Lab. Script 3

NOR and NAND gates as universal logic gates.

Canonical form of a logical expression.

NAND and NOR gates as universal logic gates

Any elementary logic gate can be represented using only NAND or NOR logic gates. Which means that any digital system, however complex, can be realized using only NAND or NOR gates. Although the circuit that is obtained after this conversion is usually more complex and dense (in terms of the number of logic gates), the fact that only one type of logic gate is used allows this circuit to be realized using a smaller number of integrated circuits. This will become evident in the following scripts. Now consider the following Boolean function with three input variables.

$$f(x,y,z) = \overline{\overline{x}\cdot y + \left(x+\overline{z}\right)\cdot\left(y+z\right)}$$

a) Draw, in your workbook, the logic diagram of this function.

b) Using the software logic.ly, implement the logic diagram of the previous exercise and obtain its truth table.

c) Replace all the logic gates of the circuit from exercise (a) by its equivalent using only NOR logic gates.

d) Resorting to logic.ly, implement the logic diagram of the previous exercise and derive its truth table. Check that this table is equal to the one obtained at (b).

e) (**homework**) Repeat the exercises from (c) and (d) assuming now that only NAND gates should be used.

Canonical form of a logic expression

Consider the following truth table:

x	y	z	F(x,y,z)
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	0

a) Obtain the conjunctive canonical form and draw its logic diagram.

b) Implement the logic diagram of the previous exercise using logic.ly and check that the circuit responses are aligned with the ones presented in the truth table.

c) (**homework**) Resorting to the Boole's algebra theorems, prove that the logic expression from (a) is equivalent, from a logical point-of-view, to the logical equation: $f(x,y,z)=(\overline{x}+y)\cdot(y+z)\cdot(\overline{y}+\overline{z})$.

d) Draw the logic diagram of $f(x,y,z)=(\overline{x}+y)\cdot(y+z)\cdot(\overline{y}+\overline{z})$ and simulate its response using logic.ly . Check that the truth table of this new circuit is equal to the original one.

e) (**homework**) Obtain a logic circuit equivalent to the one of (d) but using only NOR gates Check its correctness using the software logic.ly.