EGR 270
Fundamentals of Computer Engineering
File: N270L1

Lab # 1

Introduction to Logic Circuits

A. Objectives

The objectives of this laboratory are to introduce the student to:

- basic breadboarding and wiring techniques
- the use of input switches and output LEDs in generating truth tables for a combinational logic circuit
- circuit documentation and report writing

B. Materials

Breadboard
5V Power Supply
7408 Quad 2-input AND
7432 Quad 2-input OR
7486 Quad Exclusive-OR
220 Ω resistor
LED

C. Introduction

This lab focuses on several practical issues related to breadboarding and testing combinational logic circuits. Several helpful points are made below.

Wire gauge - Use only 22 gauge wire. The breadboard may be damaged by forcing smaller gauge (larger diameter) wire into the holes.

Wire color - Use organized color schemes when wiring circuits. For example, use RED wire for all Vcc connections, BLACK wire for all ground connections, BLUE wire for all input switches, and YELLOW wire for all intermediate signal connections.

Wire length and placement - Use wires that are the appropriate length so that they can lie flat on the breadboard. Avoid running wires over IC's in case the IC's need to be removed.

Testing IC's - If a chip tester is available in lab, always check your IC's before you begin wiring the circuit.

Inserting IC's - IC's are not difficult to insert in the socket strips once they have been properly adjusted. Brand new IC's are shipped with their pins bent apart from the vertical (typically 15° outward) in order to facilitate handling by automatic insertion equipment. Therefore, before an IC is used for the first time its pins must be bent back so that their spacing is vertical.

IC Orientation - Arrange all IC's in the same direction. This will facilitate connecting Vcc on each IC to a 5V strip on the breadboard and GND on each IC to a ground strip. If an IC is reversed (thus Vcc and ground are reversed), it may be destroyed. It is recommend that you begin wiring by making all Vcc and ground connections.

IC Removal - It is recommended that you use some sort of extraction tool for removing IC's. Attempts to remove IC's by hand may result in bent pins.

LEDs - LEDs (light emitting diodes) are diodes that emit light when they are forward biased (a positive voltage placed across the LED from anode to cathode as in Figures 2A and 2B). The amount of light produced is proportional to the current through the LED (see Figure 2C).

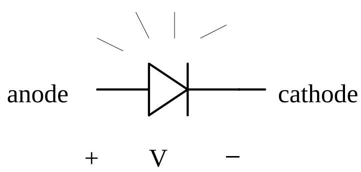


Figure 2A: Forward-biased LED

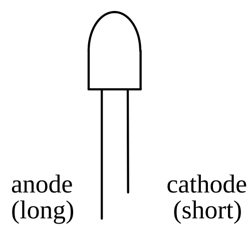


Figure 2B: Physical appearance

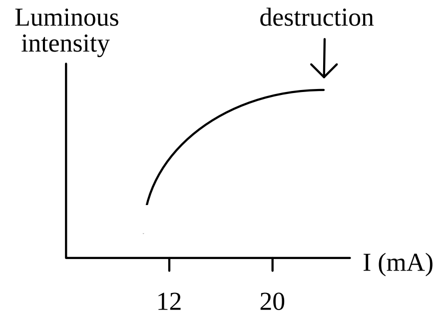


Figure 2C: typical LED characteristics

The resistance of an LED is sufficiently low such that if 4V is placed directly across an LED, it will be destroyed. Therefore, a current-limiting resistor should always be used with an LED. The resistor must be chosen to yield a current such that an appropriate brightness is obtained. If the typical output of a TTL gate is 4V and if the desired current range to produce a suitable brightness is 12 - 20 mA, then the value of the current-limiting resistance can be calculated as follows:

$$R_{min} = \frac{4\text{ V}}{20\text{ mA}} = 200\ \Omega \qquad R_{max} = \frac{4\text{ V}}{12\text{ mA}} = 333\ \Omega$$

Common values for current-limiting resistors are 220 Ω , 270 Ω , and 330 Ω. LEDs can be wired either to light when the output of a gate is HIGH (active-HIGH) or to light when the output of a gate is LOW (active-LOW). Both methods are shown in Figure 3.

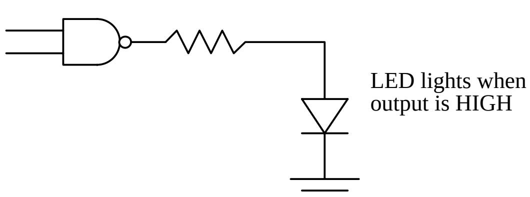


Figure 3A - Active-HIGH LED connection

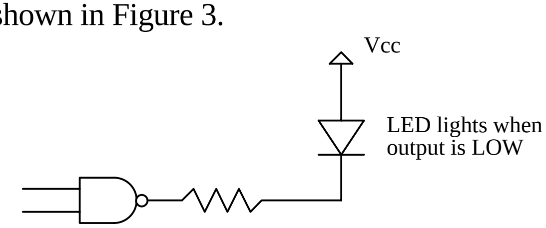


Figure 3B - Active-LOW LED connection

Switches - If switches are not available on the breadboard, they can be formed easily using single-pole single-throw (SPST) switches as shown in Figure 4.

