Lab 12: Combinatorial Logic

U.C. Davis Physics 116B
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INTRODUCTION

In this lab, you will explore the operation of the most popular logic gates and build some useful circuits with them.

We are now beginning the topic of digital circuits in earnest. Most of the labs from now on will use many digital ICs. The lab has several digital data books which contain the pinout diagrams for these ICs. Rather than include the pinouts in the lab writeups, I want you to get used to using data books to get the information you need. So, please use the data books. They are here for you.

1. LOGIC GATE TRUTH TABLES

Begin with the basics. *Experimentally* construct truth tables for the 2 input NAND, AND, NOR, OR, and XOR gates. To do this, find the part numbers and pinouts for each of these gates in a TTL data book. Get one of each IC from the parts bins. Doing one IC at a time, connect the power supplies and test one gate on the IC. Use two of the logic switches for the two inputs. Use one of the LED monitors as the output. Set the switches in all 4 of their possible configurations and record the inputs and output in a truth table. Note that you do not need to record exact voltages; a "1" or a "0" is enough information for a digital system.

For your lab report, give your 5 truth tables along with the logic symbol for each gate. For each truth table, note whether or not it agrees with the expected truth table given in the text or in lecture. (I would expect these to agree.)

2. LOGIC COMPARATOR

The function $XNOR = \overline{XOR}$ is often called the equality or comparator function. It is similar to the voltage comparator but it compares two *digital* numbers and tests for equality. For this circuit, let us compare two 2-bit numbers, A and B. The 2 bits of A will be called A1 and A0 for the most significant and least significant bits, respectively, and similarly for B. The circuit shown in figure 1 will compare these two numbers. The Q output will be high when the two numbers are equal.
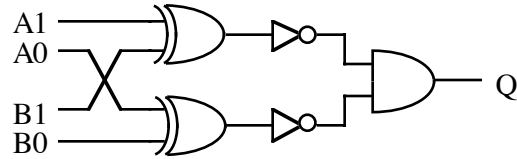

Figure 1: Logic comparator.

Construct this circuit (or an equivalent circuit which you can calculate using Boolean algebra). Use the 4 logic switches for the 4 inputs and an LED monitor for the output. Test its operation by inputting several combinations of numbers and observing the output. For your lab report, explain in your own words how the inputs represent two numbers and how this circuit compares the two numbers.

3. MULTIPLEXER

A multiplexer is a digital circuit that selects one of several inputs. We will make a 4-input 1-bit multiplexer. This means we have 4 data lines, A, B, C, and D, and four control lines, A_c, B_c, C_c, and D_c, one for each of the four data lines. The function we must implement is $Q = AA_c + BB_c + CC_c + DD_c$. Draw a circuit that will implement this function. Wire that circuit using any available ICs and verify its operation. The AND-OR-Invert, or AOI, circuit may be a good choice for implementing this function. For your report, include your circuit diagram and a description of how you tested your circuit.