COMP2340
Lab #1 – Digital Logic
Sem 2, 2013/2014

Section 1:Introducing Logisim

Logisim is a computer program that can be used to simulate digital logic circuits. It makes learning about logic gates and circuits easier than it would be if you had to actually connect wires on a physical circuit.

Preparation

- Download Logisim and install the program on your computer.
- Download the files *Ex1.circ, Ex2.circ,* and *add4.circ* and save them to a location from which you can open them later.

2.1 Using Logisim

Start the Logisim program and open the file *Ex1.circ*. You should see several circuits. Each circuit has logic gates with wires that are connected to square boxes, and round shapes.

The square boxes are switches that you can turn toggle between the value 0 or 1when they are clicked with the hand tool. For this lab we will consider 1 to mean high voltage and 0 to mean low voltage. Remember! A bit is represented as a voltage on a wire.

The little round shapes represent LED's (light emitting diodes). An LED glows whenever the wire to which it is connected has the value 1. In Logisim, a glow is present if the LED is coloured light green. Otherwise, the LED is coloured dark green. In the simulator, any wire carrying a 1 will glow.

The icon that is shaped like a hand is the manipulation tool. Click on this icon in order to make sure that you can set the values in the input. The mouse pointer should now be shaped like a hand. Test it out by clicking on the input to the NOT gate. The value at the input should toggle from 0 to 1 or vice versa. Click on the input again to turn it off.

Observe the behavior of the logic gates for the AND, OR, NAND and NOR gates, and complete the truth table (on the Exercise Sheet) based on the behavior.

Add a XOR gate to the circuit.

Add two switches to the inputs, and a LED at the output, using the wiring tool to make the connection.

Complete the truth table based on information observed in the simulator.

Add a XNOR gate to the circuit, and repeat the steps taken in the previous section

Section 2. Combinational Logic Circuits

Digital logic gates can be wired together to create circuits that perform more involved operations than just basic Boolean operations. It may be a good idea to review the **beginner's tutorial** in the Logisim documentation prior to this exercise.

3.1 **Open the file *Ex2.circ* and complete Exercise #2.**

3.2 **Create a half-adder component**

i. Start a new project in Logisim.

ii. Open the Combinational Analysis tool (under the Window menu.)

iii. Use the Inputs tab to create two inputs labelled a and b.

iv. Use the Outputs tab to create two outputs labelled sum and carry.

v. Use the Table tab to specify the truth table for

sum = a XOR b

carry = a AND b

vi. Build and test your circuit.

vii. Save your circuit to a file named hadd in your circuits directory.

3.3 Create a full adder using the half adder component

Most addition problems will involve adding numbers with more than one bit. For example, to add the value 7 to the value 5 you need to add the binary values 0111 an 0101. Addition of such values can be accomplished by simply adding the bits in corresponding positions of the two values from right to left just as we do with decimal values. A half adder cannot do this properly because it does not have an input that allows it to add a carry (if any) from the previous position after adding the two bits in a position. In order to even contemplate anything more than simplistic addition we need a device that can add two bits in the proper manner, accommodating addition of a carry where necessary. The circuit that does this is called a full adder. You will now use a half adder to compose a full adder.

i. Start a new Logisim project.

ii. Load hadd from your circuit library. (Use the Project/Load Library/Logisim Library menu.)

iii. By clicking on the hadd component, drag two half adders onto the workspace. Add three one-bit inputs labeled a,b and cin respectively and two one-bit outputs labeled sum and cout.

iv. Connect the components to form a full adder using the strategy discussed in the lecture slides.

v. Save your file with the name add.circ in your work folder.

Section 4. More complicated circuits (20 marks)

Review the "Wire bundle" section of the Logisim documentation

4.1 An 8-bit adder (4 marks)

a. Load add4.circ from your circuit library (This will allow you to insert 4-adder circuits). Add two 4-adders to the workspace. (If a prompt appears asking for add or had, select the file from your folder).

b. Create two 8-bit wide input pins named arg1 and arg2.

c. Create a 1-bit wide output pin named cout.

d. Create a 8-bit wide output pin named sum.

e. Attach West-facing splitters to arg1 and arg2. Before adding these splitters, make sure the bit-width is 8 and the fan-out is 2. Make sure the fan wires are not blue.

f. Attach an East-facing splitter to sum. It's wires will be blue.

g. Implement the connections between the adders that will allow the two 4-adders to work together to perform the function of an 8-adder.

h. Connect the input of each adder (or half adder) to the corresponding wire of the splitter connected to arg1.

i. Repeat for arg2.

j. Test your circuit.

k. Save it to your library in a file called add8.

ii. ON your answer sheet, you will see a table in which you are to record the results of performing a few computations using the adder – Complete the table. (7 marks for table, 3 marks for explanation of exceptions)

4.2 An 8-bit ALU (6 marks)

i. Using the components from logisim's library, create a 8-bit ALU that can perform the four functions addition, subtraction, division and multiplication. (You will need appropriate inputs for your device.)

ii. Save your file as alu.circ