

## Task 4

In this case we need to convert a 4-bit number into its complement to two. A truth table is built first with four outputs corresponding to the four input bits of the number complemented, as shown below.

4-Bit In				2-Comp. Out			
$d$	$c$	$b$	$a$	$f_d$	$f_c$	$f_b$	$f_a$
0	0	0	0	0	0	0	0
0	0	0	1	1	1	1	1
0	0	1	0	1	1	1	0
0	0	1	1	1	1	0	1
0	1	0	0	1	1	0	0
0	1	0	1	1	0	1	1
0	1	1	0	1	0	1	0
0	1	1	1	1	0	0	1
1	0	0	0	1	0	0	0
1	0	0	1	0	1	1	1
1	0	1	0	0	1	1	0
1	0	1	1	0	1	0	1
1	1	0	0	0	1	0	0
1	1	0	1	0	0	1	1
1	1	1	0	0	0	1	0
1	1	1	1	0	0	0	1

Table 1: Outputs with complement to two.

The output functions are expressed based on the minterms. They are simplified using Karnaugh's Maps. Starting with  $f_d$  function:

$$f_d = \sum (m_1, m_2, m_3, m_4, m_5, m_6, m_7, m_8)$$

		ba			
		00	01	11	10
dc	00	0	1	1	1
	01	1	1	1	1
	11	0	0	0	0
	10	1	0	0	0

Solving the map with the indicated groups, the simplified function remains as:

$$f_d = (d \cdot \bar{c} \cdot \bar{b} \cdot \bar{a}) + (\bar{d} \cdot c) + (\bar{d} \cdot \bar{c} \cdot a) + (\bar{d} \cdot b \cdot \bar{a})$$

Now, taking the  $f_c$  function, we do the same:

$$f_c = \sum (m_1, m_2, m_3, m_4, m_9, m_{10}, m_{11}, m_{12})$$

dc \ ba	ba			
	00	01	11	10
00	0	1	1	1
01	1	0	0	0
11	1	0	0	0
10	0	1	1	1

With the indicated groups, we get the simplified function:

$$f_c = (c \cdot \bar{b} \cdot \bar{a}) + (\bar{c} \cdot a) + (\bar{c} \cdot b \cdot \bar{a})$$

Next, with the  $f_b$  function:

$$f_b = \sum (m_1, m_2, m_5, m_6, m_9, m_{10}, m_{13}, m_{14})$$

dc \ ba	ba			
	00	01	11	10
00	0	1	0	1
01	0	1	0	1
11	0	1	0	1
10	0	1	0	1

Solving the map, we get:

$$f_b = (\bar{b} \cdot a) + (b \cdot \bar{a})$$

For the last function  $f_a$ :

$$f_a = \sum m_1, m_3, m_5, m_7, m_9, m_{11}, m_{13}, m_{15}$$

In the table it can be observed that the output depends directly from input  $a$ . We can write the simplified function without making the Karnaugh's map:

$$f_a = a$$

Having already the four output functions, the implementation can be carried out in a circuit with AND, OR and NOT logic gates, as shown in the next page.

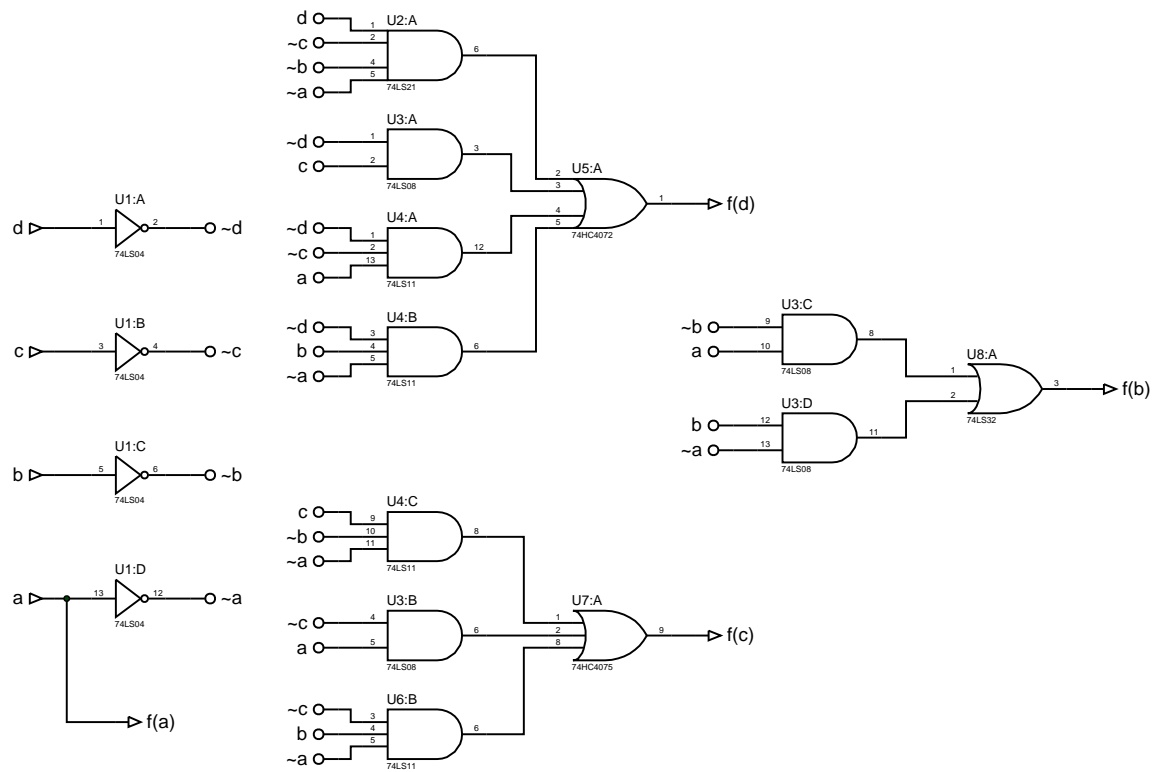


Figure 1: Implementation of 2-complement circuit for a 4-bit input number - Designed in Proteus 7.8