ECE 150 Digital Logic Design, Fall 2023

Homework 1: due September 13th before class

Total: 24pts

Complete the following problems. Show your work through equations, diagrams, and a demo of any circuit built during class.

Use the TTL ICs for the multiplier *xor* CMOS ICs (not both together)!

Problem 1 (Number Systems (*3 pts total, each answer worth 0.5pts*)).

(a) Convert 33_{10} to:

    (a) Base 2

    (b) Base 6

    (c) Base 16

(b) Convert the following values to base 10:

    (a) 1001 0010 1101$_2$

    (b) 273_8

    (c) $3DB_{16}$

Problem 2 (Arithmetic (*3 pts total, each answer worth 0.5pts*)).

(a) Convert $FC9_{16}$ to binary and octal without converting to base 10.

(b) Perform the addition $33_{10} + 17_{10}$ in binary.

(c) Perform the subtraction 17_{10} - 33_{10} in binary (using two's complement).

(d) Give the largest number (in decimal) representable by:

    (a) 4 Hex symbols.

    (b) N symbols from Base B.

Problem 3 (Boolean Algebra (*3pts total, each answer worth 1pts*)).

Use boolean algebra to simplify these expressions:

(a) $X = \bar{A}BC + \bar{B}C + \bar{A}\bar{B}C$

(b) $Y = \bar{A}\,\overline{BC} + \overline{A + C}$

(c) $Z = \overline{\overline{(A + B)C}} + AB\bar{C}$

Problem 4 (Logic Diagram (*5pts total*))**.**
Consider the diagram in Figure 1:

(a) Write a boolean expression for Z (*1pt*).

(b) Fill out a truth table for the diagram (*1pt*).

(c) Simplify the expression using a Karnaugh map (*2pt*).

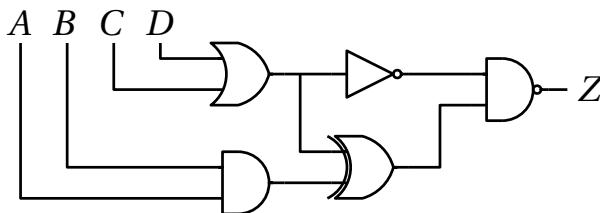(d) Use the simplified expression to draw a sum of products implementation of the circuit (*1pt*).

Figure 1: logic diagram

Problem 5 (2 Bit Multiplier). (*8pts total*)]
Consider the multiplication of two two-bit (unsigned) binary numbers, $A_1 A_0 \times B_1 B_0$, where A_1 and B_1 are the most significant bits of A and B.

(a) How many bits are required to represent all possible outputs of $A \times B$? (*1pt*)

(b) Fill out a truth table for the two-bit multiplication. (*1pts*)

(c) Simplify expressions for each output variable using Karnaugh maps. (*4pts*)

(d) Draw an implementation of the circuit based on your expressions. (*2pts*)

Problem 6 (2 Bit Multiplier Circuit). (*2pts*)]
Using a single breadboard, and any of the following IC chips in the lab,

- NOT, AND, OR, NAND, NOR, XOR, XNOR

implement a 2 Bit multiplier circuit from the previous problem.
You must:

- Use red wire for 5V and black for ground

- Provide inputs $A_1 A_0 B_1 B_0$ via a 4-input DIP switch with pull-down resistors.

- Display your outputs on LEDs with current limiting resistors in series.

You may want to rearrange your previous boolean expressions to use as few IC chips as possible. If so, draw a logic diagram of your final implemented circuit.
You will demo your circuit at the start of class on the due date.
(*1pt for performing demo, 1pt for correctness*)