

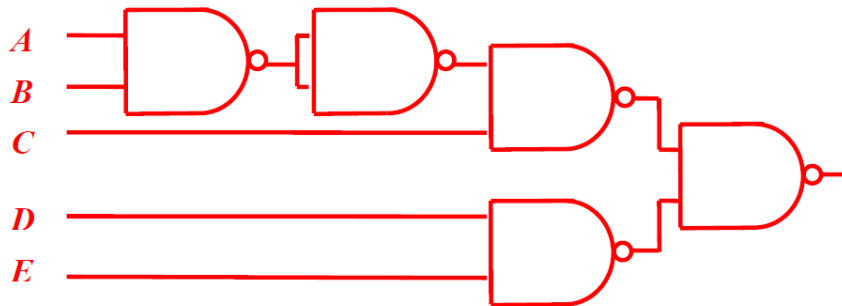
EE 2000 Logic Circuit Design
Semester A 2014

Tutorial 3

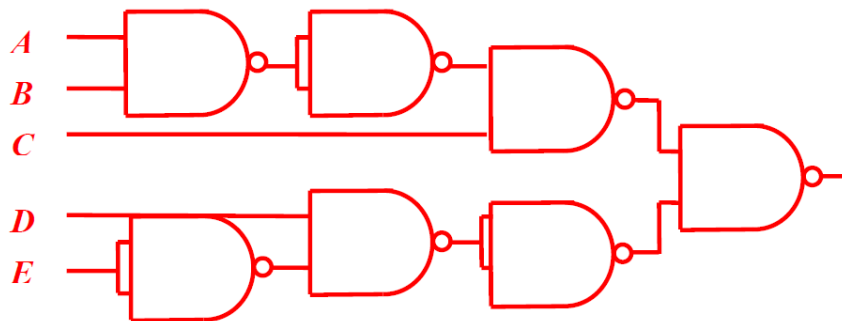
1. How to implement the following expression with **2-input NAND gates only**:
- (a) $ABC + DE$
(b) $ABC + D' + E$

Answer:

$$\begin{aligned} &ABC + DE \\ &= \overline{\overline{ABC + DE}} \\ &= \overline{\overline{ABC} \overline{DE}} \\ &= \overline{((AB)C)(DE)} \end{aligned}$$



$$\begin{aligned} &ABC + \overline{D} + E \\ &= \overline{\overline{ABC + \overline{D} + E}} \\ &= \overline{\overline{ABC} \overline{D} \overline{E}} \\ &= \overline{((AB)C)(D)(E)} \\ &= \overline{((AB)C)(D)(E)} \end{aligned}$$



2. Simplify the following expressions using k-map.

- (a) $f = \overline{a}bc + \overline{b}\overline{c}\overline{d} + bcd + ac\overline{d} + \overline{a}\overline{b}c + \overline{a}bcd$
(b) $f = wxy + yz + x\overline{y}z + \overline{x}y$
(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.

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

Ans:

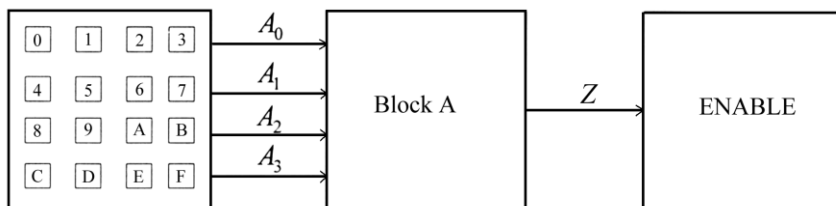
		<i>CD</i>			
		00	01	11	10
<i>AB</i>	00	1	1		
	01				
	11	1	1		
	10	1	1	1	1

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)

