**Computer science department, Langara college**

**Digital Systems Design (with FPGAs)**

**Spring 2019**

# Lab 1: Combinational circuits 1

by S. Arash Sheikholeslam

In this lab, you will become familiar with the software and hardware we will be using in the labs, and use the hardware and software to implement a simple combinational logic circuit. The software we will be using for most of this course is called Quartus II, and is produced by Altera. The software contains a VHDL compiler, a graphic entry system, a simulator, a waveform editor, and a programmer (to program Altera FPGA devices). You can obtain the academic version of the tool from Intel’s web site.

**Preparation:**

The following must be done before you come into the lab:

1. Read this handout carefully (Preferably even attempt doing it.)
2. Familiarize yourself with Quartus before the lab.
3. A VHDL file is provided to you by your TA. Try that one and make sure you know how to assign the pins.

Part 1:

Lab 1 design is a combinational block with 4 inputs and 1 output. The inputs are connected to switches, and the output is connected to an LED. The LED should turn on if you are inputting a number that can be divided by three. Write the truth table, and plot your circuit bellow (You can use what you know about normal form and Karnaugh maps)

Use the following methods to code, compile, and download your design onto the board using Quartus II. Use the pin assignments file provided.  
  
Method 1:  
  
Use the “process” statement and code your circuit behaviorally.  
  
Method 2:  
  
Use an structural design (using ANDs ORs and NOTs) and code your circuit structurally.

Part 2:

A two-bit multiplexer is a device that has three inputs a, b, and sel. The output will be equal to a whenever sel is 0 and equal to b when sel is equal to 1. Use three switches for a, b and sel and an LED for output.

Code, compile and download your design onto the board.

**Performance in the lab: (10 marks)**

In this lab, you will download the circuit you designed in the Preparation on the FPGA board. The input and output pins of this FPGA are tied to the various lights and switches.

1. Read the manual carefully

1. BE SURE that you set the pin assignments before compiling your design (not doing so could damage the board!). If you have any questions about how to do this, please talk to the TA.

You must demonstrate that your circuit works to the TA or to me by the end of your lab section. *A*nswer the following questions (for part 1: method 1 and 2 and part 2):

* 1. What is the maximum combinational delay of your circuit in each case? (use Processing -> Timing Analyzer Tool)
  2. How many logic elements are required to implement your circuits? What proportion of the entire chip is this? (Check the report file produced when compiling).
  3. Are the switches on our board active-low or active-high? What about the red LEDs? You should search the meaning of active low and active high.
  4. What is the difference between method 1 and 2?

*Marking:*

Your mark for the performance part of the lab will be:

0/10: If you don’t even show up, or if you show up and don’t do anything

3/10: If you make an attempt, but really don’t get anywhere near it working

7/10: If you almost get it working, or if you get it working but can’t answer TA’s questions.

10/10: If you successfully demonstrate your design to the TA, and can answer TA’s questions.

Anything in between 0 to 3, 3 to 7 and, 7 to 10 is at instructor/TA’s discretion based on how satisfied they are with your performance and knowledge.

Note that this lab is quite easy, and you will likely finish early. Use some of the extra time to play with the software to understand what else it can do.