

## Lab 2: Introduction to VHDL and Xilinx ISE

### Objectives

The purpose of this laboratory exercise is to become familiar with the Xilinx ISE development environment, next with basic VHDL syntax, and input/output devices.

### Materials

You will use push buttons on the CoolRunner-II CPLD starter board (XC2C256-TQ144, manual, schematic) as inputs and light emitting diodes (LEDs) as output devices.

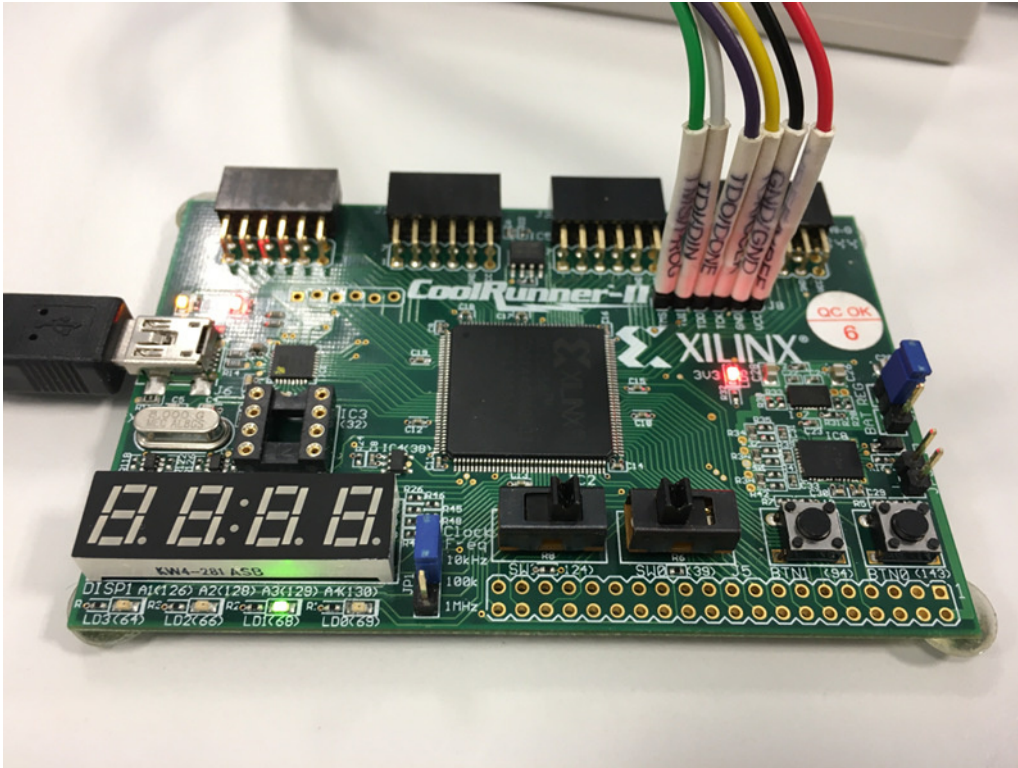


Figure 1: CoolRunner-II CPLD starter board

### 1 Preparation tasks (done before the lab at home)

1. *Digital* or *Binary comparator* compares the digital signals A, B presented at input terminal and produce outputs depending upon the condition of those inputs. Complete the truth table for 1-bit *Identity comparator* (A equals B), and two *Magnitude comparators* (A greater than B, A less than B). Note, '1' represents true, '0' represents false.

A	B	A greater than B	A equals B	A less than B
0	0	0	1	0
0	1			
1	0			
1	1			

According to the truth table, create canonical SoP (Sum of Products) or PoS (Product of Sums) forms as follows:

$$f(b, a)_{greater}^{SoP} =$$

Figure 2: Greater than

$$f(b, a)_{equals}^{SoP} =$$

Figure 3: Equals

$$f(b, a)_{less}^{PoS} =$$

Figure 4: Less than

Create K-maps for all three functions.

Use the K-map to create the simplified PoS form of the function.

$$f(b, a)_{less, Simple}^{PoS} =$$

Figure 5: Simplified PoS form

## 2 Synchronize Git and create a new folder

1. Open a Linux terminal, use `cd` commands to change path to your Digital-electronics-1 working directory, and synchronize the contents with GitHub.

```
$ pwd
/home/lab661
$ cd Documents/your-name/Digital-electronics-1/
$ pwd
/home/lab661/Documents/your-name/Digital-electronics-1
$ git pull
```

