EE 112 16 March 2015

Lab Project 5 Report Due Date 27 March 2015

LOGIC CIRCUITS - INVESTIGATE THREE CIRCUITS:
1 – INVESTIGATE HAZARD LOGIC CIRCUIT BUILT FROM NANDS;
2 – FULL ADDER DESIGNED TO ADD TWO 3-BIT NUMBERS;
3 – A LOGIC CIRCIT TO CONTROL A LIGHT FROM ANY OF FOUR POSITIONS

OBJECTIVE:

The objective of this experiment is to design, simulate, analyze, and demonstrate the performance of a few digital circuits.

The first is a combinational logic circuit that must be analyzed for hazards and corrected if one is found; the circuit only uses 2-input NAND gates.

The second is a Full Adder that is designed with 2-input NAND gates only.

The third is a combinational logic circuit that satisfies some specific user requirements.

GENERAL LAB WRITE-UP INSTRUCTIONS:

In all lab projects, you will be required to document your work and answer questions related to the project. I will expect one lab report from each group. For the write-up, follow the format described in the handout.

Provide data, sechematic, and diagrams as required and written answers to the questions. Reports are due the week after completing the lab.

PROCEDURE:

1) INVESTIGATE A COMBINATIONAL LOGIC CIRCUIT FOR HAZARDS:

Prelab:

The only prelab required for this lab is to generate the circuit diagram as given by the equation shown below and analyze the circuit behavior to determine if there is a static or dynamic hazard. The logic circuit being investigated is described by the following logic function

$$F(X, Y, Z) = (X' Y) + (Y' Z)$$

Build and demonstrate performance:

After completing the prelab, in the lab you are to simulate the circuit, using only 2-input NAND gates. Assume that only uncomplemented inputs are available so X' and Y' must be generated explicitly by your circuit.

Now using the simulation program, analyze the circuit for static and dynamic hazards. Exhibit input combinations which differ only in one bit, such that the output of the circuit is 1 for both input combinations, but the output may momentarily go to 0 when the differing input bit (simulated by a signal generator running at 1 KHz.) changes value.

Now modify the circuit from the first part to eliminate the hazard. Write the logic equation and draw the logic diagram for the circuit. Remember, you are to use only 2-input NAND gates in the circuit. Measure the dynamic behavior of the circuit (propagation delay) to demonstrate the performance of the circuit, and observe and document the difference in performance between the two circuits.

In the write-up of this lab, turn in the circuit diagrams requested, scope images of the resulting performance, and answer the questions for this part of the lab:

Q1-1) Include in the write-up, both a schematic diagram showing the integrated circuits with pin numbers on the devices and also a wiring diagram.

Q1-2) How did you go about eliminating the hazard in the first circuit?

Q1-3) What was the cost difference required to eliminate the hazard?

2) FULL ADDER DESIGNED TO ADD TWO 3-BIT NUMBERS:

Prelab:

The pre-lab for the full adder involves designing a full adder logic using only gates with a fan-in of two. Also show the truth table for the circuit you designed, demonstrating the full add capability of the circuit. Draw the physical layout (wiring diagram) showing the pin numbers on the IC's and all connections to the devices (ground, power, etc.)

Build and demonstrate performance:

In this part of the lab, you are to build in Multisim, a 3 bit adder, test the circuit, and demonstrate the circuit you simulated. Demonstrate that it satisfies the requirements of a Full Adder. That is, it does effectively and accurately add two digital numbers, each 3 bits wide, outputting the correct result. Use switches to control inputs and LED's to show the status of the input bits, and the status of the "sum" and "carry" outputs. As part of the write-up, include the following items and answer the following questions:

Q2-1) Show a block diagram of the set up you used to demonstrate the performance of the full adder circuit.

Q2-2) Include in your write-up a logic diagram (schematic) showing the integerated circuits used and the pin number and connections that would be used if it was to be built in hardware.

Answer the following questions.

Q2-3) How long would you estimate it takes the adder to add the two input bits and produce a result?

How would you calculate this time?

How would you measure this time?

Q2-4) How many operations, that is, adding two 8-bit numbers, could be performed in one second using the scheme you developed in this lab project?

Q2-5) What is the "cost" (inputs and gates) of this circuit?

Q2-6) Can you think of some ways in which the cost could be improved?

3) DESIGN A SWITCHING ARRANGEMENT SO A LIGHT IN A ROOM CAN BE CONTROLLED (ON/OFF) FROM ANY OF 4 LOCATIONS IN A ROOM:

Prelab:

The pre-lab for the switch involves designing switching arrangement that allows the user to control a light from any of 4 locations in a room. By control means the user can turn the light on or off from any of the four positions. Also show the truth table for the circuit you designed, demonstrating the logical control and then the circuit.

Build and demonstrate performance:

In this part of the lab, you are to build in Multisim, the switching arrangement and then demonstrate the circuit operation to the professor or TA.

Q3-1) Show a logic diagram of the set up you used to demonstrate the performance of the circuit.

Q3-2) Include in your write-up a logic diagram (schematic) showing how the logic diagram was translated to the actual switching arrangement used to control the lighting.