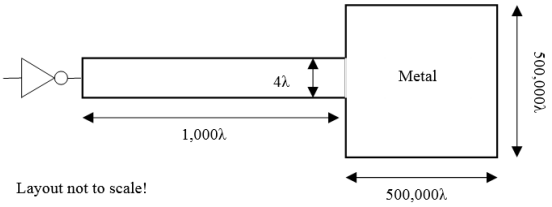
Homework 2

ECE 445 – Intro to VLSI Design

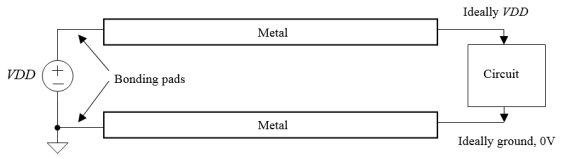
Note: Use Cadence schematic capture, layout and Spectre simulation tools, available on the servers for the homework problems.

Problem 1: Estimate the capacitive load presented to the inverter seen below if the inverter drives a piece of metal measuring $4\lambda \times 1000\lambda$ and a bond pad that measures $500,000\lambda$ square. Assume $\lambda = 100\,nm$ and the bottom capacitance of the metal is $10\,aF/\mu m^2$ while the sidewall capacitance is $100\,aF/\mu m$.



Problem 2:

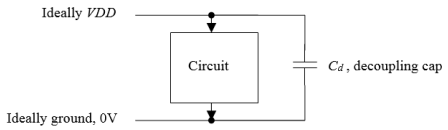
Consider the circuit configuration shown below. The metal wire that supplies current to the black boxed circuit has dimensions of $100\mu m \times 0.1\mu m$ and the supply voltage is $V_{DD} = 5V$. The sheet resistance of the metal is $0.1\Omega/\square$.



a) Find the resistance of each of the supply and ground wires. What will be the local V_{DD} and ground voltages at the circuit if it pulls a DC current of $I_{load} = 100\mu A$. Simulate this scenario using Cadence (model metal lines by lumped resistors, ignore wire capacitance and inductance. Model the circuit using a DC current source).

b) Now, the circuit periodically pulls a current of $I_{load} = 100\mu A$ for a pulse width $\Delta t = 1ns$ with a time period of $T_{clk} = 10ns$. Find the supply ripple voltage at the circuit and confirm with simulation (model the circuit using a pulsed current source).

c) Now a decoupling capacitance, C_d, is placed between the local V_{DD} and ground of the circuit, to reduce the supply ripples across the circuit. Estimate the value of C_d to obtain a supply voltage ripple, $\Delta V_{DD} < 10mV$. Confirm your design using transient simulations.



Problem 3: Estimate and simulate the delay through a metal wire that measures $100\,nm$ in width and is $10\,\mu m$ in length if it is periodically loaded with $100\,fF$ every $250\,nm$ and the sheet resistance of the metal line is $0.1\Omega/\square$. **Hint:** Use recursive nets to simplify your schematic.

Problem 4: If V_{DD} and ground are supplied through conductors that are $10\,\mu m$ wide and $500\,\mu m$ long estimate the maximum DC current we would want to put through the conductors due to electromigration considerations assuming $J_{Al} = 1mA/\mu m$. Repeat if we don't want more than 1 mV voltage drop across the conductors when the sheet resistance is 0.1 ohms per square.