

Homework Assignment V

Reading Assignment: Kuc Chapter 4 and Kerns-Irwin Chapter 13

1. You need a few inverters in your circuit design. Unfortunately, the stock room only carries NAND and/or NOR gates.
 - (a) Can you design INVERTERS from NAND gates? Please elaborate. Sketch your design if the answer is YES.
 - (b) Can you design INVERTERS from NOR gates? Please elaborate. Again, sketch your design if the answer is YES.
2. Consider the design of a digital divisible-by-3 circuit which takes in as inputs a 4-bit non-negative binary number $X_3X_2X_1X_0$ and outputs a 1 whenever the decimal equivalence of the binary input is divisible by the decimal number 3. In other words, the circuit yields a 0 output when the input in decimal is not a multiple of 3. Note that zero is considered to be divisible by 3.
 - (a) Construct the truth table for the 4-input ($X_3 X_2 X_1 X_0$) divisible-by-3 circuit.
 - (b) Find the simplified Boolean expression for the output Y in terms of the inputs $\{X_3, X_2, X_1, X_0\}$.
 - (c) Implement the divisible-by-3 circuit using only basic gates: INVERTER, 2-input AND, 2-input OR, and 2-input XOR gates.
 - (d) Re-design your circuit so that it now becomes a divisible-by-6 circuit. Implement your modified design with basic gates.
 - (e) What about a divisible-by-2 circuit (in other words, an even-number detection circuit)?
3. Consider the design of a multiplier which accepts two 3-bit non-negative binary numbers – $A_2A_1A_0$ and $B_2B_1B_0$ – as inputs and yields the 6-bit output $Y_5Y_4Y_3Y_2Y_1Y_0$. Assume that the stock room has an ample supply of basic gates as well as full adders.
 - (a) Why do we need 6 bits to represent the multiplication output?
 - (b) Find the logic function for Y_0 , the least significant bit (LSB) of the output.
 - (c) Find the logic function for Y_1 , the next to least significant bit (LSB) of the output.
 - (d) Sketch your implementation of the multiplier.
Hint: compute the partial products, then use a cascade of full adders (beware of the shift) to sum up the final result.

Due date: **Thurs. October 20** in class