Lab- 7

EL 114 Digital Logic Design

Notes:

- In your lab-book, remember to write your steps/methods, and the observations/results.
- Get TA's signature after you have shown him/her your completed Lab-work.
  - Show your work to the TA after completing each question, and get the TA's signature after each question.

Note: The CMOS ICs work with V_{DD} = 12 Volt, and V_{ss} = GND (ground). Do not apply any other voltages to the chip. If any student is found tampering with the voltage ranges, he/she will be removed from the lab immediately.

In this Lab you need to familiarize yourself with the digital trainer board. Learn/get familiar with the following:

- Light-emitting diode (LED) indicator lamps
  - Observing the binary outputs of your gates/circuit on these LEDs
- Power on/off switch, Power supply
- CMOS/TTL (voltage level) selection switch. (Keep this switch on CMOS)
- Toggle switches, to provide inputs 1 or 0
- Breadboard for mounting ICs (IC = Integrated Circuit, aka "chip")
- Seven-segment LED for displaying numbers
- Wires for connecting the gates
- Wires for connecting the Toggle switches (that act as input signals) to the gates, and connecting the gate's output to the LED

IC numbering: (IC diagrams are shown on the last two pages of this document)

4081 Quad 2-input AND gate IC
4001 Quad 2-input NOR gate IC
4071 Quad 2-input OR gate IC
4069 Hex 1-input INV gate IC
4030 Quad 2-input Ex-OR gate IC

1. Connect the output of a toggle switch to an LED and observe the output of the switch at logic-1 and logic-0 position.
2. Connect a pulser to an LED and observe its output.
3. Observe the output of the clock generator at frequencies of 10 Hz, 100 Hz, etc.

Experiment-1: (Implementing one AND gate)

1. Take a Quad 2-input AND gate IC ("Quad" means it has four AND gates on this IC). Take note of the function/label of all 14 pins (see the last 2 pages of this document). If you hold the IC with notch facing up, the pins are numbered from 1 through 14 in the counterclockwise direction.

2. Turn the breadboard off. Insert this IC into the breadboard. Connect the inputs of one of the gates (say, pins 1 and 2) to the input switches and the output (pin 3) to an LED.
3. Turn the power on. Apply all the combination of inputs and observe the output and generate the truth table for the AND gate.
4. Follow the same procedure for the other gate ICs (OR, Ex-OR, INV), and verify the truth tables for the same.

Experiment-2: (Implement a Boolean function using ICs)

1. Design a three-input circuit that realizes $F(A, B, C) = \Sigma m(0, 1, 3, 4, 6, 7)$.
2. Use minimum/reduced AND-OR (aka SOP) Boolean expression. Reduce using K-map. (Show the reduced expression to the TA before proceeding)
3. Apply all input combinations to your circuit, and verify the truth table manually. In your truth-table include the columns for your prime implicants. It would be a good idea to check/verify if the binary output values of the prime implicants are correct (i.e the product terms are correct), before doing the final SOP (i.e. connecting the final OR gates)

Experiment-3: (Implement a binary Half-Adder using ICs)

1. The Boolean expressions for the outputs C (Carry) and S (Sum) of a binary Half Adder having two binary inputs A and B are given as follows:

$$C = A\cdot B$$
$$S = A'\cdot B + A\cdot B'$$
$$= (A\cdot B + A'\cdot B')'$$
$$= (C + (A + B)')'$$

   On the breadboard, build a Half Adder using one AND and two NOR gates.
2. Connect two LED indicators to the C and S outputs, and apply the binary inputs A and B through two switches. Test the Half Adder for all combinations of inputs. In your table include the columns/observations for the intermediate terms.