Phy 415/515 Lab #11 2009 Digital Logic Gates

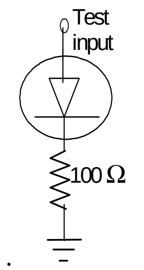

Figure 1. LED sensor.

__1. Switches and LEDs

___1.1.Power supply

Set the 0-20 side of the power supply to 5V. Create columns on the breadboard for +5, and ground.

___1.2.LEDs

Wire 2 simple LED sensors, as shown in Figure 1. Test them by connecting the input to +5 or gnd and seeing whether the LED lights.

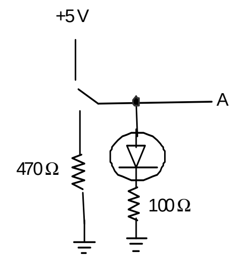

Figure 2. Switched input A with LED tester.

___1.3.Switches

Wire two SPST DIP switches to the two LED testers, as shown in Figure 2, to make two inputs, A and B, and make sure the LEDs toggle on or off depending on the switch positions. These will be used as inputs.

___1.4.More LEDs

Wire two more LED sensors to be used to test outputs.

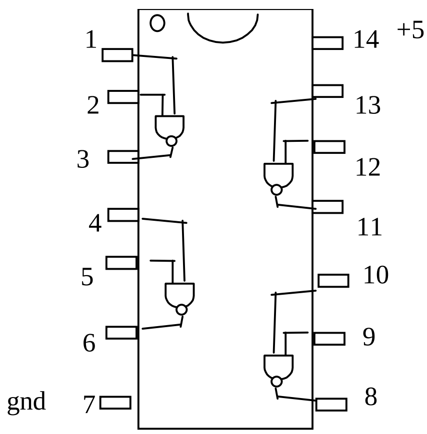

Figure 3. TTL Nand gate, 7400.

__2.TTL Nand

__3.Nand Tester

___3.1. Power the gates

Plug a 7400 TTL nand gate into the breadboard. The pin diagram is shown in Figure 3. Jumper from pin 7 to the ground column and from pin 14 to the +5 V.

___3.2. No inputs

Measure with a voltmeter the voltage on a couple of the input pins (for example pins 1 and 2) and an output pin (for example pin 3). Do TTL inputs float high? Is the output consistent with that?

___3.3. NOT

Make an inverter from the first nand gate on the chip: take a short wire and connect one of the inputs, pin 2, to +5. Connect the other input, pin 1, to the output A from the switched input of Figure 2. Connect one of the output sensors from part ___1.4. Toggle the switch and fill in the truth table, Table 1.

A	Q
0	
1	

Table 1 . Not Gate

___3.4. NAND

Remove the wire connecting pin 1 to +5, and instead connect pin 1 to the switched input B. Toggle the switches, and observe the outputs to fill in Table 2.

A	B	Q
0	0	
0	1	
1	0	
1	1	

Table 2 . Nand

___3.5. OR

Use the fact that $A + B = \overline{\overline{A} \cdot \overline{B}}$ to make an OR gate. Connect the switched inputs and observe the output using the LED sensor. Toggle the switches to fill in Table 3.

A	B	Q
0	0	
0	1	
1	0	
1	1	

Table 3 . Or

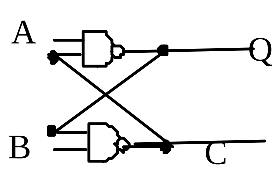

Figure 4. Flip flop constructed from TTL nand gates.

__4.TTL NAND Flip flop

___4.1. Connect

Move the input B wire to a second nand gate, and wire the two nand gates to each other, as shown in Figure 4. Connect the switched inputs to A and B. Connect the LED sensors to Q and C.

___4.2.Truth table (Do 4.2 later if time is short)

	A	B	Q
1	0	X	1
2	1	0	0
3	1	1	Q_o

Table 4 . Summary Flip flop results. X indicates “don’t care” and Qo is the previous value of the output.

full truth table for the flip flop, in addition to a column for A and for B, you need a column for Q_o, the value of the output before changing the inputs, as shown in Table 5. First, fill in the theoretical results for the first four blank columns ($\overline{C}$ is the expected output of the bottom nand gate in Figure 4). Follow the pattern below to fill in the experimental, Q, column.

