

CSE464 Homework #4 Due 2005.02.23

Note: Please list at top of first sheet of homework submission anyone or anything from which you obtained any help for this homework assignment other than the text, class lecture/notes/discussion, and the instructor. Please give a word or two as to the nature of the help (e.g.: discussed problems, copied verbatim, whatever). Acknowledging source of help is a requirement for this assignment, and for all assignments in CoE464. It has no effect on your grade as long as you do it.

1. A 1 meter transmission line has $Z_0=50$ Ohms, and propagation velocity of $1\text{m}/6.6666\text{ns}$. It is driven by V_s , which generates a step from 0V to 1V at $t=0$, in series with a 500 Ohm resistance, R_s . The receiving end is open circuit ($R_t=\text{infinity}$). Calculate/plot the voltage waveform at the receiving end as a function of time, and compare with the waveform for V_s and R_s driving a lumped capacitor of the same capacitance as the total t-line capacitance. An excellent way to compare is to put both results on the same plot. Hint: Excel can be used for the calculations and plot. Note that the voltage at the sending end, and the receiving end, will be essentially the same. This circuit is a model for a high-impedance CMOS driver and interconnection. Because the currents are small, inductance has little effect.
2. The transmission line of problem 1 is driven with the same V_s , and with $R_s = 5$ Ohms and $R_t=0$. Calculate/plot the current at the receiving end as a function of time, and compare with the waveform for V_s and R_s driving a lumped inductor of the same inductance as the total t-line inductance. Note that the current at the sending end and the receiving end will be essentially the same. This circuit can be used as a model for power distribution in digital systems. Because the voltages are small, the capacitance has little effect. We have not directly developed equations for transmission line current, however, you can calculate the voltage at the receiving end with R_t , and find I at the receiving end as the limit of V/R_t as R_t approaches zero.
3. A 2-foot transmission line with unloaded $Z_0=25$ Ohms and propagation velocity of $1\text{ft}/2\text{ns}$, has 10pF loads attached every 2 inches. Transition time (rise/fall time) of signals on this line are 2ns. A) What is the loaded value of Z_0 and propagation velocity? B) If the loaded line is terminated at each end (with the loaded value of Z_0), what resistance must a driver at the center of the line drive? C) How does Z_0 change if the length of the line and the number of loads are both doubled, keeping the spacing the same?
4. A source with $R_s=50$ Ohms and a length of 50 Ohm transmission line are to be connected to a load which consists of a section of 75 Ohm transmission line and R_t of 75 Ohms. You are to design a matching network to place between the two lengths of transmission line so that there will be no reflections in either direction (the 50 Ohm line will see 50 Ohms, the 75 Ohm line will see 75 Ohms).
5. Design a resistor network to connect two 50 Ohm transmission lines and to provide A) attenuation of 2:1; B) Attenuation of 10:1. Input impedance to the network plus second t-line is to be 50 Ohms. Signals will propagate in only one direction ($V_r=0$ everywhere) so impedance matching is required in only one direction.
6. Use HSPICE to simulate a Motorola MPC948 clock buffer driving a transmission line through a series resistor. The MPC948 output resistance is on the order of 7 Ohms. For reference, the MPC948 data sheet is [here](#) (This is data sheet is actually for the MPC9448, a pin-compatible replacement for the MPC948). The

MPC948/MPC9448 has 12 outputs and is designed to distribute a clock signal to 12 sources with minimum skew. The MPC948 is designed to allow clock distribution to be all point-to-point signals. The IBIS model for the MPC948 driver is available from a link on the homework web page. IBIS models have been designed to allow simulation of the terminal behavior of circuits without revealing the internal construction or component properties in order to protect the manufacturers secrets. Thus IBIS models are not as accurate as those using FET components and actual circuit interconnection, but for many circuits IBIS models are all that are available. A .sp file providing a starting point for this problem is available from a link on the homework web page. This file has three copies of the circuit for different process, temperature, and Vdd: one for maximum output currents, one for typical output currents, and one for minimum output currents. The transmission line impedance is set, for each buffer strength, to give worst case overshoot or undershoot (you should check this to convince yourself that the worst case conditions are covered). Alter statements are given to simulate for several different series resistor values in order to allow choosing the best one over the range of possible conditions. Resistors are readily available with 1% tolerance which is small enough to ignore in this problem.

A) First simulate the file as given. There are many many currents and voltages that can be viewed. Most important are the t-line inputs and outputs ($t_line_xxx_out$ and $t_line_xxx_in$). Look at the inputs and outputs for one condition (such as max) for a few minutes and decide whether or not they look reasonable.

B) From the waveforms at the t-line output, and any additional simulations you wish to perform, what series resistor value would you choose to use with the MPC948 assuming the max, typ, and min conditions used to generate the IBIS models of the MPC948 are appropriate for your application? On what did you base your choice?

Problem 7, CSE564 Only.

A) Find the V_o and V_i for the circuit shown below for a transition of the source in either direction. $R_s=10$ Ohms, The diodes have a forward voltage of $0.4V$, and a resistance of 5 Ohms (Schotky Diodes). Bergeron method is one way to solve for voltages on this circuit. However, you can also find the waveforms from the equivalent circuits and the forward and backward waves. B) consider the output waveform of the source to be a ramp with $2ns$ transition time (shorter than l/v for the transmission line) and find the voltage at $x=l$ for time up to $4l/v$.

