Labs - 01 - gates

Lab assignment

1. Submit the GitHub link to your `Digital-electronics-1` repository.

2. Verification of De Morgan's laws of function f(c,b,a). Submit:

   - Listing of VHDL code `design.vhd`,
   - Screenshot with simulated time waveforms,
   - Link to your public EDA Playground example.

3. Verification of Distributive laws. Submit:
   - Listing of VHDL code `design.vhd` ,
   - Screenshot with simulated time waveforms,
   - Link to your public EDA Playground example.

1. Submit the GitHub link

My GitHub link.

2. Verification of De Morgan's laws of function f(c,b,a)

Formulation of function

$$f(c,b,a) = \overline{b}\,a + \overline{c}\,\overline{b}$$

$$f(c,b,a)_{\mathrm{NAND}} = \overline{\overline{\overline{b}\,a}\;\overline{\overline{c}\,\overline{b}}}$$

$$f(c,b,a)_{\mathrm{NOR}} = \overline{\overline{\overline{b}} + \overline{a}} + \overline{\overline{\overline{c}} + \overline{\overline{b}}} = \overline{b + \overline{a}} + \overline{c + b}$$

EDA Playground code (LINK)

Architercture code for De Morgan's laws

> Excerpt from `design.vhd` :

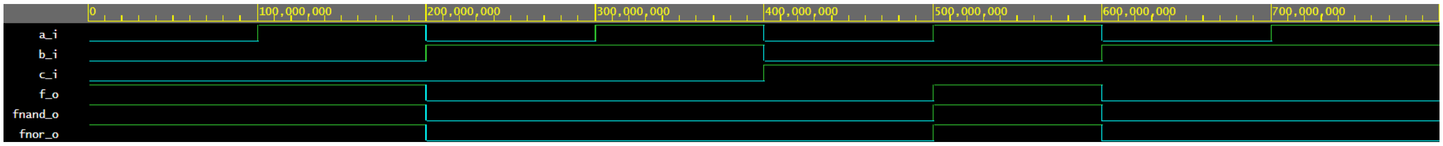
```
architecture dataflow of gates is
begin
    f_o  <= (not b_i and a_i) or (not b_i and not c_i);

    fnand_o <= not(not((not b_i) and a_i) and not(not c_i and not b_i));

    fnor_o <= not(b_i or not a_i) or not(c_i or b_i);

end architecture dataflow;
```

Results in table

c	b	a	f(c,b,a)	f(c,b,a)nand	f(c,b,a)nor
0	0	0	1	1	1
0	0	1	1	1	1
0	1	0	0	0	0
0	1	1	0	0	0

c	b	a	f(c,b,a)	f(c,b,a)nand	f(c,b,a)nor
1	0	0	0	0	0
1	0	1	1	1	1
1	1	0	0	0	0
1	1	1	0	0	0

Waveform of the De Morgan's laws (simulation)



3. Verification of Distributive laws

Formulation of function

$$\begin{aligned} x \cdot y + x \cdot z &= x \cdot (y + z) \\ (x + y) \cdot (x + z) &= x + (y \cdot z) \end{aligned}$$

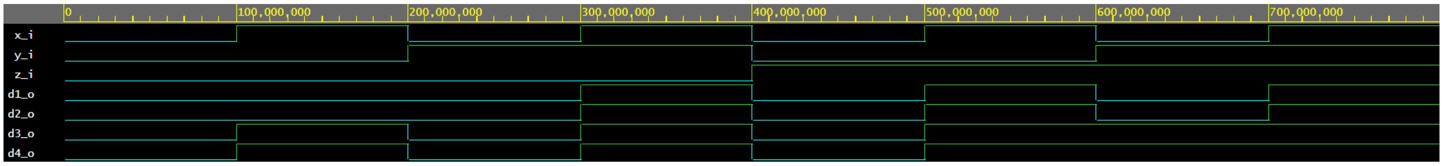
Distributive Laws Architecture

> Excerpt from `design.vhd` :

```
architecture dataflow of gates is
begin
    d1_o  <= (x_i and y_i) or (x_i and z_i);

    d2_o  <= x_i and (y_i or z_i);

    d3_o  <= (x_i or y_i) and (x_i or z_i);

    d4_o  <= x_i or (y_i and z_i);

end architecture dataflow;
```

EDA Playground code (LINK)

Waveform of the Distributive Laws (simulation)


0
100,000,000
200,000,000
300,000,000
400,000,000
500,000,000
600,000,000
700,000,000
x_i
y_i
z_i
d1_o
d2_o
d3_o
d4_o