was considered correct too.

(b) At what frequency is the skin depth going to start increasing the resistance over the DC resistance? [2 points]

$\delta_S = \sqrt{\frac{\rho}{\pi\mu f}}$, and $\delta_S = \frac{0.0656}{\sqrt{f}}$. Therefore $R_{AC} = \frac{\rho}{w}\frac{\sqrt{f}}{0.0656} = 26\times10^{-3}\sqrt{f}$

Two parallel R_{AC} value, $\frac{R_{AC}}{2}$, is equal to 85Ω at $f = 42.751MHz$.

(c) At what frequency does the dielectric loss exceed the skin effect loss? [2 points]

Skin effect loss is $\alpha_{skin} = \frac{R_{DC}}{2Z_0}\sqrt{\frac{f}{f_s}}$, where $f_s = \frac{\rho}{\pi\mu\left(\frac{t}{2}\right)^2}(t = 20\mu m)$.

Dielectric loss is $\alpha_{diel} = \frac{\pi f\sqrt{\varepsilon_r}\tan\delta_D}{c} = 6.511\times10^{-10} f$

$\alpha_{skin} = \alpha_{diel}$ at $f = 39.86GHz$

A_s = f^1/2 * 2.6E-4. A_d=6.5E-10 * f. 159 GHz
You would get a slightly different (but actually more correct) answer if you included the return path skin resistance (which doubles the total R).

Question 2
Consider PAM-4 Signaling vs. PAM 2 signaling. Please answer the following questions.

(a) If the PAM-2 signal levels for a differential driver are 600 mV and 900 mV, what would the signal levels be for the PAM-4 driver, if the 0 and "3" level are the same as "0" and "1" are for PAM-2? (This is meant to be a simple question). [1 point]

600 mV, 700 mV, 800 mV, 900 mV

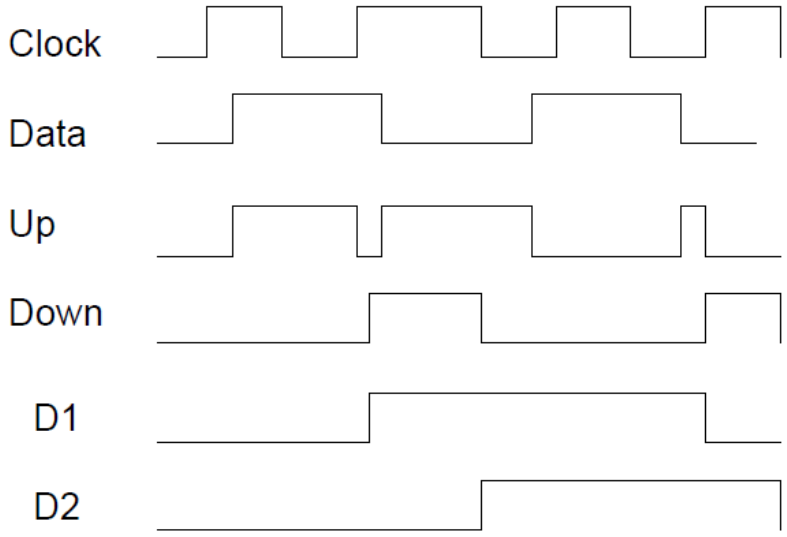
(b) Compare two sets of differential lines next to each other. If using PAM-4, will the impact of crosstalk on the Bit Error Rate be the same, better or worse for PAM-4 when compared to PAM-2 signaling? Please explain your answer clearly. [3 points]

SNR is worse as a full transistion (from 0 to 3) can interfere with a small transition (e.g. from 2 to 3). So BER is worse.

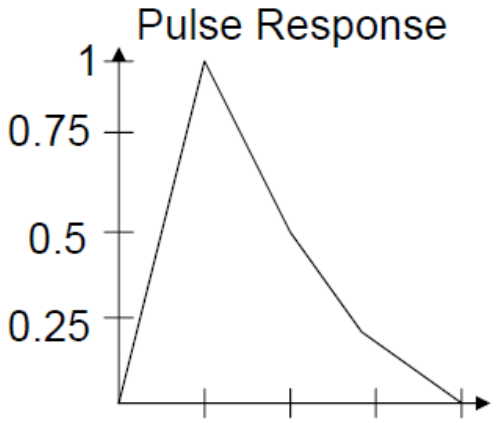
Question 3
Please answer the following short answer questions:
(a) What is the biggest source of clock jitter in a recovered clock? [2 points]

Power and ground noise

(b) For the Hogge phase detector, show the Early Late signals for the following clock and data stream. [2 points]



(c) Consider the following unequalized pulse response. If we build a 3-tap filter with tap weights a1=0.3 and a2=0.1, is the resulting waveform likely to be over-equalized or under-equalized? Please explain your reasoning. [2 points]



under

(d) You are tasked to implement a 10 Gbps transceiver for an existing interconnect system. The customer can supply you with an interconnect structure to measure. You intend to use this to build a simulation model. Will you use TDR or a Vector Network Analyzer to extract the model? Or can you use either? Please explain your reasoning. [2 points]

VNA. TDR edge rate limits high frequency fidelity of model.