The UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

## Comp 411 Computer Organization
Fall 2012

Problem Set #4
Issued Monday, 11/5/12; Due Monday, 11/12/12

Note: You may enter your answers in the space provided, or attach additional sheets of paper.

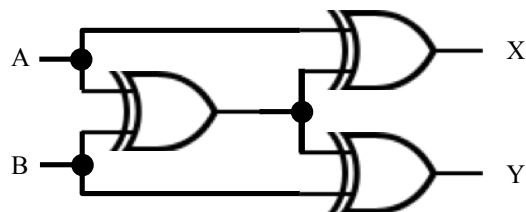### Problem 1. Circuits to Truth Table (20 points)

For each of the parts, simply <u>draw a truth table</u> corresponding to the given circuit. If there are more than one outputs, draw them as separate columns in the same truth table.

a)
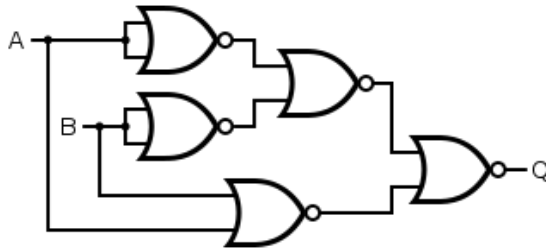
From the truth table, do you recognize what this circuit does?

b)

From the truth table, do you recognize what this circuit does?

Problem 2. Equations to Circuits (16 points)

For each of the parts, simply convert the given Boolean expression directly into a circuit diagram consisting of basic gates. *Do not implement using transistors!* Please do not perform any simplification/optimization. Simply replace each Boolean operation by the appropriate gate. You can assume you have all of these gates available (with any number of inputs): AND, OR, inverter, NAND, NOR, XOR, XNOR. Also, you may assume that for each input, its complement is also available (e.g., both X and $\overline{X}$ are available).

a) $Y = \overline{(A \oplus B \oplus C) \cdot (\overline{XY})} + Z$

b) $Y = (A \overline{\oplus} B) \cdot XY + (A \oplus B) \cdot \overline{X} \cdot \overline{Y}$

Note: The $\oplus$ and $\overline{\oplus}$ symbols represent XOR and XNOR operations, respectively.

Problem 3. Complex CMOS Gates (32 points)

For each of the parts, you are to draw a single CMOS gate that implements the given function, *using transistors*. That is, draw a single gate with complementary pull-up and pull-down networks (using p-type and n-type transistors, respectively). Be sure that the circuit you draw corresponds exactly to the expressions given, i.e., do not perform any simplification. You may assume that for each input, its complement is also available (e.g., both A and $\overline{A}$ are available).

a) $Y = \overline{(A + B)(CD + \overline{E}) + \overline{F}}$

Note carefully: The E and F in the equation have bars above them (i.e., they are complemented), and the entire expression for Y also has a bar above it.

b) $Y = ABC + \overline{DE} + \overline{E}F$

Note carefully: The entire term DE has a bar over it; remember that $\overline{DE}$ is *not* the same as $\overline{D} \cdot \overline{E}$. Also, only E in the last term has a bar over it.

Hint: You do not need to draw a truth table for Y for this problem. You could, but it would be rather large (with $2^6 = 64$ rows). Instead, as described in class, figure out directly from the Boolean expressions which combinations of inputs $A...F$ result in the function evaluating to 0 or 1. In one case it is easier to figure out when the function equals 0, and in the other case, it is easier to determine when the function equals 1. That should allow you to directly draw half of the gate (i.e., either the pull-down or the pull-up network). Then you draw the other half simply as its complement.

Problem 4. Sum of Products (32 points)

For each of the parts, do the following in this order: (i) first draw a truth table, (ii) then give the _sum-of-products_ Boolean expression for the output, and (iii) finally, draw a circuit diagram. You may only use inverters, AND gates and OR gates for your circuit. The AND and OR gates can have two or more than two inputs, as many as you need. You do not need to simplify/optimize your Boolean expression. You may assume that for each input, its complement is also available (e.g., both A and $\overline{A}$ are available).

a) Implement a function F whose inputs are A, B and C, such that the value of F is the same as the majority of the inputs (i.e., at least two out of three inputs have that value).

b) Implement a function F whose inputs are A, B, C and D, such that the value of F is the same as the majority of the inputs (i.e., at least three out of four inputs have that value), but if there is a 2-2 tie, then the value of F is simply the value that A has.

Problem 5. "Bits of Floating-Point" (20 points)

Represent the following in *single-precision* IEEE floating point. Give your answers in *hexadecimal.* Enter the answers in the table below.

  a)   -205.0
  b)   60.125
  c) $(2^{11} - 1)$

Decimal	S field	E field (binary)	F field (binary)	Complete Number (Hex)
-205.0				
60.125				
2^{11} -1				

Convert the following single-precision floating-point number (given in hexadecimal) to decimal, and enter the answer in the table below:

  d)   0x338c0000

    After you determine the *S, E,* and *F* fields, compute the decimal value using a calculator.

Hex	S field	E field (binary)	Significand (binary)	Decimal (using calculator)
338c0000				