

Logic Design HW#1(115 points in total)

1. **(Gate Logic)** Draw schematics for the following functions in terms of AND, OR and NOT gates. (8 points / 2 points for each subproblems)

A. $XY + XZ$

B. $\overline{X(Y + Z)}$

C. $\overline{X} + \overline{YZ}$

D. $\overline{\overline{X} + \overline{Y}} + \overline{X + Y} + \overline{Y + Z}$

2. (Gate Logic) Draw the schematics for the following functions using NAND gates and inverters only: (4 points / 2 points for each subproblems)

A. $\overline{X(\overline{YZ})}$

B. $XY + XZ$

3. **(Laws and Theorems of Boolean Algebra)** Use DeMorgan's law to compute the complement of the following Boolean expressions: (10 points / 2 points for each subproblems)

A. $\overline{A+B} \overline{C+B} \overline{D}$

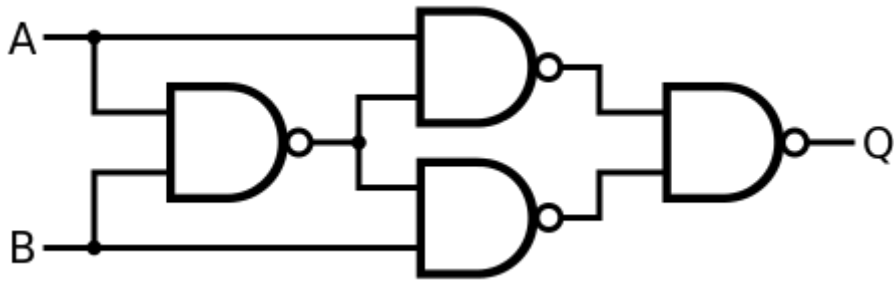
B. $(\overline{A}+\overline{B}+\overline{C})(\overline{B}+CD)$

C. $\overline{X}(\overline{Y}+\overline{Z})$

D. $X+Y\overline{Z}$

E. $X(YZ+Z\overline{W}+\overline{V}S)$

4. (Laws and Theorems of Boolean Algebra) Using Boolean algebra, verify that the schematic of figure below implements an XOR function. (4 points)



5. (Boolean Simplification) consider the function: (6 points / 3 points for each subproblems)

$$f(A,B,C,D) = (AD + A\overline{C})[B(C + \overline{B}D)]$$

- A. Draw its schematic using AND, OR, and NOT gates.
- B. Using Boolean algebra, put the function into its minimized form and draw the resulting schematic.

6. (Canonical Forms) consider the function: (12 points / 3 points for each subproblems)

$$f(A,B,C,D) = \sum m(0,1,2,7,8,13)$$

- A. Write this as a Boolean expression in canonical minterm form.
- B. Rewrite the expression in canonical maxterm form.
- C. Write the complement of f in “little m ” notation and as a canonical minterm expression.
- D. Write the complement of f in “big M ” notation and as a canonical maxterm expression.

7. (Boolean Simplification) Use Karnaugh maps(K-maps) to simplify the following functions in sum-of-products form. How many literals appear in your minimized solutions? (9 points / 3 points for each subproblems)

A. $f(X,Y,Z) = \prod M(0,1,6,7)$

B. $f(W,X,Y,Z) = \prod M(1,3,7,9,11,15)$

C. $f(A,B,C,D) = \sum m(0,2,4,6)$

8. (Boolean Simplification) Use Karnaugh maps(K-maps) to simplify the following functions in sum-of-products form taking advantage of the don't cares provided. (6 points / 3 points for each subproblems)

A. $f(A,B,C,D) = \sum m(0,1,4,10,11,14) + \sum d(5,15)$

B. $f(A,B,C,D) = \sum m(2,3,7,9,11,13) + \sum d(1,10,15)$

9. (Boolean Simplification) What are the prime implicants for each of the expressions in Problem 8? Which are essential? How many don't cares are set to 1 in each case? (6 points)

10. (Quine-McCluskey Method) Use the Quine-McCluskey method to find the minimum sum-of-products form for the following Boolean expressions. (6 points)

$$F(A,B,C,D) = \sum m(1,3,5,7,11,12,13,14,15) + \sum d(4,8,10)$$

11. (Mapping to NANDs/NORs) Draw schematics for the following expressions, mapped into NAND-only networks. You may assume that literals and their complements are available. (9 points / 3 points for each subproblems)

A. $(\overline{AB})(\overline{AC})$

B. $\overline{(AB + \overline{A}C)}$

C. $\overline{A}B + A + \overline{C} + \overline{D}$

12. (Mapping to NANDs/NORs) Draw schematics for the following expressions, mapped into NOR-only networks. You may assume that literals and their complements are available. (6 points / 3 points for each subproblems)

A. $(A+B)(\bar{A}+C)$

B. $\overline{(A+B)(\bar{A}+C)}$

13. (Multilevel Logic) Consider the following multilevel Boolean expressions:

$$F(A,B,C,D) = (A+(BC))(\overline{C}+D)$$

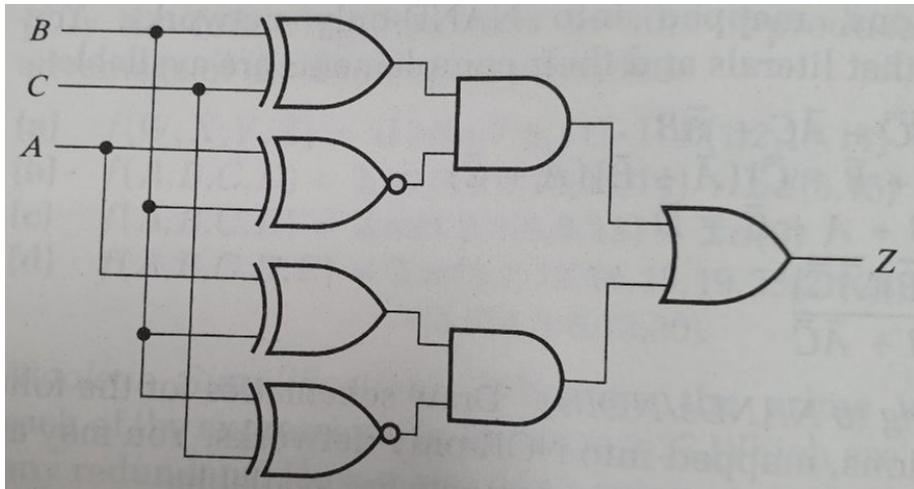
$$G(A,B,C,D) = ((A+\overline{B})D)+(A+(BC))$$

Perform the following: (9 points / 3 points for each subproblems)

- A. Show how to implement each function as a multilevel NAND-only gate-level implementation.
- B. Repeat A., but using NOR gates only.
- C. Find the two-level minimized sum-of-products forms.

14. (Multi level logic) Reverse engineer the circuit shown in the schematic of figure below in order to derive a two-level realization. (12 points / 3 points for each subproblems)

- A. Find the Boolean expression that describes the circuit.
- B. Construct the truth table for the function.
- C. Write the function in canonical sum-of-products form (little m notation).
- D. Simplify the function using K-maps.



15. (Hazard-Free Design) Given the following specifications of Boolean functions, implement them as hazard-free circuits: (8 points / 4 points for each subproblems)

A. $F(A,B,C) = B\overline{C} + \overline{A}C$

B. $F(A,B,C,D) = \overline{A}D + B\overline{C} + AC$