University of California, Santa Barbara

Department of Electrical and Computer Engineering

ECE 152A – Digital Design Principles

Homework #1

Problem #1:
Demonstrate by means of truth tables the validity of the following identities:

1. DeMorgan's theorem for three variables: $(xyz)' = x' + y' + z'$
2. The second distributive law: $x + yz = (x + y)(x + z)$
3. The consensus theorem: $xy + x'z + yz = xy + x'z$

Problem #2:
Simplify the following Boolean expressions to a minimum number of literals:

1. $x'y' + xy + x'y$
2. $(x + y)\ (x + y')$
3. $x'y + xy' + xy + x'y'$
4. $x' + xy + xz' + xy'z'$
5. $xy' + y'z' + x'z'$

Problem #3:
Simplify the following Boolean expressions to a minimum number of literals:

1. $ABC + A'B + ABC'$
2. $x'yz + xz$
3. $(x + y)'\ (x' + y')$
4. $xy + x(wz + wz')$
5. $(BC' + A'D)(AB' + CD')$

Problem #4:
Reduce the following Boolean expressions to the indicated number of literals:

1. *A'C' + ABC + AC'* to three literals
2. *(x'y' + z)' + z + xy + wz* to three literals
3. *A'B(D' + C'D) + B(A + A'CD)* to one literal
4. *(A' + C)(A' + C')(A + B + C'D)* to four (or fewer?) literals

Problem #5:
Find the complement of F = x + yz; then show that F (F') = 0 and F + F' = 1;

Problem #6:
Find the complement of the following expressions:

1. *xy' + x'y*
2. *(AB' + C)D' + E*
3. *AB(C'D + CD') + A'B'(C' + D)(C + D')*
4. *(x + y' + z)(x' + z')(x + y)*

Problem #7:
Given the following Boolean function:

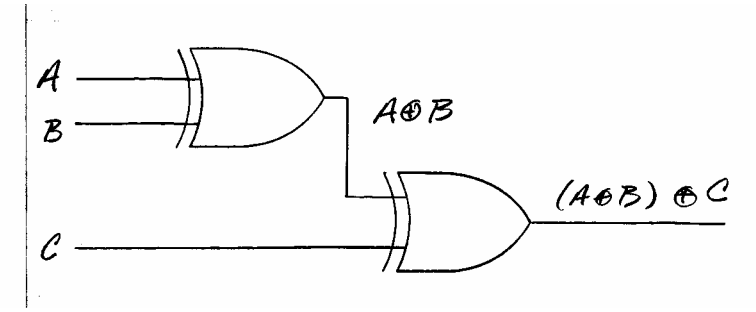
$$F = xy'z + x'y'z + w'xy + wx'y + wxy$$

1. Obtain the truth table for the function
2. Draw the logic diagram using the original Boolean expression
3. Simplify the function to a minimum number of literals using Boolean algebra
4. Obtain the truth table of the function from the simplified expression and show that it is the same as the one in part 1
5. Draw the logic diagram from the simplified expression and compare the total number of gates with the diagram of part 2

Problem #8:
Convert the following expressions into sum of products and product of sums:

1. *(AB + C) (B + C'D)*
2. *x' + x (x + y') (y + z')*

Problem #9:
A 3-input exclusive OR gate can be constructed from 2, 2-input gates as shown below:



1. Generate the truth table for the 3 input XOR gate
2. Generate the Boolean expression for the 3 input XOR gate

Problem #10:
Show (using Boolean algebra) that the dual of the 2-input exclusive-OR function is equal to its complement.

Problem #11:
Obtain the truth table of the following functions and express each function in sum of minterms (standard SOP) and product of maxterms (standard POS) forms:

1. *(xy + z)(y + xz)*
2. *(A' + B)(B' + C)*
3. *y'z + wxy' + wxz' + w'x'z*

Problem #12:
For the Boolean function F given in the truth table,

x	*y*	*z*		*F*
0	0	0	|	0
0	0	1	|	0
0	1	0	|	1
0	1	1	|	1
1	0	0	|	0
1	0	1	|	0
1	1	0	|	1
1	1	1	|	1

find the following:

1. List the minterms of the function
2. List the minterms of F'
3. Express F in sum of minterms (standard SOP) form
4. Simplify the function to an expression with a minimum number of literals

Problem #13:
Express the following functions in sum of minterms (standard SOP) and product or maxterms (standard POS) forms:

1. *F(A,B,C,D) = B'D + A'D + BD*
2. *F(x,y,z) = (xy + z)(xz + y)*

Problem #14:
Express the complement of the following functions in sum of minterms (standard SOP) form:

1. F (A,B,C,D) = $\sum$ (0,2,6,11,13,14)
2. F(x,y,z) = Π (0,3,6,7)

Problem #15:
Simplify the following Boolean functions using three-variable maps:

1. $F(x,y,z) = \sum (0,1,5,7)$
2. $F(x,y,z) = \sum (1,2,3,6,7)$
3. $F(x,y,z) = \sum (3,5,6,7)$
4. $F(A,B,C) = \sum (0,2,3,4,6)$

Problem #16:
Simplify the following Boolean expressions using three-variable maps:

1. xy + x'y'z' + x'yz'
2. x'y' + yz + x'yz'
3. A'B + BC' + B'C'

Problem #17:
Simplify the following Boolean functions using four-variable maps:

1. $F(A,B,C,D) = \sum (4,6,7,15)$
2. $F(w,x,y,z) = \sum (2,3,12,13,14,15)$
3. $F(A,B,C,D) = \sum (3,7,11,13,14,15)$

Problem #18:
Simplify the following Boolean functions using four-variable maps:

1. $F(w,x,y,z) = \sum (1,4,5,6,12,14,15)$
2. $F(A,B,C,D) = \sum (0,1,2,4,5,7,11,15)$
3. $F(w,x,y,z) = \sum (2,3,10,11,12,13,14,15)$
4. $F(A,B,C,D) = \sum (0,2,4,5,6,7,8,10,13,15)$

Problem #19:
Simplify the following Boolean expressions using four-variable maps:

1. w'z + xz + x'y + wx'z
2. B'D + A'BC' + AB'C + ABC'
3. AB'C + B'C'D' + BCD + ACD' + A'B'C + A'BC'D
4. wxy + yz + xy'z + x'y

Problem #20:
Find the minterms of the following Boolean expressions by first plotting each function in a map.

1. xy + yz + xy'z
2. C'D + ABC' + ABD' + A'B'D
3. wxy + x'z' + w'xz