2. Create a new folder Labs/02-ise

```
$ cd Labs/
$ mkdir 02-ise
$ cd 02-ise/
$ touch README.md
$ ls
README.md
```

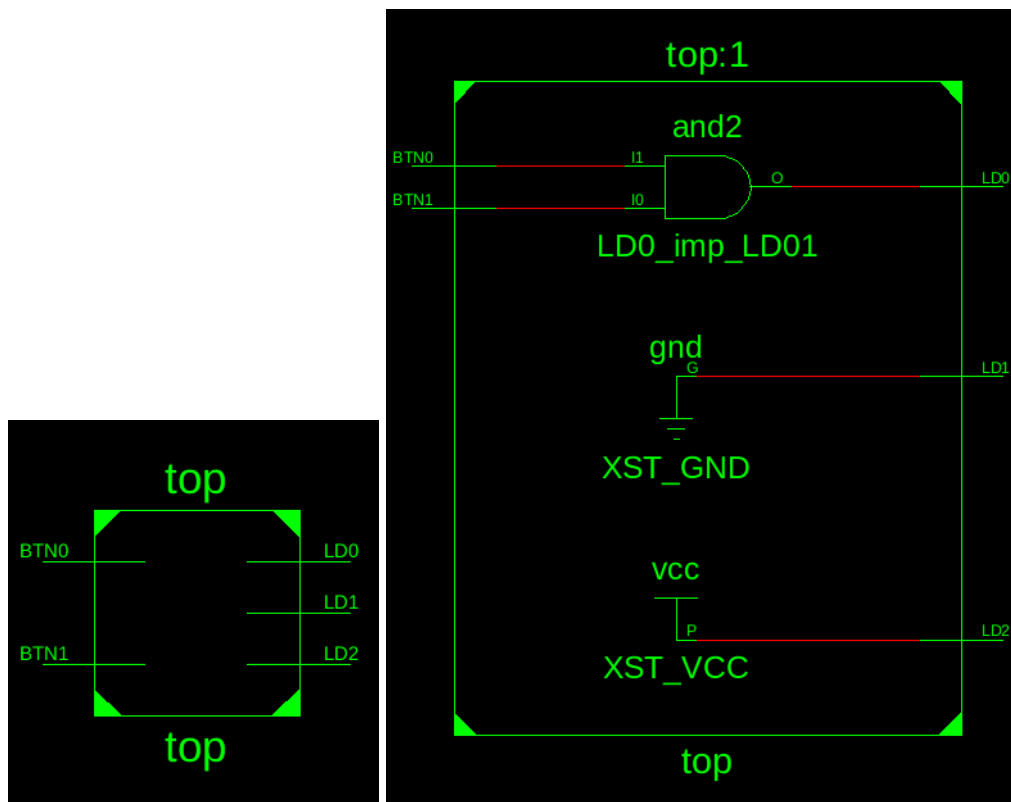
## 3 Digital circuits in VHDL language

1. Follow instructions from wiki and create a new project in ISE. Make sure the project location is `/home/lab661/Documents/your-name/Digital-electronics-1/Labs/02-ise`, ie in **your** local folder.

- Using VHDL operators, define the architecture for 1-bit digital comparator. Most common VHDL operators are shown in the table.

Operator	Description
<code>&lt;=</code>	Value assignment
<code>and</code>	Logical AND
<code>nand</code>	Logical AND with negated output
<code>or</code>	Logical OR
<code>nor</code>	Logical OR with negated output
<code>not</code>	Nagation
<code>xor</code>	Exclusive OR
<code>xnor</code>	Exclusive OR with negated output
<code>-- comment</code>	Comments

- Follow instructions from wiki, create a test bench with all input combinations, and simulate your design in ISim simulator.
- See schematic or reference manual of the board and find out the connection of LD0, LD1, LD2 LEDs and BTN0, BTN1 push buttons. Follow instructions from wiki, create a constraints file, and implement your design to CoolRunner-II CPLD starter board. Modify the internal architecture of your design so that a pressed button represents log. 1 and a LED is turn off for log. 0.
- In menu **Tools > Schematic Viewer > RTL...** select **Start with a schematic of top-level block** and check the hierarchical structure of the module.



- In menu **Project > Design Summary/Reports** check **CPLD Fitter Report (Text)** for implemented functions in section **\*\*\*\*\* Mapped Logic \*\*\*\*\***.

#### 4 Clean project and synchronize git

- In Xilinx ISE, clean up all generated files in menu **Project > Cleanup Project Files...** and close the project using **File > Close Project**.

**Warning:** In any file manager, make sure the project folder does not contain any **large** (gigabyte) files. These can be caused by incorrect simulation in ISim. Delete such files.

2. Use `cd ..` command in Linux terminal and change working directory to **Digital-electronics-1**. Then use git commands to add, commit, and push all local changes to your remote repository. Check the repository at GitHub web page for changes.

```
$ pwd
/home/lab661/Documents/your-name/Digital-electronics-1/Labs/02-ise

$ cd ..
$ cd ..
$ pwd
/home/lab661/Documents/your-name/Digital-electronics-1

$ git status
$ git add <your-modified-files>
$ git status
$ git commit -m "[LAB] Adding 02-ise lab"
$ git status
$ git push
$ git status
```

## Experiments on your own

1. Follow the Linux or Windows instructions and install ISE 14.7 on your computer.
2. Create a new project, define, and simulate a 2-to-4 decoder in VHDL (its structure was mentioned in Lab 1).
3. Complete your `README.md` file with screenshot from the simulation(s).