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Digital-electronics-1

Laboratory #1

[Link to my Digital-electronics-1 repository](#)

Exercise 1: Verification of De Morgan's laws:

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

c	b	a	$f(c,b,a)$
0	0	0	1
0	0	1	1
0	1	0	0

c	b	a	$f(c, b, a)$
0	1	1	0
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	0

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

c	b	a	$f(c, b, a)_{NAND}$
0	0	0	1
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	0

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

c	b	a	$f(c, b, a)_{NOR}$
0	0	0	1
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	1
1	0	1	1

c	b	a	$f(c, b, a)_{NOR}$
1	1	0	0
1	1	1	0

VHDL Code:

```
-- Example of basic OR, AND, XOR gates.
-- Nexys A7-50T, Vivado v2020.1, EDA Playground

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-- Dept. of Radio Electronics, Brno University of Technology, Czechia
-- This work is licensed under the terms of the MIT license.

library ieee;                -- Standard library
use ieee.std_logic_1164.all;-- Package for data types and logic operations

-- Entity declaration for basic gates

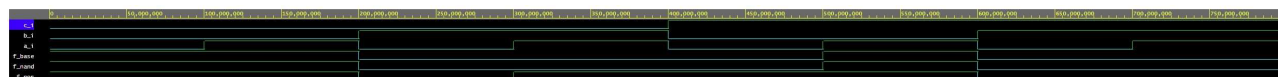
entity gates is
    port(
        a_i    : in  std_logic;    -- Data input
        b_i    : in  std_logic;    -- Data input
        c_i    : in  std_logic;    -- Data input
        f_base  : out std_logic;    -- Output function
        f_NAND  : out std_logic;    -- Output function
        f_NOR   : out std_logic    -- Output function
    );
end entity gates;

-- Architecture body for basic gates

architecture dataflow of gates is
begin
    f_base <= ((not b_i) and a_i) or ((not c_i) and (not b_i));
    f_NAND <= ((not b_i) nand a_i) nand ((not c_i) nand (not b_i));
    f_NOR  <= ((not b_i) nor a_i) nor (c_i nor (not b_i));

end architecture dataflow;
```

Waveform #1:



EDA Playground example

Exercise 2: Verification of Distributive laws:

$$a \cdot b + a \cdot c = a \cdot (b + c)$$

c	b	a	$a \cdot b + a \cdot c$	$a \cdot (b + c)$
0	0	0	0	0
0	0	1	0	0
0	1	0	0	0
0	1	1	1	1
1	0	0	0	0
1	0	1	1	1
1	1	0	0	0
1	1	1	1	1

$$(a + b) \cdot (a + c) = a + (b \cdot c)$$

c	b	a	$(a + b) \cdot (a + c)$	$a + (b \cdot c)$
0	0	0	0	0
0	0	1	1	1
0	1	0	0	0
0	1	1	1	1
1	0	0	0	0
1	0	1	1	1
1	1	0	1	1
1	1	1	1	1

VHDL Code:

```
-- Example of basic OR, AND, XOR gates.
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library ieee;                -- Standard library
use ieee.std_logic_1164.all;-- Package for data types and logic operations

-- Entity declaration for basic gates

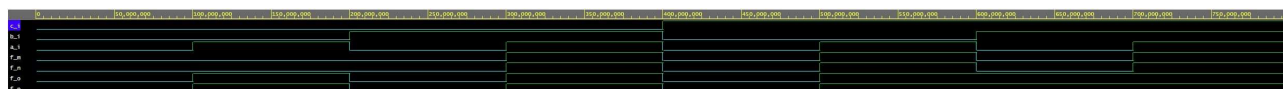
entity gates is
    port(
        a_i    : in  std_logic;    -- Data input
        b_i    : in  std_logic;    -- Data input
        c_i    : in  std_logic;    -- Data input
        f_m    : out std_logic;    -- Output function
        f_n    : out std_logic;    -- Output function
        f_o    : out std_logic;    -- Output function
        f_p    : out std_logic;    -- Output function
    );
end entity gates;

-- Architecture body for basic gates

architecture dataflow of gates is
begin
    f_m <= (a_i and b_i) or (a_i and c_i);
    f_n <= a_i and (b_i or c_i);
    f_o <= (a_i or b_i) and (a_i or c_i);
    f_p <= a_i or (b_i and c_i);

end architecture dataflow;
```

Waveform #2:



EDA Playground example