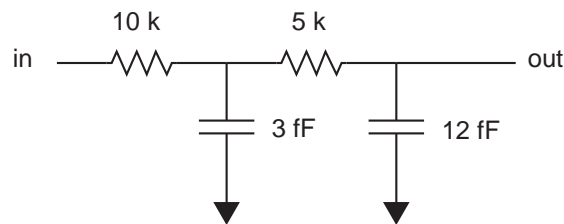


CSE 462 VLSI Design
Circuit Delay
Due Friday November 10, 2006

1. The AMI05 INV01 cell is a minimum-sized inverter where $L_n = L_p = 0.6 \mu\text{m}$, $W_n = 1.5 \mu\text{m}$, and $W_p = 2.7 \mu\text{m}$. Run an experiment using Nanosim to show that the on-resistance of the n-type device is approximately $8.5 \text{ k}\Omega$ and of the p-type device is approximately $6.9 \text{ k}\Omega$. Note that this is a repeat of the exercise that was done in the lab. Explain your procedure and results.
2. Use the Elmore delay approximation to determine the propagation delay through the circuit below, assuming that the input is a voltage step. Compare the results of your analysis to a Nanosim simulation. In addition to your analysis, turn in a printout of the CosmoScope waveform.



3. A polysilicon wire is 480 microns long and 0.6 microns wide. Assuming the parasitic resistance and capacitance values given below, what would the propagation delay to the end of the wire for an input voltage step, if we model the wire as:
 - (a) a lumped resistor and lumped capacitor,
 - (b) an RC-ladder circuit with 2 segments,
 - (c) an RC-ladder circuit with 4 segments,
 - (d) a distributed RC circuit (a ladder with an infinite number of segments)?

Use an Elmore delay approximation for your analysis.

polysilicon parallel plate capacitance	$85 \text{ aF}/\mu\text{m}^2$
polysilicon fringe capacitance	$50 \text{ aF}/\mu\text{m}$
polysilicon sheet resistance	$25 \Omega/\text{square}$

4. Now suppose that the polysilicon wire from the Problem 3 question is driven by the minimum-sized inverter from Problem 1. Using an Elmore delay approximation, what would be the propagation delay to the end of the wire, assuming a distributed RC model?
5. Using Nanosim, determine the worst-case propagation delay for the minimum-sized inverter from Problem 1 driving a 1 pF load. Assuming that the gate capacitance for this process is $3 \text{ fF}/\mu\text{m}^2$, minimize the propagation delay through inverter chains two- and three-stages long driving the same load. The first inverter in the chain must be minimum-sized. Show the results from all simulations and discuss your findings.