



HW2: 2's complement and building with gates

1. 2's complement

Fill in this table. Do row by row like we did in class. All answers need to be 8-bits.  $2^7 + 2^2 + 1$  Line ②

Row #	Base-10	Positive binary	Hexadecimal	2's complement
①	-12 <sub>10</sub>	Can't do	0xF4	1110100 <sub>2</sub>
②	21 <sub>10</sub>	00010101 <sub>2</sub>	0x15	00010101 <sub>2</sub>
③	Can't do 132 <sub>10</sub> 128 <sub>10</sub>	10000100 <sub>2</sub>	0x84	10000100 <sub>2</sub>
④	-15	Can't do	0xF1	11110001 <sub>2</sub>
⑤	9	00001001 <sub>2</sub>	0x09	00001001 <sub>2</sub>

$$\begin{array}{r} 00001110 \\ +1 \\ \hline 00001111 \end{array} \quad \text{Line ④}$$

$$\begin{array}{r} 00001100 \\ 11110111 \\ +1 \\ \hline 11110100 \end{array} \quad \text{Line ①}$$

$$\begin{array}{r} 10000100 \\ 01111011 \\ 01111100 \\ \hline 10000100 \end{array} \quad \text{Line ③}$$

$$128 + 4$$

$$64 + 32 + 16 + 8 + 4 = 124$$

2. If you need more practice, find an on-line calculator for any of these representations and test yourself. Be careful with the 2's complement calculators. Some of them flip any number you put into the calculator. Look for one that's decimal to 2's complement like:

<https://www.exploringbinary.com/twos-complement-converter/>

3. SOP (sum of product) from truth table. Find the logic for the digital circuit described by the following truth tables.

a.

Inputs		Output
A	B	Out
0	0	0
0	1	1
1	0	0
1	1	1

$$\text{Out} = \overline{A} \cdot B + A \cdot B$$

$\left[ \begin{array}{l} A=0 \\ B=1 \end{array} \right]$   $\left[ \begin{array}{l} A=1 \\ B=1 \end{array} \right]$

b.

Inputs			Output
A	B	C	Out
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	- 1
1	0	0	0
1	0	1	0
1	1	0	- 1
1	1	1	- 1

$$out = \bar{A} \cdot B \cdot C + A \cdot B \cdot \bar{C} + A \cdot B \cdot C$$

$$A=0, B=1, C=1 \rightarrow \bar{A} \cdot B \cdot C$$

$$A \cdot B \cdot \bar{C}$$

$$A \cdot B \cdot C$$

c. Make a truth table that converts 3-bit thermometer code to binary.

Thermometer code counts up:

$$000_2 \rightarrow 001_2 \rightarrow 011_2 \rightarrow 111_2$$

In thermometer code,  $000_2 = 0_{10}$ ,  $001_2 = 1_{10}$ ,  $011_2 = 2_{10}$ , and  $111_2 = 3_{10}$ .

HINT: In the truth table, any row not used can have an output of X (for don't care).

A	B	C	03	02	01
0	0	0	0	0	1
0	0	1	0	1	1
-	0	1	0	1	1
-	0	1	0	1	1
-	1	0	1	1	1
-	1	0	1	1	1
-	1	0	1	1	1
-	1	1	1	1	1
-	1	1	1	1	1
-	1	1	1	1	1

d. Find the logic for your thermometer code truth table.

