CSC258H Lab 3: Multiplexer Devices

1 Warning

If you're working in the linux lab, Quartus will not save your files if you are overquota, and you could lose your work. Please check your quota (with the "quota" command) and then remove files if necessary to stay below quota.

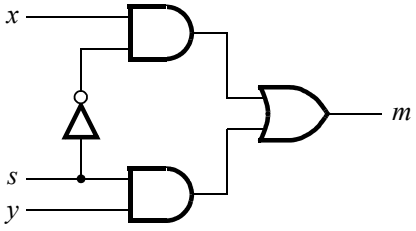
2 Introduction

This week, we will practice with one of the logical devices that we learned from last week's lecture – multiplexers. You will first implement a simple 2-to-1 multiplexer, and then use it as the building block to build a bigger 10-to-1 multiplexer. **Before lab, please read this handout and complete the 10-1 mux design, so that you are prepared to just implement your circuits during lab.**

3 The Basic 2-to-1 Multiplexer

Multiplexers (muxes) are devices which select between data inputs. A mux with n-bit *select* input can select from up to 2^n data inputs, and the selected data input is connected to the output of the mux. The data inputs are treated like an array, and the *select* input contains the index of the data input that should be forwarded to the output.

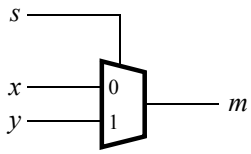
Below is the design of a simple 2-to-1 mux, in which a 1-bit *select* input can select between the two data inputs x and y.



a) Circuit

s	m
0	x
1	y

b) Truth table



c) Symbol

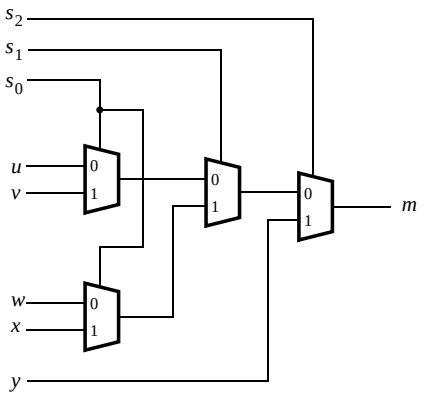
Figure 1: Design of a 2-to-1 mux

Create a new Quartus project (as usual, choose Cyclone II EP2C35F672C6) and implement the above 2-to-1 mux. Create test vectors to verify that your implementation is working correctly. **Show your TA your test vector and the 10-1 mux design described later in the lab to get your first two lab points for this week.**

After verifying your 2-to-1 mux, **save your current design as a symbol** so you can use it later in other projects. The option for creating a symbol can be found at "File → Create / Update → Create Symbol Files". When naming projects that you are going to use to create symbols, you must be very careful not to choose a name that is included in Quartus's standard library since, by default, Quartus looks in its library before searching for user-defined symbols. For example, you cannot simply call your project "mux", since that is the name used in Quartus. Something like "mux21_<UTORID>" will work.

4 Learn From Example: The 5-to-1 Multiplexer

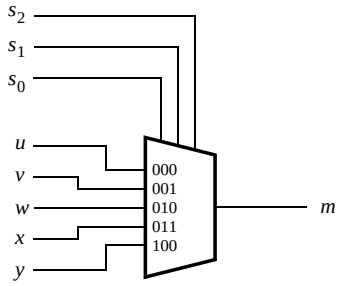
The figure below shows the design of a 5-to-1 mux, implemented using 2-to-1 muxes as building blocks. It uses a 3-bit *select* input $s_2s_1s_0$ to select from 5 data inputs: u, v, w, x and y. **Before the lab, understand how this design works, so that you will be able to design your own 10-to-1 mux**. You don't need to implement this circuit in the lab.



a) Circuit

s_2	s_1	s_0	m
0	0	0	u
0	0	1	v
0	1	0	w
0	1	1	x
1	0	0	y
1	0	1	y
1	1	0	y
1	1	1	y

b) Truth table



c) Symbol

Figure 2: Design of a 5-to-1 mux

5 Your Job: Design and Implement a 10-to-1 Multiplexer

Based on the understanding you learned from the design of the 5-to-1 mux, you will design a 10-to-1 mux, using only 2-to-1 muxes as building blocks. **Before the lab, design the circuit diagram of your 10-to-1 mux.**

Create a second new Quartus project, implement the 10-to-1 mux using **only** the 2-to-1 mux symbol that you created earlier in the lab. Create test vectors and use QSim to verify that the circuit works as you expect. **Show your TA your validated circuit to earn the final lab marks for this week. Your TA will collect your design notes.**

Once your simulation result convinces you that your design is working correctly, you may (optionally) load your circuit onto the DE-2 board. Connect the 10-bit data inputs to SW[9]–SW[0], the 4-bit *select* input to SW[13]–SW[10], and the 1-bit output to LEDG[0] (the green LED). To make a nicer presentation of the current input values, you may add 10 more outputs to your circuit which are directly connected to the 10 data inputs, and connect them with LEDR[9]–LEDR[0]. (Don't forget that there is a pin assignments file on the course webpage that you can use to make it faster to link to the board.)

6 Summary of TODOs

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

1. Before the lab, read through the lab handout, understand the design of the 5-to-1 mux, and design the circuit diagram of a 10-to-1 mux. Bring this design to class on paper.

2. In the lab, implement the 2-to-1 mux, simulate it with test vectors and show your TA the simulation results and your 10-1 mux design.

3. Save your 2-to-1 mux as a symbol.

4. Use your own 2-to-1 mux symbol to build the 10-to-1 mux and simulate it. Show your TA when it is working.

Evaluation (3 marks in total): 1 mark for the 10-1 mux design, 1 mark for showing simulation results of the 2-to-1 mux, and 1 mark for demonstrating that the 10-1 mux design works in simulation.