

ECE 201 - Lab 1

The Seven Segment Display

PURPOSE

To familiarize the student with the seven-segment LED display, and the process of converting one type of binary signal to another (decoding). A good understanding of BCD (Binary Code Decimal - Mano: p.80) should also result.

EQUIPMENT:

ECE 201 Lab Kit

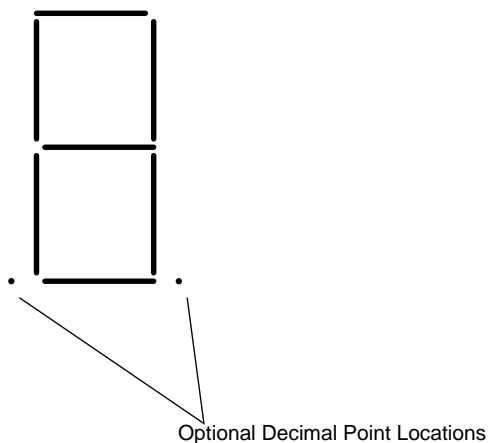
REQUIREMENTS:

Circuit diagrams with pin numbers labeled plus a concise verbal description of the operation of the circuits. Truth Table for all seven segments, plus all seven functions in MSOP. Simulation of functional seven segment display circuit.

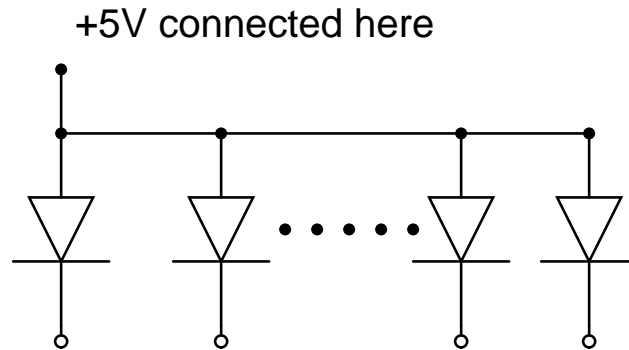
PROCEDURE

WARNING! Improper or careless connections to the seven-segment display can destroy it. Double check your connections **BEFORE** applying power.

The seven-segment LED (Light Emitting Diode) display has become a common device in consumer electronics, from calculators to clocks to microwave ovens. In this lab, you will learn the basic principles of operation of the seven-segment display and the process of converting BCD values to the proper signals to drive the seven-segment display. The seven-segment display has seven separate LED's (bar-shaped) arranged as shown.

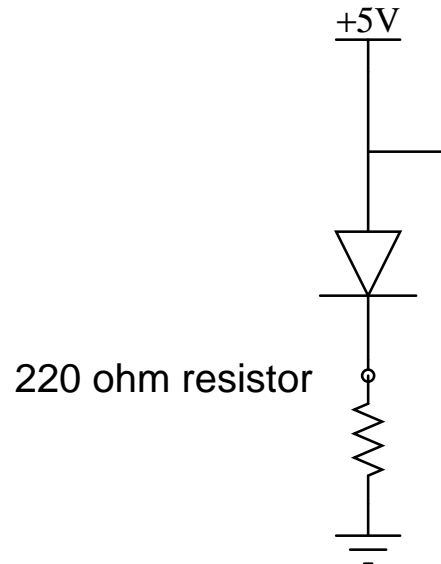


In addition, many seven-segment displays have a round LED used as a decimal point. (The decimal point can be on either side.) Inside the seven-segment display, one end of each LED is connected to a common point. This common point is tied either to ground or to the positive supply, depending on the specific device. Your seven-segment display is designed to have this common connection tied to the positive supply (+5V). A schematic for the device looks like this:



Individual inputs connected here

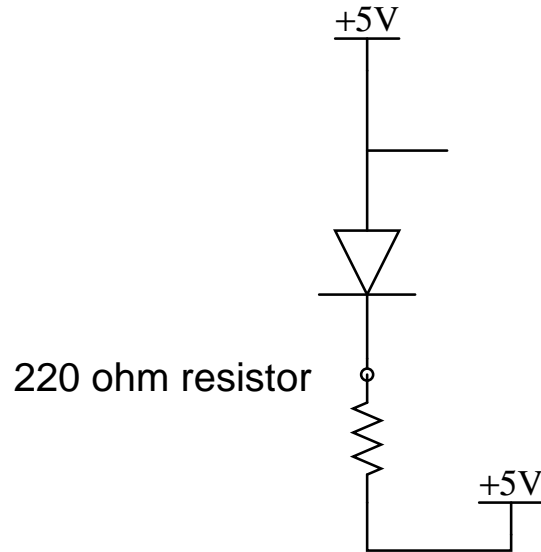
Now, let's see how to light up a single LED segment.