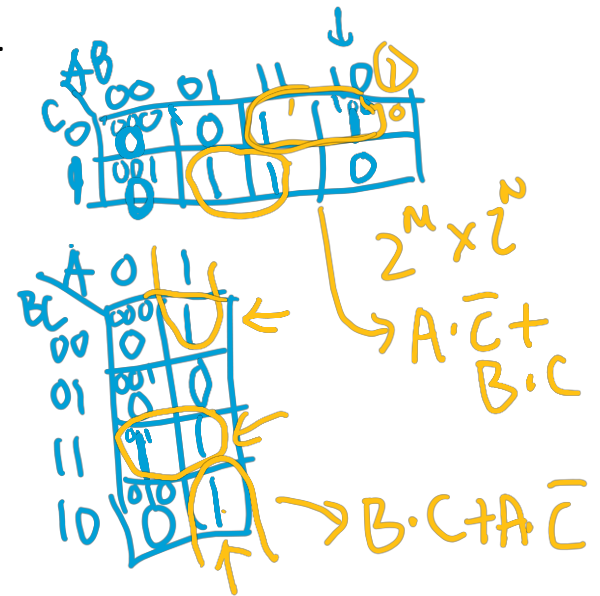
$$03 = \bar{A} \cdot B \cdot C \quad 02 = \bar{A} \cdot \bar{B} \cdot C + \bar{A} \cdot B \cdot C$$

$$01 = \bar{A} \cdot \bar{B} \cdot \bar{C} + \bar{A} \cdot \bar{B} \cdot C + \bar{A} \cdot B \cdot C$$

4. KMaps: Find the minimal logic (biggest circles).

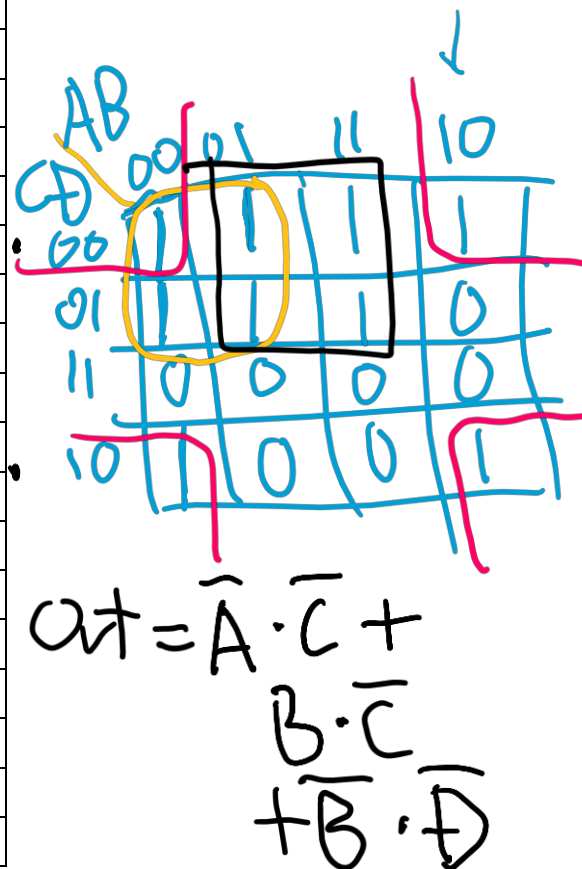
a.

Inputs			Output
A	B	C	Out
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	1



b.

Inputs				Output
A	B	C	D	Out
0	0	0	0	1
0	0	0	1	1
0	0	1	0	1
0	0	1	1	0
0	1	0	0	1
0	1	0	1	1
0	1	1	0	0
0	1	1	1	0
1	0	0	0	1
1	0	0	1	0
1	0	1	0	1
1	0	1	1	0
1	1	0	0	1
1	1	0	1	1
1	1	1	0	0
1	1	1	1	0



- c. Use KMaps to find minimal logic for the truth table for the thermometer code counter in question 3c.

(In truth table, any row not used can be care).

A	B	C	01	02	03
0	0	0	0	0	1
0	0	1	0	1	1
0	1	0	x	x	x
0	1	1	1	1	1
1	0	0	x	x	x
1	0	1	x	x	x
1	1	0	x	x	x
1	1	1	0	0	0

03

AB	00	01	11	10
C	0	1	1	1
1	0	1	0	1

$$03 = \bar{A} \cdot B$$

02

AB	00	01	11	10
C	0	1	1	1
1	1	1	0	1

$$02 = \bar{A} \cdot C$$

01

AB	00	01	11	10
C	0	1	1	1
1	1	1	0	1

$$01 = \bar{A}$$



Note that this logic is much simpler than the logic you found in question 3d.