EE 112 9 February 2015

Lab Project 3 Report due 27 February 2015

SWITCH DEBOUNCER, HAZARD MEASUREMENT & LOGIC GAME

This Lab requires some preparation out of lab to minimize the time in lab. Please complete the pre-lab assignment as indicated and be prepared to perform the lab.

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. You are required to work in groups of two. Any exceptions must be with the permission of the instructor. For the write-up, follow the format described in the handout.

Provide data as required and written answers to the questions.

OBJECTIVE:

As with all labs, one of the objectives is to continue to learn to use the lab equipment (Scope, DMM, Signal Generator, Power Supplies, and prototyping hardware).

Along with the equipment usage, another objective is to is to understand how digital logic circuit can be used to enhance the electro/mechanical performance of a switch, called a switch debouncer.

A thid objective is to investigate "HAZARDS" in logic circuits and measure the characteristics of a hazard.

An a fourth objective of this lab is to take a word problem and implement it with logic circuits.

INTRODUCTION:

Switch debouncing is employing a logic circuit to eliminate ringing and noise in the output of a switch caused by the mechanical contact bouncing as the switch is moved from one position to another. Using a couple of NAND gates, we can clean up the signals.
In this lab is we will investigate the behavior of a logic circuit that serves to debounce the output of a mechanical switch. The circuit for the debouncer is given. The student is only required to build the circuit, and then investigate the performance, **demonstrating to the lab instructor** that the "debouncer" is effective in eliminating the mechanical bouncing and hence electrical noise that occurs in the switch.

Signal delays in logic devices can cause the transient behavior of a logic circuit to differ from what is predicted by a steady-state analysis. In particular, a circuit's output may produce a short pulse, often called a glitch, at a time when steady-state analysis predicts that the output should not change. A hazard is said to exist when there is a possibility of producing a glitch. Hazards are unwanted switching transients that may appear at the output of a circuit because different paths exhibit different propagation delays in a circuit. (They are discussed in Chapter 9 of the text, so we are jumping ahead a bit, but looking at them in a simplified manner.)

Lastly, you will design, build, and demonstrate the performance of a logic game.

PROCEDURE

1) SWITCH DEBOUNCING:

Prelab:

The only prelab required for this part of the lab is to review the circuit diagrams shown in Figures 1 and 2, and sketch the output that you think would occur at the points marked "out" as the switch is moved from position A to position B.

Build and demonstrate to the TA's the performance of debounce circuits

Now you are to build the circuit, measure the dynamic behavior of the circuits, demonstrate the performance of the circuit, and observe and document in the write-up, 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:

Questions to be answered as part of this lab.:

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

1-2) For the circuit in Figure 1, describe the voltage that occurs at "output" and comment on the characteristics such as voltage magnitude as a function of time as the switch is moved from position A to position B and back again.

1-3) For the circuit in Figure 2, describe the voltage that occurs at "output" and comment on the characteristics such as voltage magnitude as a function of time as the switch is moved from position A to position B and back again.

1-4) What effect does the "debounce" circuit have on circuit performance?

1-5) If you were counting the number of times the switch was moved from position A to Position B and back again, how would the data from the two circuits compare? Be quantitative in your response. Assume that the transition from a logic zero to a logic one occurs at 1.8 vollts and that the “counting device” would count signal above 1.8 volts as a logic one and those below a 1.8 volts as a logic zero. Also, realize that you cannot move the switch faster than 100 Hz. (even the skilled musicians). So assume the switch is being switched at this rate for one second. How many counts would be experienced?

2) HAZARDS:

Pre-Lab: For the circuit diagram shown in Figure 3, assume the propagation delay for each of the logic devices is 8 nsec. Set the inputs X and Y equal to a logic "1". and let input Z vary from "1" to "0" and then "0" to "1" as shown in the timing diagram. Complete the timing diagram. The "time" axis is relative. Label it as necessary to convey the information you feel is required to understand the solution. (Does it make sense to make each division 8 nsec.?)

Also, as part of the Pre-Lab, draw the interconnection (wiring) diagram, showing the devices, the pin numbers and connections interconnecting the various devices.

Build and demonstrate to the TA’s the performance and Hazard Measurement: In this part of this lab, you are to measure the dynamic behavior of a circuit and observe the hazard. Note that both X and Y are both set to a logic "1". Let input Z be the output of the signal generator. Set the signal generator for a 10 Khz., and use the 0 to 5 volt TTL output. Measure the characteristics of the hazard. By that I mean the rise and fall times, the pulse width, and verify that it occurs (in a relative sense) where you predict it will in the timing diagram that you drew prior to coming to lab. Record this data and note any anomalies you observe. Use both the analog and digital capability of the scope to help with your analysis.

Questions to be answered as part of this lab.

2-1) Can you think of a way to eliminate this hazard problem in a digital circuit?

3) LOGIC GAME:

Pre-Lab: The pre-lab for this problem involves designing a logic circuit that will solve the problem described below. In designing the circuit, use Boolean algebra to optimize the circuit.

