Project 5 Basic Combinational Building Blocks

Shifters, Multiplexors

Introduction

This project presents the design of logic circuits that are commonly used as components in larger, more complex circuits. Althoughthey can be used by themselves in simpler settings, these components are more typically thought of as basic building blocks in larger, more involved circuits.

Although it is easier, simpler and more natural to define circuits behaviorally, any given circuit description must be translated into a detailed structural form before it can be implemented. For many years, the main job of a design engineer was translating loose behavioral descriptions into detailed structural specifications. In more recent times, logic synthesizer tools took over that task. Today, virtually all digital circuit designs use logic synthesizers, and all modern design tools (like Vivado) include synthesizers as essential components.

Before you begin, you should:

- Be able to find a minimum circuit for any given behavioral description;
- Understand the general design flow for designing any digital circuit;
- Be comfortable using Vivado and the Boolean board to define and implement designs.

After you're done, you should:

- Understand the design and use of multiplexors, and shifters;
- Be comfortable defining slightly larger circuits;
- Be comfortable using the simulator for routine circuits.

Requirements

Each of the requirements involves the design, simulation, and implementation of an independent combinational circuit. If you have multiple source files and/or test benches in a single project, you can select which one is "active" by right-clicking on the name and selecting "set as top" from the pull-down menu. Three small boxes in a triangle pattern next to a source file name indicate which source file isactive. When you run a process like synthesis or simulation, the tools will use the currently active source file(s). Before clicking Run Behavioral Simulation, right-click on the simulation source file you want to simulate and select Set as Top.

Note: You can follow the **tutorial** file for the completion of the tasks.

1- Shifter

Create a Verilog description for an **8-bit shifter** that can **shift** or **rotate left** or **right** by **0, 1, 2, or 3** bit positions. ***Implement*** the shifter on your board, using **8 slide switches for shifter input**, **8 LEDs for outputs**, and the **4 pushbuttons to select the shifter function**. **2 will be used for shift amount**, **1 for direction**, and **1 for shift/rotate** selection. When shifting, use **one switch to define the fill input**. Verify the shifter works correctly on your board.

Note: You can find an example video of the task implemented on a Blackboard (not Boolean) in the following link:

https://www.youtube.com/watch?v=yrdcZhD7HSg

2- 12:1 Multiplexor

Design and ***implement*** a **12:1 1-bit** multiplexer (MUX) on your Boolean board and connect the **output** to a **green** RGB LED. Additionally, include a **red** RGB LED that turns on **if the select input is greater than or equal to 12**, indicating an out-of-range selection. Provide the Verilog code for your MUX implementation, including the LED connections and any necessary logic.

3- Minterm multiplexor circuit

Using a **4:1 multiplexor**, implement the following Boolean function:

$$\mathbf{F(A, B, C, D)=}\sum \boldsymbol{m}(\mathbf{1}, \mathbf{3}, \mathbf{4}, \mathbf{11}, \mathbf{12}, \mathbf{13}, \mathbf{14}, \mathbf{15})$$

For the above minterms, an **LED will be illuminated**.

Create a **4-input (SW0, SW1, SW2 and SW3)**, **1 output (LED0)** Verilog circuit that uses a **4:1 behavioral multiplexor.** Connect the multiplexor output to an LED, and connect the four inputs in such a way that the **minterms** cause the LED to illuminate.

Hint: each input to the behavioral multiplexor will be driven by a simple logic **function**. **2** of the slide switches will be **inputs** to these simple logic functions, and the other **2** will**select** the multiplexor channel.

Note: You can find an example video of the task implemented on a Blackboard (not Boolean) in the following link:
https://www.youtube.com/watch?v=ElCxXvZGcLU