			Theory				From circuit	
Q_o	A	B	$C = Q_o \bullet B$	$\overline{C}$	$A \bullet \overline{C}$	$\overline{A \bullet \overline{C}}$	Q	Line from Table 4
0	0	0						
0	0	1						
0	1	0						
0	1	1						
1	0	0						
1	0	1						
1	1	0						
1	1	1						

Table 5 . Flip flop truth table.

___4.3. Inverter

Switch B to low. Switch A back and forth, and fill in the truth Table 6. Paying attention to Qo, the previous value of Q, include your results in the Q column of the appropriate rows (1 and 7) of Table 5. This corresponds to lines 1 and 2 of Table 4.

A	Q_o	Q
0		
1		
0		

Table 6 . Double nand gate inverter with B low.

___4.4.Sticky inverter

Fill in Table 7, (and rows 2, 4, 6, and 8 of Table 5) in the order given: start with A high and B low. Now make B high, and proceed down the table. Setting A low “resets” the output high. If B is high the output sticks there.

A	B	Q_o	Q
1	0		
1	1		
0	1		
1	1		
0	1		
1	1		

Table 7 . “Sticky

___4.5. Latch

Continue from Table 7 (the output should be high) to Table 8. Making B low “sets” the output low and with A high it sticks there. This should give you lines 3 and 4 of Table 5.

A	B	Q_o	Q
1	1		
1	0		
1	1		
1	0		

Table 8 . Latch.

__5. CMOS Nand Gate

___5.1. No input

Leave the 7400 intact—you will need it later.Plug in a CMOS nand chip, 4011. The pin diagram is shown in Figure 5. Note that it is NOT the same as for the 7400, although the power and first gate are the same. Jumper to +5 for pin 14 and ground for pin 7. Measure the voltage on pins 1 and 2, the inputs, and on the output pin 3. CMOS inputs do not float high.

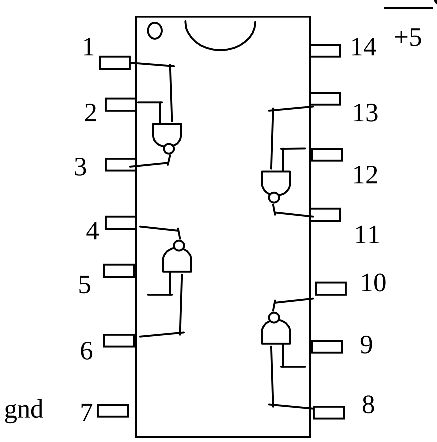

Figure 5. CMOS NAND chip, 4011.

___5.2. Truth table

Move the two switched inputs to the inputs of the cmos nand gate. Connect the second LED tester to the output of the cmos nand gate. Fill in the truth table. Is the LED every very bright?

A	B	Q
0	0	
0	1	
1	0	
1	1	

Table 9 . Nand

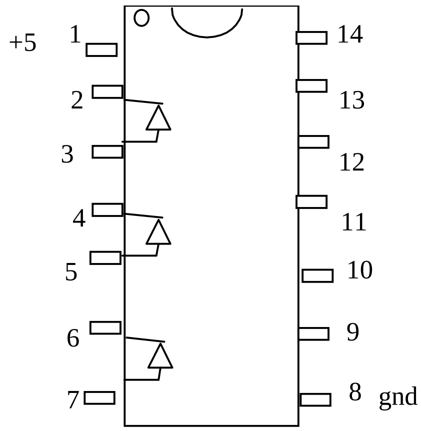

Figure 6. CMOS buffer, 4050.

___5.3. Attempt to connect to TTL

Connect the output of the cmos nand gate to the input of one of the TTL 7400 chip nand gates wired as an inverter(make sure you disconnect any other input). Connect the output sensor to look at the output of the TTL inverter. What happens? The cmos does not output enough current to drive the TTL. Leave both chips on the board.

A	B	Q
0	0	
0	1	
1	0	
1	1	

Table 10 . And

__6. Hex Buffer: the solution

___6.1. Different power connections

Plug in a CMOS buffer, 4050. The pin diagram is shown in Figure 6. Note the power connections are different than the other two ic's! Jumper pin 1 to +5 and ground to pin 8.

___6.2. Connect to TTL

Connect the cmos nand output to buffer input pin 3. Connect the buffer output pin 2 to the TTL (nand) inverter input. Construct the AND truth table.