Prior to coming to lab, design the circuit from the algebraic expression you came up with to solve the problem. You should show it to the TA to make sure you are on the right track.

Build and demonstrate to the TA’s the performance of Logic Game: In this part of the lab, you are to build, test, and demonstrate the circuit you built satisfies the problem described in detail below. Use the "Switch Board" switches to represent the farmer, fox, chicken, and sack of grain. Throwing the switch simulates crossing a stream. The object is to ultimately get all the switches from one position to another, moving only one or two at a time (simultaneously). The switch representing the farmer must be switched on every move. Use one of the LED's to indicate the output is valid as the switches are moved from one position to another since the farmer is the only one that can row the boat. Other LED's may be used to indicate the position of the four switches - that is, one side of the stream or the other for the farmer, fox, chicken and grain.

After designing the truth table, by applying the various inputs to the circuit, determine the sequence that must be employed to solve the problem. Note and explain in your write-up, any anomalies you observe.

Problem: A farmer, who owns a fox, a chicken and a sack of grain decides to go to town. (S)he decides to take the fox, chicken, and grain with her/him. As she/he goes on her/his merry way, she/he encounters a stream. There is a boat there, but it is small and she/he can only carry one item at a time, along with herself/himself. However, there is a dilemma: Realizing that the chicken cannot be left alone with the grain, for the chicken will eat the grain; and also cannot leave the chicken and fox alone together, for the fox will eat the chicken. Taking the fox in the boat first, the chicken will eat the grain; and taking the grain, the fox will eat the chicken. Thus the chicken must be taken across first. Then what? Keep in mind that the farmer is the only one that can row the boat, therefore the farmer must always be one of the passengers on the trip(s) across the stream.

What must the farmer do to cross the stream and get the fox, the chicken, and the sack of grain across the stream and into town?

Your assignment is to design a logic circuit that will represent the situation described in the problem, using switches to represent the farmer (S0), fox (S1), chicken (S2), and grain (S3). If the switch is in the "0" position, this represents one side of the stream; if the switch is in the "1" position, it represents the other side of the stream. Throwing the switch represents crossing the stream. Use one of the LED's to indicate a "valid" move condition, that is, LED ON indicates the condition resulting from throwing the switches is valid; LED OFF indicates an invalid condition occured. Remember, you can throw one or two switches at one time since that is the capacity of the boat. Also remember, one of the switches must be the one representing the farmer. (good luck).

Questions to be answered as part of this lab.

3-1) What are the characteristics of the hazard that you observed in the circuit of Figure 1?

3-2) If the switches on the "Switch Board" were not "debounced", What impact could that have on the performance of the logic circuit?

3-3) What is the impact of using 3 inverters in series as shown in Figure 1?