$ \begin{array}{c} A_0 A_1 \\ \swarrow \quad \searrow \\ A_2 A_3 \quad \begin{array}{cc} 00 & 01 & 11 & 10 \end{array} \\ \begin{array}{c} 00 \\ 01 \\ 11 \\ 10 \end{array} \quad \begin{array}{ c c c c } \hline 1 & 1 & & 1 \\ \hline 1 & 1 & & 1 \\ \hline 1 & & & \\ \hline 1 & & & 1 \\ \hline \end{array} \end{array} $ SOP: $f = A'_0 A'_1 + A'_0 A'_2 + A'_1 A'_2 + A'_1 A'_3$					$ \begin{array}{c} A_0 A_1 \\ \swarrow \quad \searrow \\ A_2 A_3 \quad \begin{array}{cc} 00 & 01 & 11 & 10 \end{array} \\ \begin{array}{c} 00 \\ 01 \\ 11 \\ 10 \end{array} \quad \begin{array}{ c c c c } \hline & & 0 & \\ \hline & & 0 & \\ \hline & 0 & 0 & 0 \\ \hline & 0 & 0 & \\ \hline \end{array} \end{array} $ $f' = A_0 A_1 + A_1 A_2 + A_0 A_2 A_3$ POS: $f = (A'_0 + A'_1)(A'_1 + A'_2)(A'_0 + A'_2 + A'_3)$ (By DeMorgan)				
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(iii) Simplify the answer from SOP:

$$\begin{aligned}
 f &= A'_0 A'_1 + A'_0 A'_2 + A'_1 A'_2 + A'_1 A'_3 \\
 &= A'_0 (A'_1 + A'_2) + A'_1 (A'_2 + A'_3) \\
 &= A'_0 (A_1 A_2)' + A'_1 (A_2 A_3)'
 \end{aligned}$$

(Please draw the circuit.)

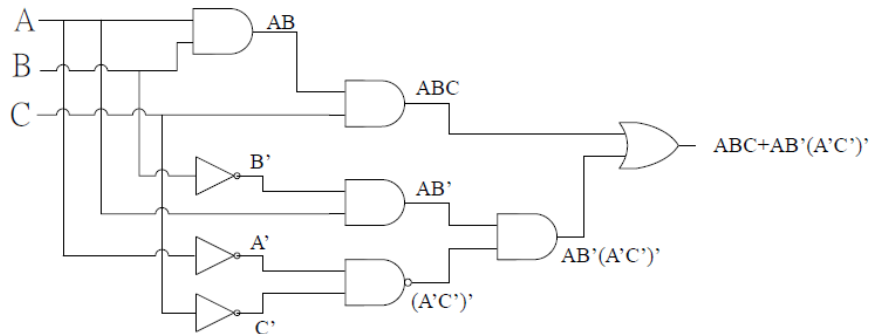
5. (a) Draw the logic circuit of the following Boolean function without simplification:

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

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

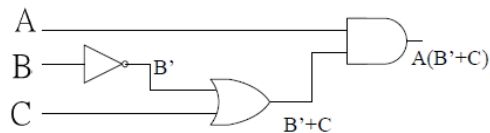
Ans:

(a)

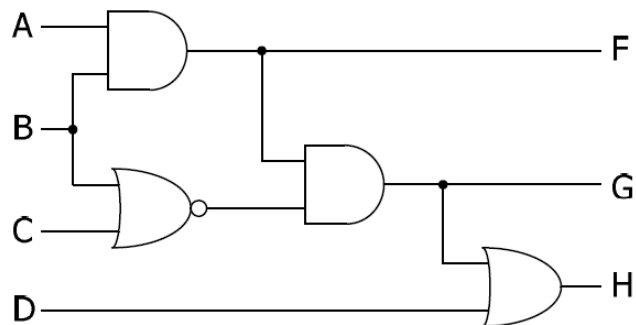


(b) $Y(A, B, C)$

$$\begin{aligned}
 &= ABC + AB'(A'C')' = ABC + AB'(A + C) = ABC + AB' + AB'C = A(B + B')C + AB' \\
 &= AC + AB' = A(B' + C)
 \end{aligned}$$



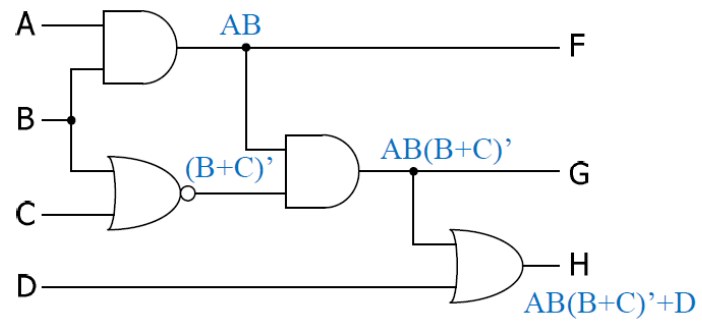
6. (a) Derive Boolean functions to describe the operations of the logic circuit as follow:



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

Ans:

(a)



(b)

Therefore,

$$F = AB$$

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

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

