This Lab Assignment will introduce you to the Xilinx ISE tool, to the lab kits, and to the 7400-series chips. You will wire wrap a small circuit on the XST board which you will demonstrate to the TA during your lab.

The circuit you will build is a three-way light controller. Imagine that you have a light in a large room with three doors. There should be a light switch by each door, and flipping a switch at each door should toggle the light. That is, if the light is currently off, flipping any of the three switches should turn it on. If it’s on, flipping any of the three switches should turn it off.

If you’ve read Chapter 2 you will notice that this is exactly the circuit described in Section 2.8.1. The only change from the circuits in the book is that I want you to build this circuit using only NAND and INVERTER gates, and I want you to build this using the red switches and LEDs from your lab kit (not the built-in versions on the XST board), and the gates in the 7400-series parts, not the Xilinx FPGA. You will NOT need to plug the XSA-50 (the Xilinx board) into the XST for this lab! Use only the XST board.

There’s an Introduction to the Lab Kit document on the class web site that talks about the components in the lab kit, and the process of wire wrapping sockets to the XST board. It also talks about how to use the switches, how to wire the LEDs, and how to wire the LEDs using the 906 and 907 buffers. It also describes a procedure that walks through designing and wiring a lab.

There is also a new tutorial on the class web site that walks you through the procedure for using ISE to design a schematic and simulate that schematic.

What it doesn’t tell you is how to use schematic symbols from the 3700 Lab Kit library. This library has schematic symbols for the red switches, the LED packs, and the 74HC906 and 74HC907 buffers that we use to drive the LEDs. Details are at the end of this lab handout.

So, the actual assignment is: Use the red switches (in the style described in the Introduction to the Lab Kit), the LEDs, and a 906 or 907 driver as the input and output devices. Use NAND (74hc00) and Inverter (74hc04) gates to build the logic for a three-way switch as described in section 2.8.1. Use the 74HCxx parts for the logic.

We don’t have symbols that correspond exactly to the 74HCxx chips, so we’ll use logic gates from the Xilinx Logic category (see the ISE tutorial). In particular, the following Xilinx gates correspond to the 74HCxx gates that you can use. Note that I’ve listed both
the “regular” and the “DeMorganized” version of the gate. Please use the best representation for the circuit!

- 74HC00 2-input NAND = nand2 or or2b2
- 74HC04 inverter = inv
- 74HC10 3-input NAND = nand3 or or3b3
- 74HC20 4-input NAND = nand4 or or4b4
- 74HC30 8-input NAND – nand8

The ISE tutorial shows a simple schematic that uses some of those gates. The new part in this lab is that I’d like you to show the red switches, the pullup resistors you use with the switches, the LED drivers, and the LEDs also in the schematic.

**Procedure:**

1. Read the Introduction to the Lab Kit handout.
2. Work through the ISE tutorial to get an introduction to how that tool works.
3. Design a schematic for the three-way switch circuit using the components in the 3700 Lab Kit, the Logic, and the General categories in ISE. Make sure to use a title_3700 block on your schematic, and spend some time making a neat schematic. Neatness counts!
4. Simulate that circuit using a Verilog testbench. Fill in the Verilog test code with your own initial block with commands that demonstrate that your circuit works.
5. Use the schematic as a guide and wire up the circuit on the XST board. I find it helpful to annotate the schematic with pin numbers that you need to wire up. You can do this in the schematic editor, or just on a printout in pencil. To find the pin assignments for the 74HCxx parts you’ll need to look up the data sheets on the class web site.
6. Double check your wiring. Did you remember power and ground connections for the components on the board? Did you wire up the LEDs and switches as described in the Introduction to the Lab Kit handout?
7. Demonstrate your working circuit to your TA in your lab 2/1, 2/2, or 2/3.
8. Print out your schematic, your testbench code, and the resulting testing waveform. Hand those in to the 3700 homework box by Friday February 3rd at 5:00pm.
Using the 3700 library parts in ISE schematics

Your lab kit includes a variety of 7400-series chips, switches, LEDs and other components. Those components are described in the lab kit handout on the class website (www.eng.utah.edu/~cs3700). Some of those components (mostly the gates) can use Xilinx gates as stand-ins for the 7400-series gates. But, there are no Xilinx versions of the red switches, no equivalent of the 907 and 906 open-drain drivers, and no LEDs in the Xilinx symbol libraries.

