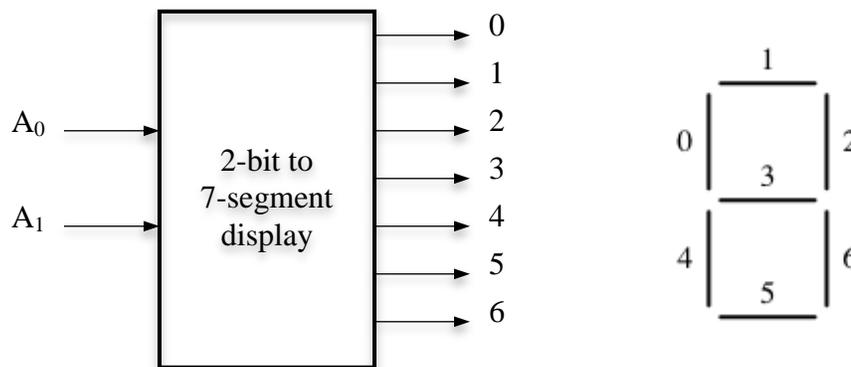


**6.111 Introductory Digital Systems Laboratory**  
Fall 2018

Lecture PSet #1  
*Due: Tue, 09/12/18*

**Problem 1 [2 points].** Consider a serial input bit stream that is either 1 or 0. Because of noise, at times the signal glitches, a 1 goes to 0 or a 0 goes to 1 momentarily. As a workaround, you sample the incoming data 4x faster (oversample) than the bit stream resulting in 4 samples ( $x_0, x_1, x_2, x_3$ ) for each data bit. For each data bit, if at least 3 samples are the same value, you consider the data valid and set  $z=1$ . Give a truth table for this function.

**Problem 2 [3 points].** A 2-bit binary-to-seven-segment decoder takes a 2-bit binary number  $A_1A_0$  as input and produces seven outputs, one for each “segment” in a standard display.



Given the appropriate binary input, this decoder produces outputs that light up the display in the following manner:



A “1” on an output lights up the corresponding segment. The input values are encoded as  $A_1A_0 = 00 = “0”$ ,  $01 = “1”$ ,  $10 = “2”$ , and  $11 = “3”$ . Give a truth table for the decoder. [You will be implementing your solution in Lab 1 with digital logic.]

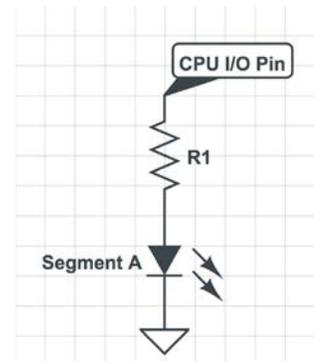
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**Problem 3 [5 points].** Rather than implement a seven segment decoder with gates, you decide to use an Arduino. The Arduino Uno uses the ATmega328P processor. For many DIY (do it yourself) projects, it's simply plug and play without any need to read the datasheet. When pushing the limits, it's important to understand what it can and can't do.

[This question is typical of the process an engineer goes through in industry. Unlike a lab or Ipset where the data for the problem at hand is neatly package and there exists a clean and sometimes unique solution, you will need to hunt through the datasheet to extract the relevant information. Many times you will need to make reasonable assumptions.]

In this problem, you are using an Uno to drive two seven segment displays. For each display, each segment consists of a LED with a forward voltage drop of 1.7V @20mA. There are 14 I/O pins on Arduino processor which are used to drive the segments.

- Operating at 5V and driving the LED using one of the I/O pins, what is the output high voltage (or range) of the processor? [To avoid reading the entire 400 page datasheet, go to [p365 and p366](#). Dedicated engineers may find the entire datasheet interesting – good bed time reading!]
- The LED is connected to the I/O pin with a resistor. What resistor value should be used to drive the LED at 20mA max?
- Assuming “88” is displayed, what is the total current for the display? Is this within the processor spec keeping the current at 20mA?
- At times a device may lack the pins needed to simultaneously transmit information. A solution is time division multiplexing. With this in mind, if you have only 14 I/O pins, describe how to implement a 4 digit seven segment display. To meet processor specification, the peak LED current may be less than 20mA. Hint: what limitation of the end-user can we take advantage of? You may additional semiconductor devices if needed. Draw a diagram of your solution. [A detailed schematic is nice but not required.]



<http://web.mit.edu/6.111/volume2/www/f2018/handouts/ATmega328P.pdf>