Experiments No. 4 & 5

DESIGN AND TESTING OF SEVEN SEGMENT DISPLAY

Thomas J. Dolan

Department of Electrical & Computer Engineering

Missouri University of Science and Technology

[tjddhd@mail.mst.edu](mailto:tjddhd@mail.mst.edu)

**Abstract:**

The experiments to be discussed will be over the conceptualization, parts, design, and implementation of a seven segment decoder, similar to the number display of a digital clock. This experiment is to be approached cautiously, as it can cause some confusion. Before even starting the laboratory, you will need to create simplified logic expressions for each segment of the display module. With these designs in hand, prepare to draw a schematic on a circuit design program (In this report, we shall be using Altera Quartus II). After debugging is complete, we will model the circuit in Altera ModelSim to observe how the design will react given a real world implementation and inputs. We will do this by observing the waveform and comparing inputs to expected outputs. The next laboratory experiment deals with taking the aforementioned design and implementing it onto a breadboard. Results can be verified by correct operation of the circuit.

**Introduction:**

The seven segment display is a fundamental of the digital world. It is an excellent tool for relaying information, whether it is the time on a clock or output from a calculator, to name a few examples. However, it is important that the display correctly displays information. In order for the display to be useful, it has to function as expected when the correct inputs are given. This is a 2 sided problem. Firstly, the display will need to show the right output given a certain input. Thus, it must work theoretically. Secondly, given a correct design, it must be physically implementable and practical. Thusly, the design must be able to work in a circuit and then connected to other electronics in order to work together to perform some task. As such, it is a good idea to know how to wire up a design and then have it display some sort of output.

**Background and Theory:**

In order to gain a good understanding of the lab and its benefits, first you must familiarize yourself with ideas behind the experiment. To help model your equations, you must first know what the display looks like and how your inputs will affect it. The seven segment display has, unsurprisingly, seven individual segments that will light up based upon your input (See attached 1 for pictorial representation). Each of the different segments A-G will have a different logic expression for itself. This is to help with the display to show different output for different input (i.e. you want 0 to display given input w=0, x=0, y=0, z=0 and 1 to display given w=0, x=0, y=0, z=1). For this experiment, we are going to display the numerical digits 0-9 and the Arabic letters A-F. This gives 16 total outputs thus we will derive 7 four variable expressions, one for each segment.

The seven segment display is active low output device, thus the display will work when a variable is equal to 0 or a logical false. Having this in mind, you should construct a truth table for each logical input of w, x, y, and z. Using this, you can then construct a Karnaugh Map (K-map) for each segment. This will give you a simplified expression that should be fairly easy to understand and represent. Using these 7 equations, you can then go into Quartus and design a circuit. Once correct, it can be simulated in ModelSim and then wired up on a breadboard.

**Procedure:**

Using your derived equations, create a logic network and circuit that can be implemented (See attached 2 for example on what network should look like). There are many variations as to what a person will design. You may be using inputs, outputs, AND gates, OR gates, NOT gates, NAND gates, NOR gates, or XOR gates. It just depends on your equation. Once you have a design that could work, compile it. That will be a preliminary test on whether your circuit will even function correctly. Once you have a good compilation, extract VHDL code and move to ModelSim software program. There you should compile the VHDL file once again to get a working module. Next, create a waveform and run for some predetermined amount of picoseconds (See attached 3). This is good as a check of your design to make sure you are getting the correct output. After you have verified these results, you are ready to move onto a breadboard. Once you have gathered the necessary pieces and parts, begin to place them on the bread board in the corresponding design spots. After you have finished, test your implementation using given inputs. Given that you were able to do all this correctly, you should be able to display the digits 0-9 and the letters A-F with no trouble now.

**Conclusion:**

As you can see, seven segment displays, though rather simple in concept, can be a challenge to make. It is an excellent way for a new student to test themselves on logic networks, K-maps, design, implementation, debugging, and physical representation. Much of what is learned in this exercise can be applied to future exercises. A student who can do this experiment well is well on their way to being a great computer engineer.