EE 2000 Logic Circuit Design
Semester A 2024/25

Tutorial 1

1. Simplify the following expressions using boolean algebra

(a) $f(w,x,y,z) = xy + \bar{w}\bar{y}z + \bar{w}x\bar{y} + wxy\bar{z} + \bar{w}yz + wz$

$= xy + z + \bar{w}x\bar{y}$

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

$= x$

(c) $f(a,b,c,d) = ab + bcd + ab'c' + abd + bc + abc'$

$= ac' + bc$

(d) $f(a,b,c) = (a+b+c)\left(a+\bar{b}+c\right)\left(a+\bar{b}+\bar{c}\right)\left(\bar{a}+\bar{b}+\bar{c}\right)$

$= (a+c)\left(\bar{b}+\bar{c}\right)$

2. Given a function $f(x, y, z) = \sum m(0, 2, 4, 6)$

(a) Show the truth table.

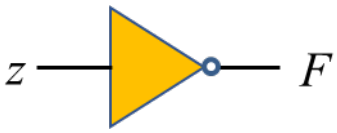
Inputs			Minterms		Output
x	y	z	Term	Designation	$f(x, y, z)$
0	0	0	$x'y'z'$	m_0	1
0	0	1	$x'y'z$	m_1	0
0	1	0	$x'yz'$	m_2	1
0	1	1	$x'yz$	m_3	0
1	0	0	$xy'z'$	m_4	1
1	0	1	$xy'z$	m_5	0
1	1	0	xyz'	m_6	1
1	1	1	xyz	m_7	0

(b) Show the algebraic expression in standard SOP form.

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

(c) Show the minimum SOP expression and draw the circuit diagram.

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



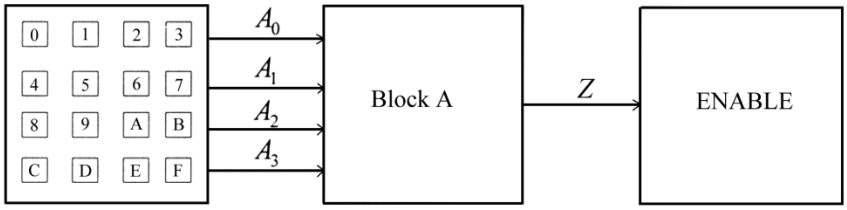
(d) Show the algebraic expression in standard POS form.

$$f(x, y, z) = (x + y + z')(x + y' + z')(x' + y + z')(x' + y' + z')$$

(e) Show the minimum POS expression.

$$f(x, y, z) = (x + y + z')(x + y' + z')(x' + y + z')(x' + y' + z')$$
$$= z'$$

3. A simple locker system that has an output signal $Z = 1$ when the hexadecimal keypad input is either 0, 1, 2, 3, 7, 8, 9, A or E; otherwise $Z = 0$. Assume that $A_3\ A_2\ A_1\ A_0$ represent a 4-digit binary number output from the keypad (A_3 as the MSB). Block A decodes these signals and outputs the signal Z.



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

Input	*Inputs*				*Output*
	A_3	A_2	A_1	A_0	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	0
5	0	1	0	1	0
6	0	1	1	0	0
7	0	1	1	1	1
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	1
F	1	1	1	1	0

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

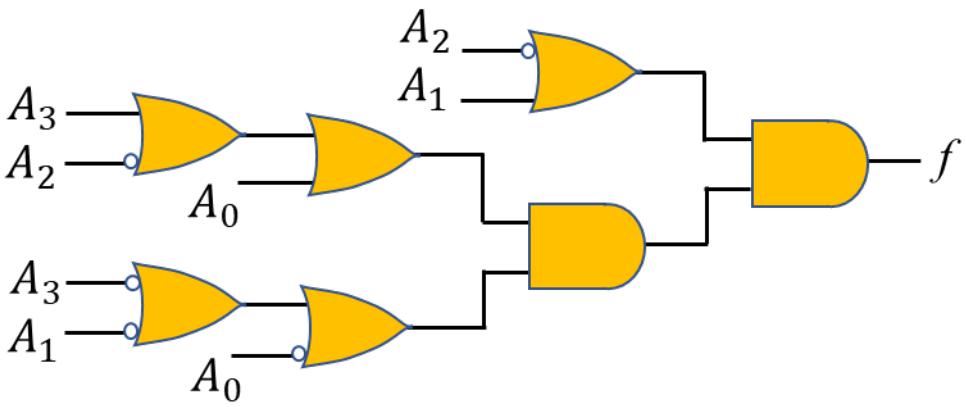
$$f(A_3, A_2, A_1, A_0) = f(w, x, y, z) = w'x'y'z' + w'x'y'z + w'x'yz' + w'x'yz + w'xyz + wx'y'z' + wx'y'z + wx'yz' + wxyz'$$

$$f(A_3, A_2, A_1, A_0) = A_3'A_2' + A_3'A_1A_0 + A_3A_2'A_1' + A_3A_1A_0'$$

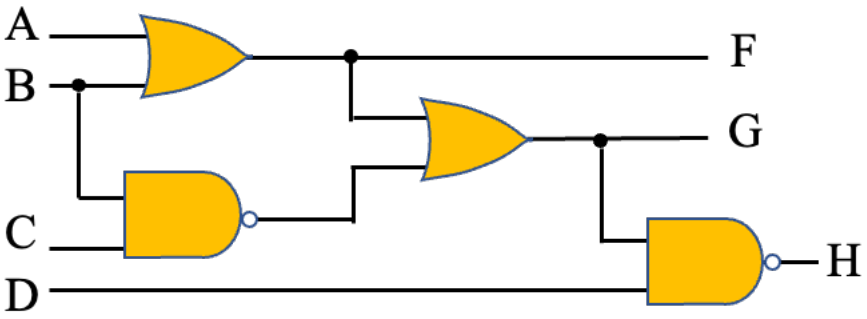
$$f(A_3, A_2, A_1, A_0) = f(w, x, y, z)$$
$$= (w + x' + y + z)(w + x' + y + z')(w + x' + y' + z)(w' + x + y' + z')(w' + x' + y + z)(w' + x' + y + z')(w' + x' + y' + z')$$

$$f(A_3, A_2, A_1, A_0) = (A_2' + A_1)(A_3 + A_2' + A_0)(A_3' + A_1' + A_0')$$

(c) Design the circuit of Block A using minimum number of 2-input AND, OR gates and NOT gates.

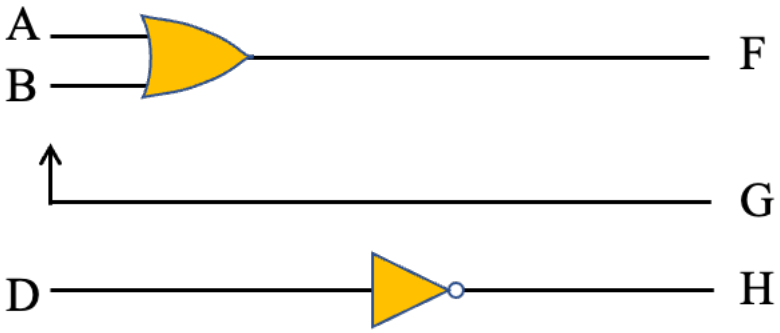


4. (a) Derive Boolean functions to describe the operations of the combinational circuit as follow:



$F = A + B$
$G = (A + B) + (BC)' = A + B + B' + C' = 1$
$H = (1 \cdot D)' = D'$

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



(c) Redraw the logic circuit with only 2-input NAND gates.