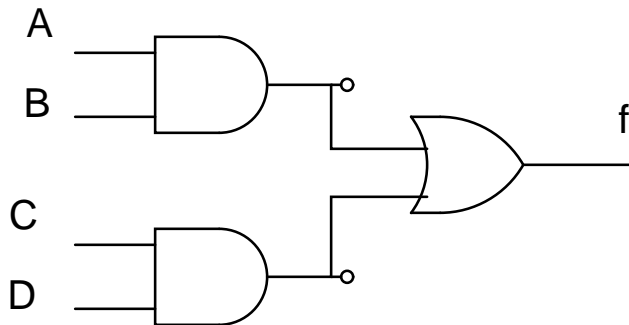
NOTE: The resistor is critical! If you connect the LED between +5V and ground without the resistor, the LED will momentarily glow bright and then

NEVER glow again.

If we connect the resistor to +5V instead of ground, there is no voltage drop across the LED and resistor, thus no current through them, and the LED remains dark.

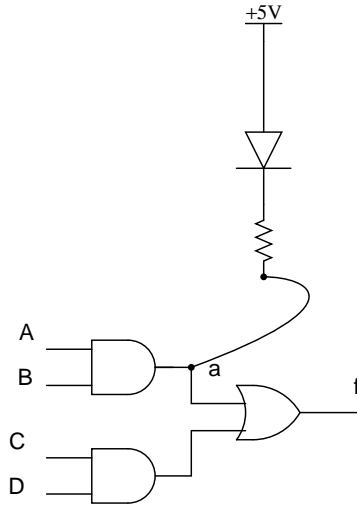


We now have a valuable tool - a logic indicator - which we can use for troubleshooting circuits. Look back at Lab 1, the burglar alarm circuit. What if f had functioned improperly



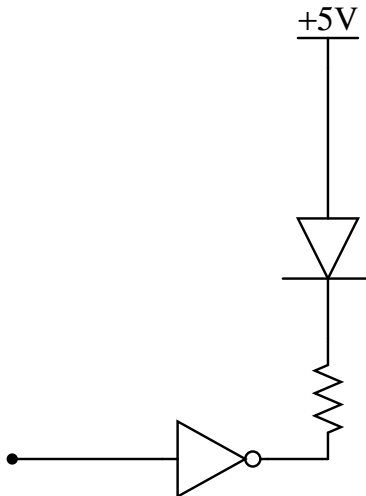
when we hooked up the circuit? Either the OR gate is connected wrong or one (or both) of the AND gates is connected wrong. How do we find the error? Using a wire from the resistor of the LED circuit as a probe, we can check points in the middle of the circuit.

example:

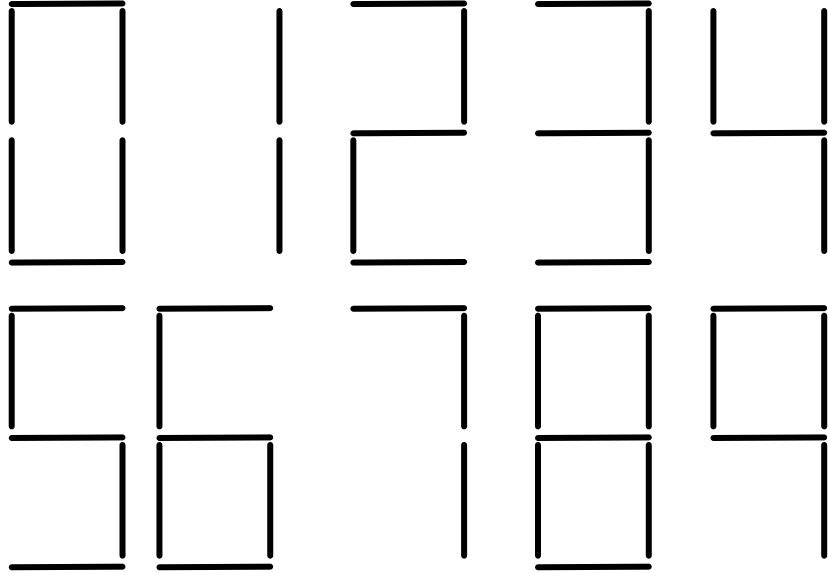


Remember, the light coming on indicates a logic 0. If the point a checked out correctly, then test point b. If point b is correct, then the problem is in the connections to the OR gate. If point a or point b checked incorrectly, the problems lies in the circuitry leading to that point. With a little practice, you should be able to trouble-shoot your own circuits, which is a valuable skill to have.

NOTE: You can also use the LED's built into the Digi-Designer for trouble-shooting, but you must remember that they come on with a logic 1. In other words, they have a NOT gate built in to the circuit.



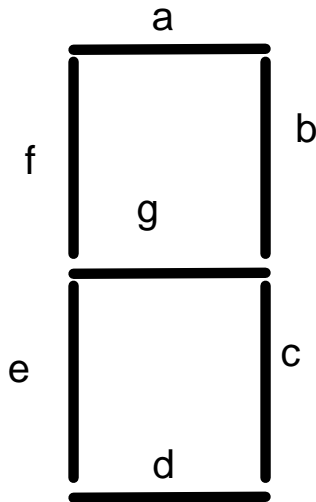
Let us now look at how the ten numerals are formed by lighting different segments.



Note: 1 has the two right side bars lit, the left side is dark.

What we wish to do is input a BCD (4-bit) number to some combinational circuit which causes the appropriate segments to light up. (e.g. if 0000 is input to the circuit, all of the LED pins on the seven-segment display should go low except the pin connected to the center horizontal LED).

For reference purposes, each segment is assigned a letter so that it can easily be referred to. The standard scheme is



If a decimal point is present, it is denoted DP. Let us determine the appropriate combinational circuit to light the a segment. Remember that BCD

numbers use only ten of the sixteen possible combinations of four bits (0-9), thus for the six inputs 1010 through 1111, we do not care what comes out of the circuit (since these inputs should never occur). First a truth table.

D	C	B	A	f_a	The "X"s in the truth table indicate the "don't care"
0	0	0	0	0	
0	0	0	1	1	
0	0	1	0	0	
0	0	1	1	0	
0	1	0	0	1	
0	1	0	1	0	
0	1	1	0	0	
0	1	1	1	0	
1	0	0	0	0	
1	0	0	1	0	
1	0	1	0	X	
1	0	1	1	X	
1	1	0	0	X	
1	1	0	1	X	
1	1	1	0	X	
1	1	1	1	X	

conditions, rows in the table where we do not care what the output of the function is. Using Boolean algebra, we can write the minimum sum-of-products expression for f_a as:

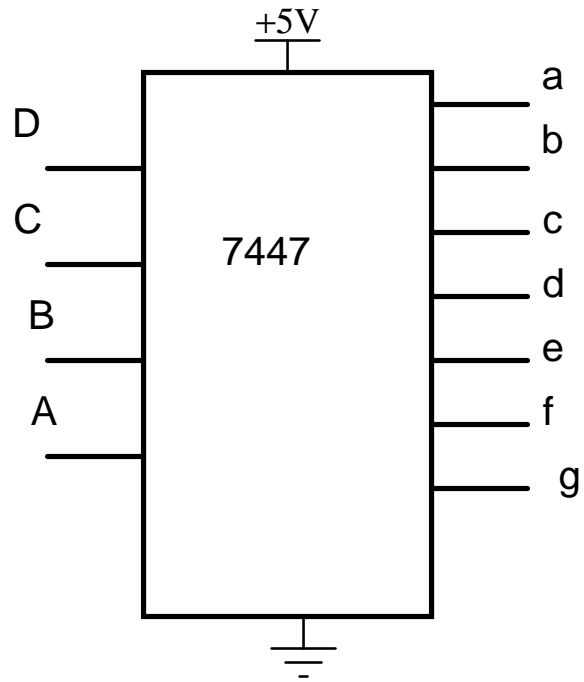
$$f_a = D'C'B'A + CB'A'$$

QUESTION: what comes out of this circuit for each of the six invalid inputs? (e.g., what is F_a if the input is 1010?)

