EE 330 Fall 2012
Homework 1

Due Friday August 24 at the beginning of the lecture. You MUST clearly indicate your name and SECTION on the first page of your HW. Submissions that do not include the section WILL NOT be graded.

Problem 1 (10 points):
Assume a simple circuit requires 10,000 MOS transistors on a die and that all transistors are minimum-sized. If the transistors are fabricated in a 32nm CMOS process and the spacing overhead for the transistors is a factor of 10, determine the number of die that can be fabricated on a 12" silicon wafer.

Problem 2 (5 points):
If the cost of a 12 inch wafer is $6000, what is the cost/die for the circuit in Problem 1?

Problem 3 (10 points):
For small circuits, the area required for bonding pads often dominates the area required for a circuit whereas for large circuits, the bonding pad area is a minor contributor to the overall die area. If bonding pads are square and of area 80µ x 80µ and the spacing between bonding pads and between any circuit components is 40µ, determine the number of die for the 10,000 transistor circuit of Problem 1 if the circuit requires 8 bonding pads. What is the cost/die if the bonding pads are included?

Problem 4 (5 points):
How does the feature size in a 20nm process compare to the approximate "diameter" of a silicon atom?

Problem 5 (5 points):
The clock frequency of microprocessors has not increased appreciably for the past several years yet performance is improving through the parallelism offered by multiple cores. Why is it more energy efficient to use multiple cores on a die each operating at a lower clock rate than to have a single core operating at a higher clock frequency?

Problem 6 (10 points):
Identify by part number a current Intel processor. How many transistors are in this processor?

Problem 7 (15 points)
The current flow into a microprocessor can be quite large. Assuming the average supply voltage of the Quad Core Intel i7 is 1.2V, what would be the voltage drop in the bonding wire if a single gold wire that is 25.5um (1 mil) in diameter and ½ inch long is used to bring power into the processor? What would be the power dissipated in this wire? How many parallel gold wires that are 25.5u in diameter would be needed to guarantee that the current in these interconnects is at most 10% of the fusing current?
(Some properties of bonding wires are attached).

Some Properties of Gold and Aluminum Wires

GLX, Incorporated

Manufacturer's Representative

Current carrying capacity of bonding wire

Wire Type	Diameter (mils)	Wire Area (sq. mils)	Resistivity (ohms/inch)	Typical Fusing Current (amps)	Recommended Bond Pad (mils)
Aluminum	1.00	0.79	1.33	0.27-0.30	3.5 x 3.5
	1.25	1.23	0.856	0.4-0.5	4 x 4
	1.50	1.77	0.595	0.6-0.7	6 x 6
	2.00	3.14	0.335	1.0-1.2	6 x 8
	3.00	7.07	0.149	2-2.5	9 x 12
	4.00	12.57	0.0838	3.5-4.0	12 x 20
	5.00	19.63	0.0537	5-6	15 x 25
	8.00	50.27	0.0210	11-12	20 x 32
	10.00	78.54	0.0134	16-18	25 x 40
	12.00	113.10	0.0093	21-23	30 x 48
	15.00	176.71	0.0059	20-35	40 x 60
	20.00	314.16	0.0033	50-60	50 x 80
Gold	1.00	0.79	1.16	0.6-0.7	4 x 4
	1.30	1.33	0.693	0.9-1.0	5 x 5
	1.50	1.77	0.521	1.2-1.4	6 x 6
	2.00	3.14	0.294	1.6-2.0	8 x 8

Resistivity is based on:
16 ohms/foot for 1.0 mil aluminum wire (99.99%) at 20 degrees C.
14 ohms/foot for 1.0 mil gold wire (99.99%) at 20 degrees C.

Problem 8-9 (30 points):
Data is stored in many different ways but today the most popular strategies for storage that can be rapidly retrieved are CDs, DVDs, Blue Ray DVDs, hard disks, static memory (SRAM), dynamic memory (DRAM), and Flash Memory. The first three store data physically on metal/plastic media and retrieve it optically. Hard disks store data magnetically. SRAMs and DRAMs store data electronically in semiconductor materials. Flash memory devices store data electronically in floating gate transistors. Using a table, make a comparison of the storage density (bits per cm^2) and the cost of storage per bit in these 7 different media. In making this comparison, try to use state of the art parts or components and, when appropriate, state which part you are using and the approximate cost for the component or device. Based upon this comparison, what is the lowest cost method for storing data and what is the ratio in the cost/bit between the most expensive and the least expensive data storage approaches?

Problem 10 (10 points):
A major engineering effort is required to support the cell-phone industry. This includes engineers that work all the way from the infrastructure level down to process development area. Worldwide cell phone sales for 2010 were 1.4 Billion units. To get a very approximate estimate of the level of the engineering workforce that is needed to support the cell phone industry, we will make some basic simplifying assumptions. Assume the average cell-phone selling price is $100 and the average salary of engineers is $60,000 (of course some get paid much more and some much less in different parts of the world). If 10% of the total cell-phone sales revenue is invested in the salary of engineers responsible for development of the cell-phone infrastructure, how many full-time engineers are needed worldwide to support the growing cell-phone industry?