Lab 3 – Combinational Logic II ELE202 FALL2007

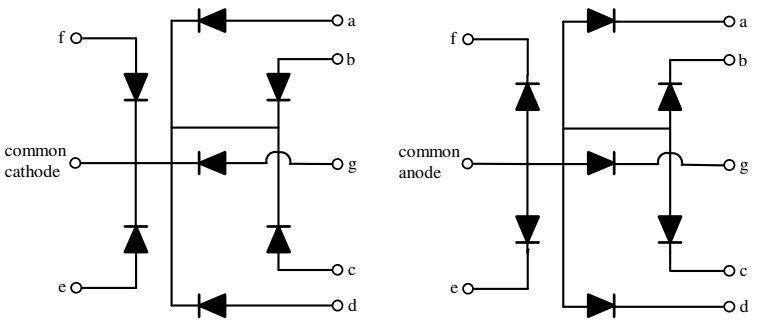
Objectives

- Learn to use a 7-segment display
- Build and test a larger, multi-output combinational circuit

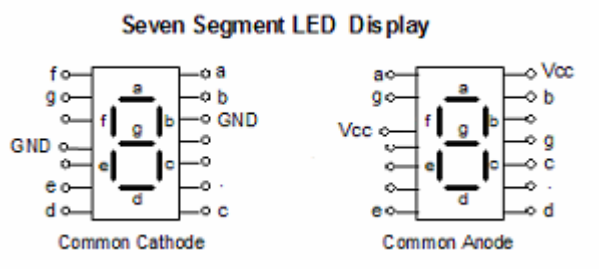
Procedure

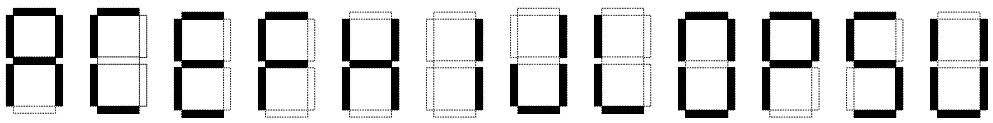
1. 7-segment displays (technologies include LEDs, liquid crystal, etc.) are often employed to display decimal data to a human user. The typical LED display consists of 7 rectangular shaped LEDs in a figure 8 pattern with segments labeled "a" through "g" as shown below (also shown are the representations for zero through nine).

(Over time there have been other implementations of these displays; some have had more segments to enlarge the set of characters available for display.) The 7 LEDs are wired in one of two ways, *common cathode* or *common anode*, as shown to the right, which shows that one of the leads of each of the LEDs are wired together so as to save pins required for the device and to allow for multiplex operation (more on this at a later date). For use in a circuit, the device's normal pin connections are shown below for both types of device. The first thing that you should do is identify which one you have in your kit.



With a little imagination, various letters of the alphabet can also be displayed using 7 segments. For example, an E can be generated by lighting segments a, d, e, f, and g; an L is segments d, e, and f. In all, the uppercase letters A, C, E, F, H, I, J, L, O, P, S, and U are easy to construct; specific segments to create these letters are shown below:





2. For this week you are to design a 3-input, 7-output combinational circuit that displays a particular set of letters depending upon the values for the inputs. You will pick an unique word or words to display; some examples are shown in the section below. The intent is that as you sequence the inputs **A**, **B**, and **C** through the 8 values in the usual binary count (i.e. **ABC** = 000, 001, 010, …111), then your circuit should sequentially show the 8 letters, displaying a word on your 7-segment display.

   For example, if I wanted to display the sequence "ELE 202 " (with spaces between), I could design a 3-input, 7-output combinational circuit to:
   - Display an "E" on the 7-segment display (i.e. turn on segments a, d, e, f, and g) when the inputs take on values **ABC** = 000 or 010.
   - Display an "L" (segments d, e and f) when **ABC** = 001
   - Display an "2" (segments a, b, d, e and g) when **ABC** = 100 or 110
   - Display an "0" (segments a, b, c, d, e and f) when **ABC** = 101
   - Blank the display (all segments off) when **ABC** = 011 or 111

   Using Karnaugh maps to reduce the logic, an implementation of "ELE 202 " would require the following combinational logic:

   a = **C' + A B'** b = **A B' + A C'** c = **A B' C'**

   d = e = **B' + C'** f = **A' B' + B' C + A' C'** g = **C'**

   for a total of 10 gates.

Notes:

- As was seen in earlier labs, a counter is a useful method to generate all combinations of a set of input variables for exercising a combinational circuit. As in Lab 1, apply a 2 Hz clock to the counter chip (from the 555 timer chip) and using three adjacent outputs of the counter to sequence through inputs **A**, **B**, and **C** (you want **C** to change most quickly), you should be able to observe your word spelled out.
- To do this lab, you must create a truth table for each of the 7 segments (outputs) versus the 3 inputs. Reduce each output logic to simplest form.
- The display contains multiple LEDs that need some voltage protection. When wiring, use a separate (500-1000Ω) resistor in series with <u>each</u> diode (i.e. in series between the logic functions for a through g and the pins on the display – you will need 7 resistors).
- If a segment is to be on for all counts, you can just connect its resistor to the power supply. Similarly, segments that are always off don't need any connection at all.
- If a segment is to be connected to **A**, **B**, or **C** directly, use some sort of buffer to isolate it from the rest of your circuit; otherwise, the LED might "load" the signal and cause other gates to malfunction. This buffer could be two invertors, an AND gate, or an OR gate.

Lab 3 – Word Assignments

Pick real word or words for your display for the demonstration. Examples are: "ACE_FISH", "PEA_SOUP", "HELLO_JO", "_JOSEPH_", and "SEASHELL", where "_" denotes a space.

Lab 3 – Combinational Logic II Report Requirement

This is a full report submission that worths 12 points:

- The report begins with a cover page. It should include the title of the lab (include your "word" as part of the title), your name, your lab section, and the date the lab was submitted. Print this up ahead of time so that the instructor or TA who observes your circuit operation can sign it.
- Next, write a short abstract to summarize the lab – this should be 3 sentences or less.
- The main body of the report should be a concise, but complete description of what you did. I'm not expecting a long report, but be sure to include a discussion of your methods and results (include any references beyond the lab manual that you used). I'll be looking for the following components:
    - A clear table showing the required logic
    - K-maps, algebraic expressions, and logic diagrams for each output
    - A count of the number of gate inputs used

Grading will be split between the circuit working as expected, the accuracy of the information provided, report formatting (missing cover pages or necessary information, poor grammar and spelling, unlabeled and/or confusing figures, plots without units, etc. will all be penalized), and the overall quality of the report.