M A S S A C H U S E T T S   I N S T I T U T E   O F   T E C H N O L O G Y
DEPARTMENT OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

6.111 Introductory Digital Systems Laboratory
Fall 2018

Lecture PSet #2
Due: Thu, 09/13/18

One of the goals of the lpset is to get you up to speed with digital systems, Verilog, simulation, etc.. as quickly as possible. For that reason, the first few lpsets will be every lecture. Future ones will be spaced further apart as the term progress. Don't panic. There are only eight lpsets.

Problem 1. [As noted previously, MIT lpset problems are clearly and neatly structured. But in the real world, necessary information for a design is there but typically scattered across multiple sources. This problem is another sample of what you might encounter as an engineer.]

One way to transfer data from the 6.111 labkit to a PC is to use a serial to USB adapter. One approach (as you will see in lab 2) is to transfer data from the labkit to PC via the RS232 port on the labkit using a CH340 serial to USB IC. For this transfer, the only signals used in the labkit are transmit data (TXD) and received data (RXD) plus ground.

The labkit RS232 serial port is implemented using the MAX32222 IC
http://web.mit.edu/6.111/www/f2017/serial/max3222.pdf

The schematic of the labkit with the RS232 port details are provided in
http://web.mit.edu/6.111/www//labkit/labkit_schematic.pdf

The specifications for the CH340g IC are shown in the datasheet
http://web.mit.edu/6.111/www/f2017/serial/ch340g.pdf

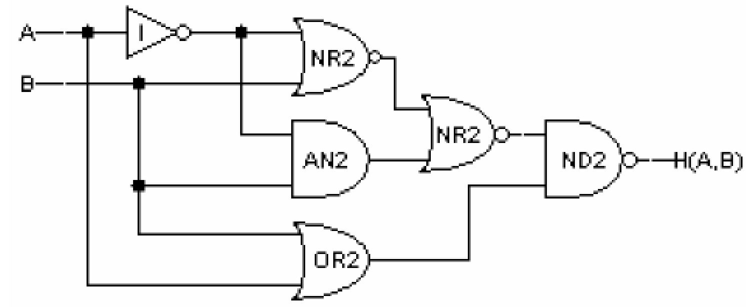
For a project you want to transfer data as fast as possible. Based on the above information,

(a) What device limits the maximum data transfer rate?
(b) What is the maximum data transfer rate?
(c) Are there potential problems interface problems? If so describe the problem.

(see other side)

Problem 2.

Consider the following circuit that implements the 2-input function H(A,B):



(A) Write a truth table for this circuit

(B) Give a sum-of-products expression that corresponds to the truth table in (A) (the expression does not have to be minimal sum-of-products) and check if it is minimal using a Karnaugh map. If not, provide a minimized sum-of-products.

(C) Using the following table of timing specifications for each component (roughly corresponding to a 45nm CMOS technology – state of the art circa **2018**: 10nm), what are t_{CD} and t_{PD} for the circuit shown above? (Write-out the delays that contribute to each of the two.)

Gate	t_{CD} [ps]	t_{PD} [ps]
I	5	15
ND2	7	25
AN2	8	45
NR2	9	35
OR2	11	55

Problem 3. A certain function F has the following truth table:

A	B	C	F(A,B,C)
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

(A) Write a sum-of-products expression for F.

(B) Write a minimal sum-of-products expression for F. While you can use Karnaugh maps, in some situation you can arrive at the solution by inspection. Show a combinational circuit that implements F using only INV and NAND gates (make sure that you use the right gate symbols with bubbles placed so that inversions are cancelled).

Problem 4. (From Katz, problem 4.9) Implement the 2-bit adder function (i.e., 2-bit binary number AB plus 2-bit binary number CD yields a 3-bit result XYZ) using three 8:1 multiplexers.

(A) Give the truth table showing the values for the outputs X, Y and Z given all possible combinations of the inputs A, B, C and D.

(B) Show how to implement X, Y and Z using three 8:1 multiplexers. You can assume you have the constants 0 and 1, along with the inputs and their complements.