The 3700 library does have these parts so you can make a schematic that includes these components using the ISE schematic editor. This library is “attached” to the Spartan2 device models in ISE as it’s installed in the DSL. So, when you enter new components in your schematic, you should have the 3700 components available as well as the Xilinx components. When you select the “symbols” tab to see the available schematic symbols, you should see the 3700 parts in a separate category:
For example, I can use a SPST switch (the red switches are actually SPDT but I can wire up only one throw if I want to use it as a SPST), pullup and gnd (from the Xilinx “General” category), a 907 buffer, and a 907-LED to make a simple schematic of a circuit where the LED goes on when I flip the switch. It looks like this:

You should be able to see the function of this circuit, and how to wire it up with the components from the lab kit, by looking carefully at the Lab Kit handout.

**Simulating this Circuit:** Making a new test fixture named `switch_tf`, and making sure to associate it with the `switch.sch` schematic, I get the following test fixture template:
I can fill this in with an initial block to drive the input (switch) and look at the output (light). If I got it right, the light should light up whenever I flip the switch value (which simulates actually flipping the switch).
The simulation shows that it works. Note that in order to make this intuitive to use, the interpretation of the switch “S” input is a little tricky. When S is 0, the switch is closed (so the output of the switch is pulled low). The S is 1 the switch is open, so the output of the switch is pulled high through the pullup. This lets you drive the S signal with the intended output of the switch.

The simulation shows how this works. When my Switch input is low, the switch is closed so the input to the buffer is low (pulled low through the switch) and the light is off (low). When my Switch input is high, the switch is open, so the input to the buffer is pulled high through the pullup and the light is on (high)
This example has showed how to use the cells in the 3700Parts library in your Lab1 project so that you can use schematic symbols for the red switches, the pullup resistors, the 907 and 906 drivers, and the LEDs in the lab kits. Use these symbols, along with the Xilinx nand and inv parts, to build your three-way switch circuit for Lab1.

**Adding the 3700 parts to your own installation of ISE**

If you’d like to add the 3700 parts library to your own installation of the ISE tools, follow these steps.

1. Copy the 3700-parts.zip file from the class web site http://www.eng.utah.edu/~cs3700/labs/3700_parts.zip

2. Unzip the file and put it on your local disk. I put mine on the C: drive root. There should now be a C:\3700_parts folder that contains two files: 3700_parts.lib and 3700_parts.cat

3. Now fire up the ISE 10.1.03 tool. Navigate to Edit->Preferences and expand the Schematic Editor tab
4. Now expand the Device Families tab and then expand the Spartan2 tab
5. You'll now expand each of the Symbol Library, Symbol Category, and Macro Schematic tabs and add a link to the files that are in your C:\3700_parts folder

Start by expanding all three of those tabs
6. Select each one in turn and select the Edit button from the upper right of the main dialog box. For example, for the Symbol Library Files and Path, you'll select Browse File and navigate to select the 3700_parts.lib file from the C:/3700_parts folder.

7. Make sure to click Add before leaving this dialog box. You should see the new file added to the list.
8. When you’ve added the .lib file to the Symbol Library, the .cat file to the Symbol Categories, and the 3700_parts folder itself to the Macro Schematic tabs, you should see the following:
Now, whenever you make a new library using the Spartan2 technology (which is the FPGA that we have on our board), you will also see the 3700 parts as symbols that you can use (and simulate) in your shcematics.

Note that the 3700 parts are for simulation only. That is, they will not synthesize onto the FPGA. This will be more clear in later labs...