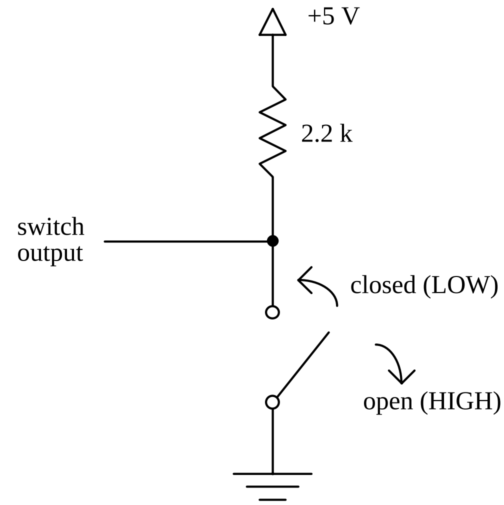


Figure 4 - Simple switch

The switch shown above is sufficient for combinational logic circuits, but not for sequential logic circuits, due to potential problems with "contact bounce". When the switch above is thrown, the contacts will bounce for several milliseconds before settling down. This could cause several transitions in a sequential circuit (such as a counter), but causes no problem with a combinational logic circuit since the transitions occur to quickly for us to detect with our eyes. "Debounced" switches will be required later in the course for sequential circuits to insure that only one transition (from LOW to HIGH or from HIGH to LOW) occurs. Figure 5 illustrates the difference in debounced switches and switches that experience contact bounce.

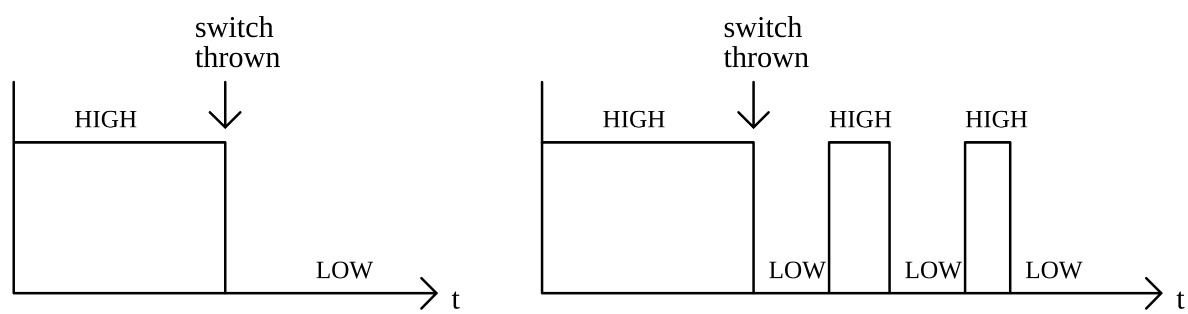


Figure 5A - Debounced switch

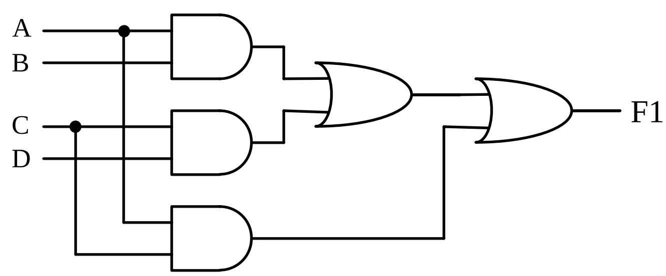
Figure 5B - Switch with contact bounce

D. **Preliminary Work**

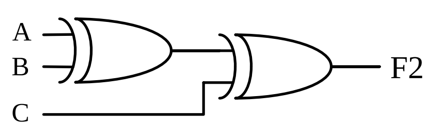
1. No design work is required for this lab. Simply present a documented circuit layout for Circuit 1 below including pinouts for all IC's used, a detailed circuit diagram with pin numbers labeled (also include input switches and output LEDs), a diagram showing the ordering of the IC's on the breadboard and the numbering (U1, U2, …) of each IC, and a wiring list.
2. Determine the truth table for Circuit 1
3. Repeat steps 1 and 2 for Circuit 2.

E. **Laboratory Work**

1. Construct Circuit 1 from the wiring list. Note any changes.
2. Test Circuit 1, filling in a truth table prepared for recording the circuit response for all possible input combinations. The truth table should match the truth table prepared in the Preliminary Work.
3. Construct Circuit 2 from the wiring list. Note any changes.
4. Test Circuit 2, filling in a truth table prepared for recording the circuit response for all possible input combinations. The truth table should match the truth table prepared in the Preliminary Work.



Circuit 1



Circuit 2