EE 2000 Logic Circuit
Design Semester A 2021/22A

Tutorial 1

1. Simplify the following expressions using boolean algebra

(i) $f(x,y,z) = \bar{x}z + y\bar{z} + \bar{x}\bar{y}z + xy$

$= x'z(1+y') + yz' + xy$
$= x'z\,(1) + (x + x')\,yz' + xy$
$= x'z + xyz' + x'yz' + xy$
$= x'(z + yz') + xy\,(1 + z')$
$= x'(z + y) + xy$
$= x'z + x'y + xy$
$= x'z + y\,(x + x')$
$= x'z + y$

(ii) $F(A,B,C) = A\bar{B}(\bar{B} + \bar{C})(A + C)$

$= AB'(AB' + AC' + B'C + CC')$
$= AB' + AB'C' + AB'C$
$= AB'$

2. Simplify the following expressions using k-map.

(a) $f = a\bar{b}c + \bar{b}\,\bar{c}\,\bar{d} + \underline{b}cd + \underline{\bar{a}}cd + \bar{a}\,\bar{b}\,\bar{c} + \underline{\bar{a}}bcd$

(b) $f = wxy + yz + x\bar{y}z + xy$

(c) $f(a,b,c,d) = \Sigma m(4,6,7,15)$

(d) $f(a,b,c,d) = \Sigma m(3,7,11,13,14,15)$

(e) $f(a,b,c,d) = \Sigma m(0,6,8,13,14) + \Sigma d(2,4,10)$

(f) $f(a,b,c,d) = \Sigma m(1,3,5,7,9,15) + \Sigma d(4,6,12,13)$

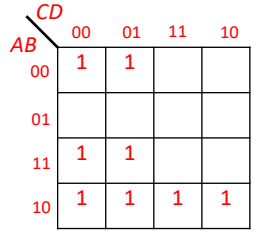
Answer:

(a) ac + b'd' + a'bd + b'c or ac + b'd' + a'bd + cd
(b) xz + wy + x'y
(c) BCD + A'BD'
(d) CD + ABC +ABD
(e) B'D' + CD' + ABC'D
(f) A'D + BD + C'D

3. Map the following SOP expression on a K-map.

$B\bar{C} + A\bar{B} + AB\bar{C} + A\bar{B}C\bar{D} + \bar{A}B\bar{C}D + A\bar{B}\bar{C}D$

Ans:

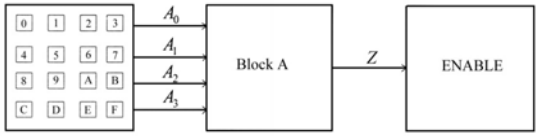


4. A simple locker system that has a output signal $Z = 1$ when the hexadecimal keypad input is either 0, 1, 2, 3, 4, 5, 8, 9, or A; otherwise $Z = 0$. Assume that $A_0\,A_1\,A_2\,A_3$ represent a 4-digit binary number output from the keypad. Block A decodes these singals and outputs the signal Z.

(i) Write down the truth table of Block A.

(ii) Find the SOP and POS expression of Block A.

(iii) Design the circuit of Block A using minimum number of AND, OR and NOT gates.



(The answer can be different if $A_0\,A_1\,A_2\,A_3$ represent by Gary Code, and others.)

(i) Assume a conventional BCD for $A_0\,A_1\,A_2\,A_3$.

Hexadecimal	A_0	A_1	A_2	A_3	Z
0	0	0	0	0	1
1	0	0	0	1	1
2	0	0	1	0	1
3	0	0	1	1	1
4	0	1	0	0	1
5	0	1	0	1	1
6	0	1	1	0	0
7	0	1	1	1	0
8	1	0	0	0	1
9	1	0	0	1	1
A	1	0	1	0	1
B	1	0	1	1	0

C	1	1	0	0	0
D	1	1	0	1	0
E	1	1	1	0	0
F	1	1	1	1	0

(ii)

A_2A_3 \ A_0A_1	00	01	11	10
00	1	1		1
01	1	1		1
11	1			
10	1			1

SOP: $f = A'_0A'_1 + A'_0A'_2 + A'_1A'_2 + A'_1A'_3$

A_2A_3 \ A_0A_1	00	01	11	10
00			0	
01			0	
11		0	0	0
10		0	0	

$f' = A_0A_1 + A_1A_2 + A_0A_2A_3$

POS: $f = (A'_0+A'_1)(A'_1+A'_2)(A'+_0A'_2+A'_3)$

(By DeMorgan)

(iii) Simplify the answer from SOP:

$f = A'_0A'_1 + A'_0A'_2 + A'_1A'_2 + A'_1A'_3$

$= A'_0(A'_1 + A'_2) + A'_1(A'_2 + A'_3)$

$= A'_0(A_1 A_2)' + A'_1(A_2 A_3)'$

(Please draw the circuit.)

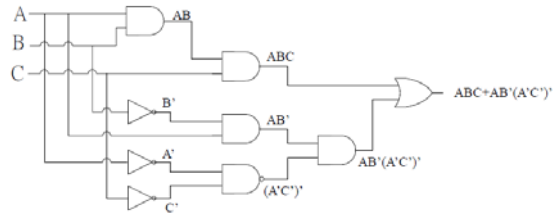
5. (a) Draw the logic circuit of the following Boolean function without simplification:

$Y(A, B, C) = ABC + AB'(A'C')'$

(b) Simplify the logic function in (a) and, hence, re-draw the logic circuit.

Ans:

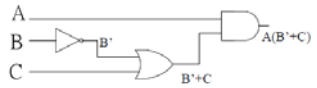
(a)



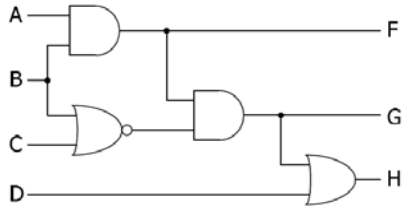
(b) Y(A, B, C)

= ABC + AB'(A'C')'= ABC + AB' (A + C) = ABC + AB' + AB'C = A(B + B') C + AB'

= AC + AB' = A (B' + C)



6. (a) Derive Boolean functions to describe the operations of the logic circuit as follow:



(b) Hence, simply and draw a new logic circuit.

7. (a) Use a K-map to convert the following canonical SOP expression into a minimum POS expression.

$f(a,b,c,d) = \Sigma m\,(0,1,2,5,7,8,10,13,14,15)$

cd \ ab	0	0	1	1
	0	1	1	0

00		0	0	
01				0
11	0			0
10		0		

$f(a,b,c,d) = (b' + c + d)(a' + b + d')(a + b' + d)(b + c' + d')$

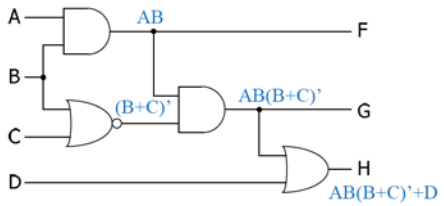
(b) Use a K-map to convert the following canonical POS expression into a minimum SOP expression.
$f(a,b,c,d) = \prod M\ (0,2,5,7,8,9,13)$

cd \ *ab*	00	01	11	10
00		1	1	
01	1			
11	1		1	1
10		1	1	1

$f(a,b,c,d) = ac + bd' + a'b'd$

Ans:

(a)



(b)

Therefore,
F = AB

G = AB (B+C)' = ABB'C'=0

H = AB (B+C)' + D = D