Lab #15: Introduction to Computer Aided Design

Revision: November 14, 2007

Print Name:	Section:

GETTING FAMILIAR WITH YOUR NEXYS BOARD

Problem 1: (26 points) Visually inspect the Digilab Nexys board, enter the number of components in the blanks for all entries. (Get to know the Nexsys.)

COUNT ONLY INSTALLED DEVICES! Some positions are empty.

count	item
	resistors (Rx)
	capacitors (Cx)
	LEDs (LDx)
	7-segment display digits
	pushbutton switches
	slide switches
	diodes (Dx)

count	item
	integrated circuits (ICx)
	connectors (e.g J8 & JD)
	jumpers (e.g. JP4 & J7)
	inductors (Lx)
	crystal oscillator (X1)
	transistors (Qx)

Problem 2: (16 points) Complete the following test procedure for the Nexys board, circling Y (for Yes) or N (for No) for all entries.

Digilab Nexys Manual Test Procedure

Section 1. Power-on test. Connect USB cable to Nexsys and to your computer. Locate J4, set shunt to USB position (power from USB).

1.1	Proper USB cable obtained	Y	N
1.2	Power-on LED illuminates brightly	Y	N

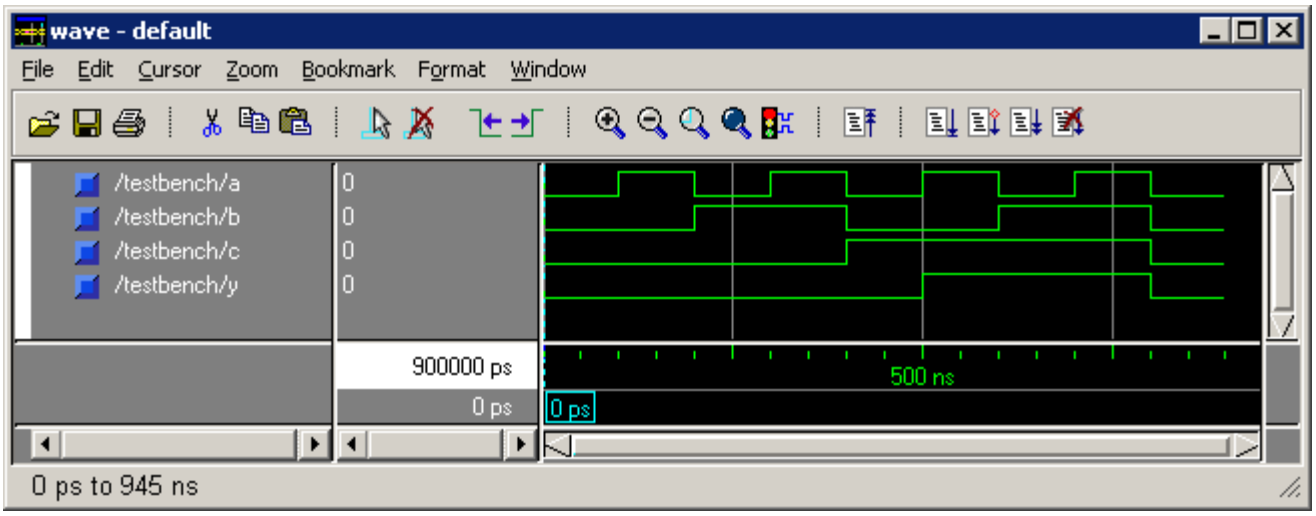
Section 2. Manual tests

2.1	red “power” LED illuminates when power switch is in the on position	Y	N
2.2	yellow “done” LED goes out when reset button pressed, comes on when released after brief delay.	Y	N

Section 3. Automated tests (diagnostic program running)

3.1	Both display digits count 0 – 9 with no dark segments	Y	N
3.2	All buttons function correctly (BTN0-BTN3)	Y	N
3.3	All switches function correctly (SW0-SW7)	Y	N
3.4	LEDs function correctly (LD0-LD7)	Y	N

Problem 3: (8 points) Create a truth table from simulation data. The following simulation shows the logic states of the 3 inputs and of the output as functions of time. The green trace shows the states of each signal at different points in time. Naturally there are only two states for each. When the green trace is low, the state is 0 (zero), when it is high, the state is 1. Thus the far left end of the trace shows a=0, b=0, c=0, and y=0. Proceeding to the right, we see that a changes state so that we then have a=1, b=0,, c=0, and y=0. Continuing to the right, the next change gives us a=0, b=1, c=0, and y=0. The entire truth table can be read off such a representation of the states of the system provided that enough combinations are displayed. The time dependence is not important here, but it gives us a simple way to see the output voltage at all possible combinations of the input voltages. (Continued on next page)



Create a truth table that corresponds to the simulation shown above. Show all input and output values in the truth table, and sketch a logic circuit that could have been used to create the waveform.

