

# CSC258H Lab1: Introduction to the Design Tools

## 1 Introduction

This week, we introduce the hardware design tools we will use in this course. The majority of the lab uses design tools that are loaded on the PCs in the lab, and you should spend as much time as necessary in this lab to make sure you are comfortable with these tools. If you run into problems or have questions, ask the TA or see if another student near you can help.

For this week, you should work alone, so that you get practice using the tools. In future weeks, you may work in groups of two. After this lab, you should be able to:

- Use the Quartus design software to build a circuit.
- Simulate and test a circuit design.
- (optional) Load a design onto a DE-2 FPGA.

**Before lab, read through the Quartus tutorial linked in the next section** so that you have a high-level understanding of the steps required for the lab. The TA will be available to answer questions during lab or to help you if you get stuck, but you must be familiar with the steps to complete to complete the lab in two hours.

**Evaluation:** The TAs will be checking attendance and progress to award credit for the lab. To earn full credit on this week's participation mark, wave your hand at your TA and ask them to review your vector waveform (the test vector for the mystery circuit).

## 2 Working from Home

If you wish to use your own computer to work on the lab, the software we are using (Quartus II Web Edition) can be downloaded free by following the instructions on the following page:

<http://www-ug.eecg.utoronto.ca/msl/handouts/quartus.html>

Make sure to download **version 11.1**, as that is the version in the lab. (13.1+ does not support our boards.) To make sure all DE-2 boards are available for the labs, we don't lend the DE-2 boards for out-of-lab uses during the term. After the course finishes, if you're interested working on a project with the boards, you can ask the instructor to borrow one.

You should also download QSim from the following link (Windows only):

[ftp://ftp.altera.com/up/pub/Altera\\_Material/11.1/altera\\_upds\\_setup.exe](ftp://ftp.altera.com/up/pub/Altera_Material/11.1/altera_upds_setup.exe)

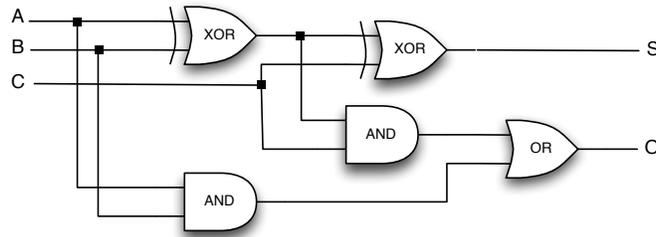
## 3 Quartus Tutorial

Altera, the maker of the software and hardware we are using, has provided a tutorial that explains how to set up a new design project, specify a circuit, simulate the circuit, and load the design onto an FPGA. Download the tutorial from here:

[https://mcs.utm.utoronto.ca/~peters43/258/practicals/w2/tut\\_quartus.pdf](https://mcs.utm.utoronto.ca/~peters43/258/practicals/w2/tut_quartus.pdf)

Complete the first eight sections of the tutorial, paying special attention to Sections 5 (schematic design) and 8 (simulation). In section 8, the tutorial has you use the application "QSim" to simulate your circuits; on the U of T machines, that application can be accessed via the "vector waveform editor". For large projects, you should verify each component with its own test vector, since debugging a complete design is incredibly difficult if you are uncertain whether each component is reliable.

## 4 Mystery Circuit



Investigate and explain the operation of the circuit shown in the figure. Draw a truth table that predicts the behavior of the circuit.

In lab, create a new project, populate it with a schematic, and perform a functional simulation to determine how the circuit behaves. The test vector for your simulation should exercise every possible combination of inputs.

## 5 Using a DE-2 FPGA

If you have additional time at the end of the lab, complete Sections 9 and 10 of the tutorial, which explain how to load the circuit you've designed onto the DE-2 board. Ask the TA to get a DE-2 FPGA board.

You will need to assign your inputs and outputs to specific devices on the board. We will use switches for the inputs A, B, and C and LEDs for the outputs S and O. Use the pin assignments (PIN\_N25, PIN\_N26, PIN\_P25) to connect the inputs to switches 0-2 and the pin assignments (PIN\_AE23, PIN\_AF23) to connect the outputs to red LEDs 0 and 1.

Use the JTAG method for loading the circuit onto your DE-2. In addition to the instructions in the tutorial, be sure to set SW19 back to the "RUN" position after the POF bitstream downloading is finished. Then, reset power (turn the board off and then back on) so that the bitstream can be loaded into FPGA from the Serial Configuration Device.

## 6 Summary of TODOs

Below is the summary of the steps to be completed for this lab:

1. Before the lab, read through the Quartus tutorial and/or install the tools on your own computer.
2. Predict the behaviour of the mystery circuit before implementing it.
3. Implement the mystery circuit using Quartus.
4. Simulate the circuit, explain the waveforms and show them to your TA.
5. (optional) Load your the circuit to the DE-2 board, make sure it's working as expected, and show it to your TA.

**Evaluation (3 marks in total):** 2 marks for attending and making an honest effort; 1 mark for showing and explaining the simulation waveforms.