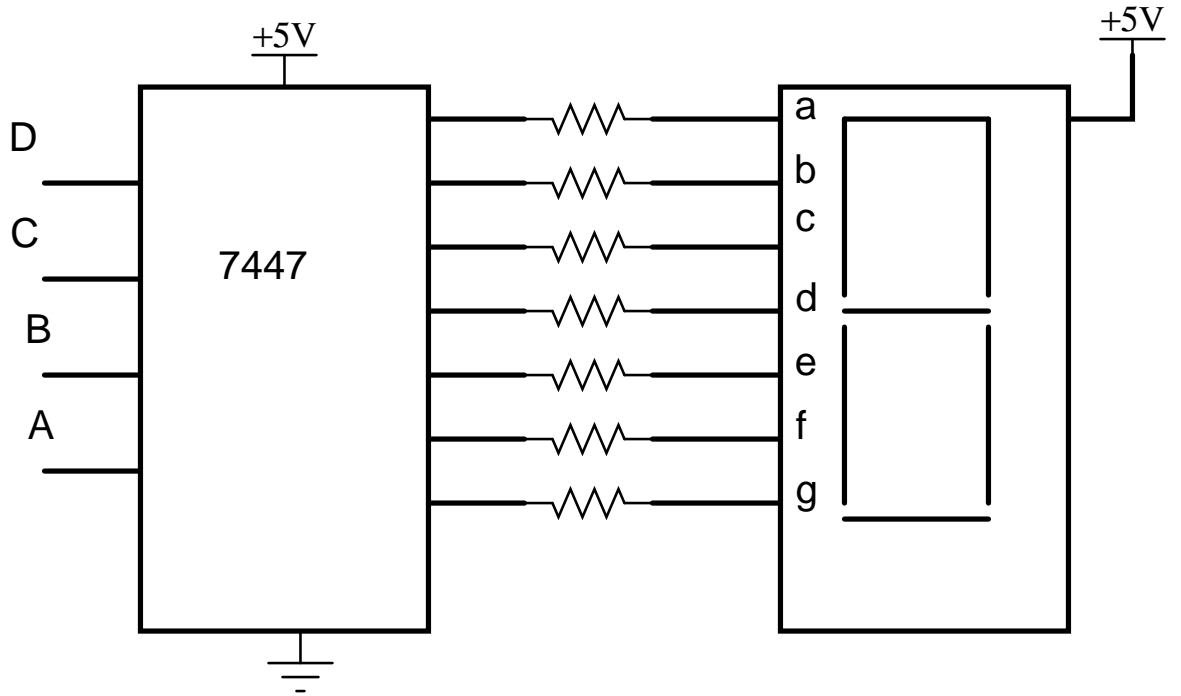
Now, make up a truth table for all seven segments and find a function (MSOP) for each. NOTE: you need not make a separate truth table for each segment - just list the inputs once, and have seven output columns.

D	C	B	A	f_a	f_b	f_c	f_d	f_e	f_f	f_g
0	0	0	0	0	0	0	0	0	0	1
etc								etc		

We need not build all these circuits in order to use the seven-segment display, however, because this group of seven circuits can be found in a single IC, the 7447. The 7447 is called a BCD to seven-segment display. A Block diagram.



Now, using the 4 switches of the Digi-Designer as the BCD input, connect the following circuit and verify that it functions properly. Include a description of the circuit operation in your report.



Resistors = ~200-500 ohms

Remember - be very careful wiring this circuit, making sure that no resistor leads are shorted anywhere and that the power to the seven-segment display is connected to the correct pin. DO NOT short any pin of the seven-segment display to the ground! (Unless you want to kill it forever.)

Check the six unused input combinations (1010 through 1111) and report which segments light up. Does this match what you would expect from the seven equations you got for the decoder? If not, can you think of one reason why the output might not match your equations?