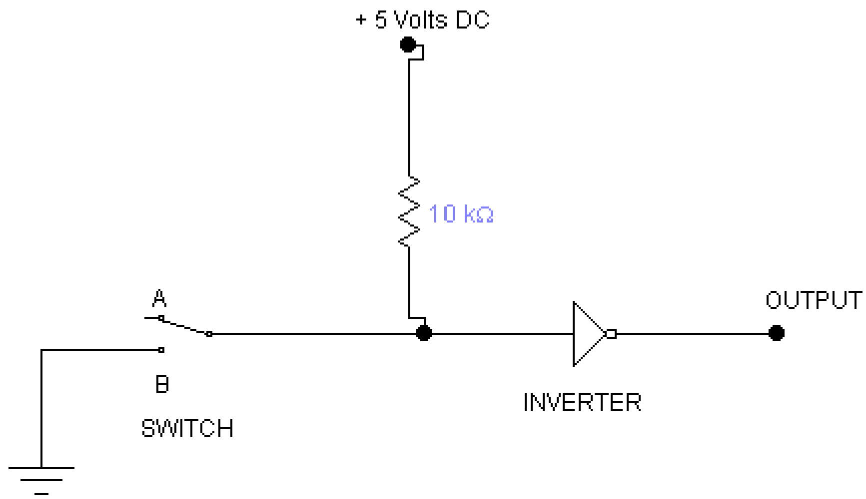


FIGURE 1

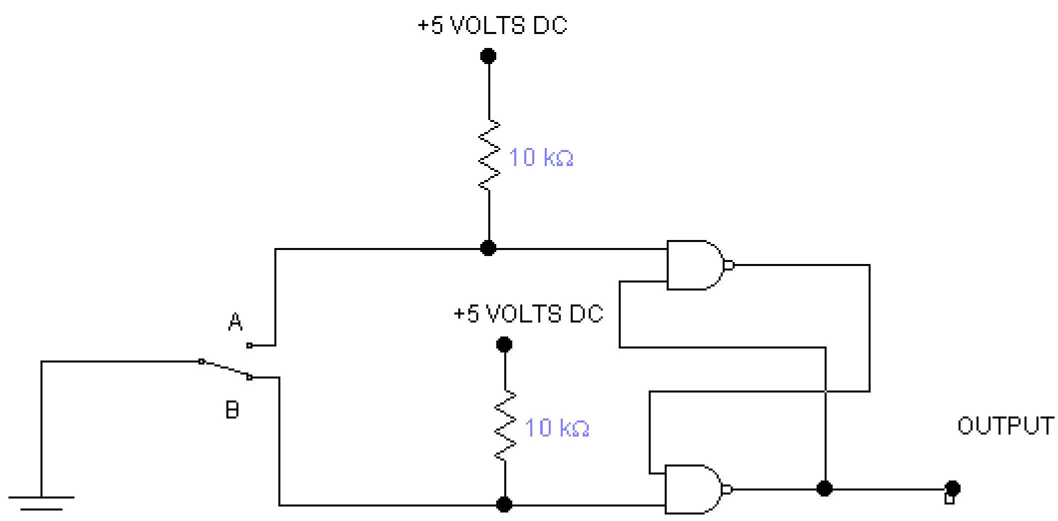
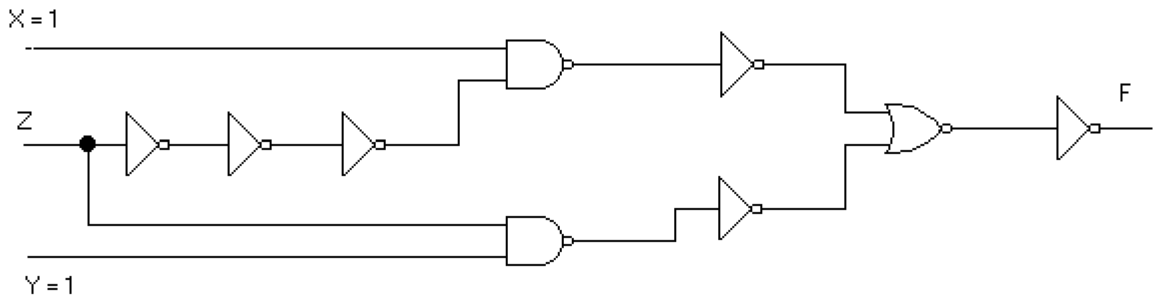


FIGURE 2



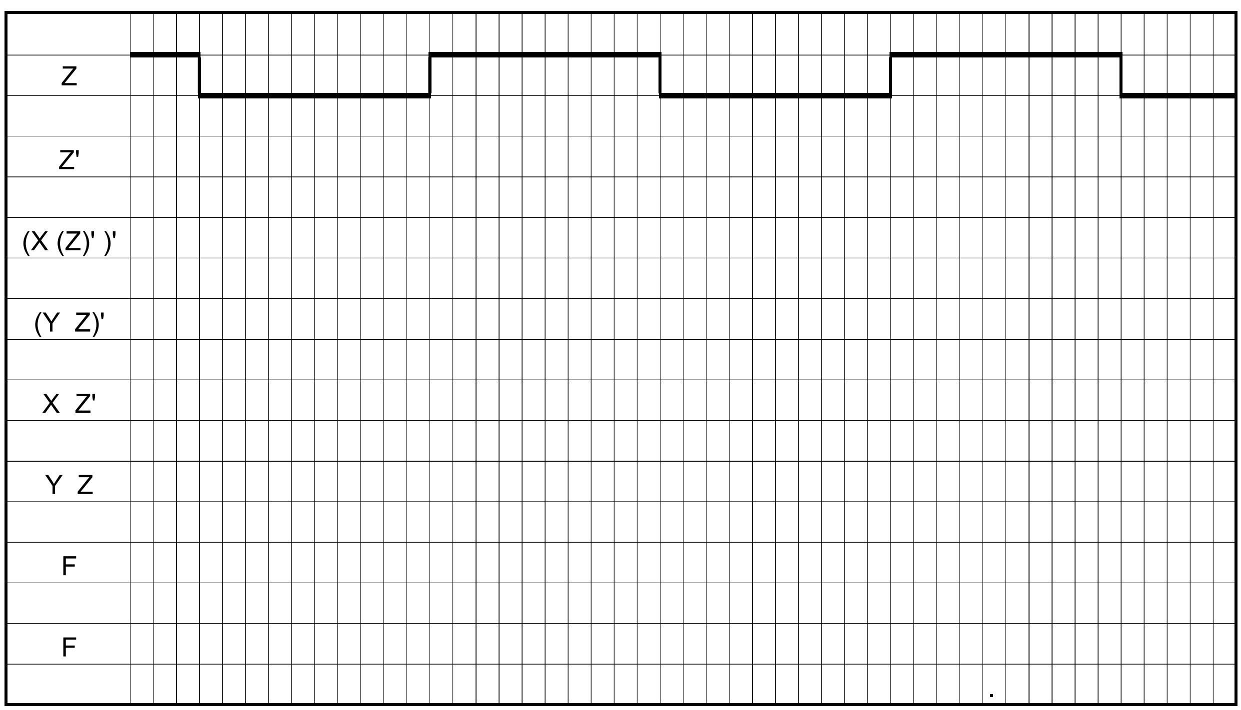


FIGURE 3

(Note that time is relative – you pick the scale you want to use.)