A	B	C	Y
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

Problem 4: (15 points) Use the schematic capture tool and other required Xilinx CAD tools to enter the following three individual circuits. Be sure to add I/O markers to both inputs and outputs (and be sure to change the output signals to *output*). Also connect A, B, and C to outputs so you can more easily troubleshoot your circuit. For testing, assign the inputs A, B, & C to SW0, SW1, & SW2, respectively. Assign the outputs A, B, & C to LD0, LD1, & LD2, respectively, and the remaining output to LD3. When the circuits have been completed and simulated, print and attach a copy of each schematic & UCF file.

1) Y = A'C + AB'C' 2) F = BC' + A'BC + A'C' 3) G = (A+B+C)(A'+C')(B'+C')

Problem 5: (15 points) Create macros for all three circuits and add them to a new (fourth) schematic page. Include three inputs (A, B, C; SW0-SW2) and six outputs (A, B, C, Y, F, G; LD0-LD5), and connect the macros in parallel. Print a copy of the schematic & UCF file. Demo this circuit to the lab assistant and have them initial your lab submission form.

demo date:

TA initials:

Problem 6: (20 points) Implement a circuit for the Overhead Coffee Company buy decision. Show any work performed in arriving at a minimal circuit below. Implement the circuit using the Xilinx CAD tools, and then construct the circuit on the Digilab board. Print a copy of the schematic & UCF file. Demo this circuit to the lab assistant and have them initial your lab submission form.

demo date:

TA initials:

Homework (100 points)

1. (16 points) Sketch circuits for the following logic equations. Recall a tick mark (‘) following a variable or parenthetical expression means to invert that variable or expression.

   Y = BC + A’D

   F= (A’B) XOR (C + D)’

   G = ((AB’)’ + BC’)’

   Z = ((A + C)·(B+D)’)’

2. (18 points) Sketch minimal circuits defined by the truth tables below.

A	B	C	F
L	L	L	1
L	L	H	1
L	H	L	0
L	H	H	0
H	L	L	0
H	L	H	0
H	H	L	1
H	H	H	1

A	B	C	F
L	L	L	0
L	L	H	1
L	H	L	0
L	H	H	0
H	L	L	1
H	L	H	1
H	H	L	0
H	H	H	0

A	B	C	F
L	L	L	1
L	L	H	0
L	H	L	1
L	H	H	0
H	L	L	1
H	L	H	0
H	H	L	1
H	H	H	0

3. (20 points) Simplify the following expressions using the laws of Boolean Algebra

A. A(B’ + A’) + C’(A + B’)

B. (X + Y’)(X’Z + Y’)

C. (A + AB’ + (B’C)’)’

D. A’B + A’B’C + AD’ +ACD’

E. (AB)C’ + (AB)’C

5. (18 points) In a logic function with n inputs, there are 2^n unique combinations of inputs and 2^{2^n} possible logic functions. The table below has four rows that show the four possible combinations of two inputs ($2^2 = 4$), and 16 output columns that show all possible two-input logic functions ($2^{2^2} = 16$). Some of these output columns are associated with logic circuits, and some are not. Write the name of the logic function in the blanks below the output columns, or write N/A if the column is not associated with a common function (4 blanks have already been filled in).

2^n Inputs		ALL 2^{2^n} POSSIBLE LOGIC FUNCTION OUTPUTS															
A	B	F0	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15
LV	LV	LV	HV	LV	HV	LV	HV	LV	HV	LV	HV	LV	HV	LV	HV	LV	HV
LV	HV	LV	LV	HV	HV	LV	LV	HV	HV	LV	LV	HV	HV	LV	LV	HV	HV
HV	LV	LV	LV	LV	LV	HV	HV	HV	HV	LV	LV	LV	LV	HV	HV	HV	HV
HV	HV	LV	LV	LV	LV	LV	LV	LV	LV	HV	HV	HV	HV	HV	HV	HV	HV
Function		GND		N/A				XOR									VDD

A table like the one above for 3 inputs would need _____ rows and _____ columns.

A table like the one above for 4 inputs would need _____ rows and _____ columns.

A table like the one above for 5 inputs would need _____ rows and _____ columns.

6. (12 points) In the table below, the voltage levels from the table above have been mapped to 1's and 0's. Six of the columns represent common logic functions of two variables. Circle the six columns, and label them with the circuit function. Draw the circuit symbols for the functions represented.

INPUTS		ALL POSSIBLE OUTPUTS															
A	B	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0	0	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
0	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1
1	0	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1
1	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1

7. (16 points) Design and sketch a *minimal* four-input circuit that outputs a LHV whenever two or more inputs are asserted.