

The University of Texas at Dallas
Electrical Engineering Department
EE 2110: Beginning Digital Logic and Computer System Fundamentals
Experiment #4 – Laboratory Design Project

1. **Introduction:** In laboratory exercises 1-3, we became familiar with most of the basic circuit elements needed to design digital circuits. Today we will use these elements to design a more complex circuit.
2. **Goal of this exercise:** The purpose of Experiment #4 is to familiarize students with the steps involved in doing a digital design. We will go through most of these steps in order to complete a small design project.
3. **Theory of experiment:** In real world design projects there are always limitations, on what can be done during a given project. These limitations include power, size, cost, performance, design time (or time to market) to name just a few. Today's design project will focus on one of these limitations – number of pins. In this case your design will be limited by the number of available inputs (switches) and outputs (LEDs) on the IDL-800 breadboard.

A typical small digital design project goes through the following steps:

- **Initial concept and specification**
- **High level design and verification**
- **Detailed design**
- **Simulation**
- **Hardware implementation**
- **Final testing**

This is a simplified process. For today's experiment, step 1 will be given to you. You will complete steps 2,3,5, and 6. Since our design is small, and to speed up the overall process, we will skip step 4 (which you would NEVER do in the real world!). We will rely on the final testing of our hardware to determine if our design is correct.

4. **Experimental Equipment List:** The following experimental components are required for this experimental procedure:
 - **IDL-800 circuit prototype unit**
 - **IDL-800 User Manual (as required)**
 - **Any of the devices in the digital logic kit**
 - **Breadboard wire connection kit**
 - **Pin assignment diagrams for circuits noted above (last two pages of this exercise)**
5. **Pre-Work:** Make sure you are up-to-date in all readings in Tokheim, P&H, and the class lecture material in EE 2310. Although the circuit will be built in class, you and your lab partner should proceed through the design process and try to come to lab with a first-pass design.

6. Design Process: Today we will be designing an 8-bit adder. This circuit will take two 8-bit numbers as inputs, add them together (along with the carry in) and display the result on the LEDs. As we are limited by the 8 input switches, you will have to store each 8-bit input separately in order to provide the two inputs to the adder. We are also limited to 8 LEDs for the output, so you will need to be creative and design a way to display the carry out signal. Here are some tips to help you get started:

- You can only use the bank of 8 switches for the two inputs.
- You can use the momentary switches to help you store the inputs, provide the carry in, etc.
- Use the largest scale integration devices that you have. In other words, do not build a register out of flip-flop chips. Use the SN 74LS75 4-bit latch chips (4-bit registers) in your kit to store data and the 74LS83 circuits as your adder elements.

(Note: Of the six design steps enumerated in section #3 above, we will do only four, as noted above.)

Step 1: Draw out your initial high-level design on paper (or with a CAD system if available). Verify that what you have drawn looks conceptually correct. Some tips to help:

- Use large functional blocks for your high-level design. For instance, since you are designing an 8-bit adder, start with a block that you label as the entire 8-bit adder. It does not matter that there is no 8-bit adder chip available to you. As you move down the levels of hierarchy toward the detailed design, this block will be subdivided into actual hardware blocks (i.e., chips that are available to you).
- Don't forget your physical design limitations – in this case the limited number of input switches and output LEDs.

Step 2: Take each large functional block from step 2 and begin to decompose it into actual hardware blocks. As mentioned above, utilize the largest blocks you can. As noted above, you can start on steps 1 and 2 at home.

Step 3: Build your circuit on the breadboard. Verify the operation of the circuit.

Step 4: Test the cases below and list the results in your lab report. These last two steps must be done in the lab.

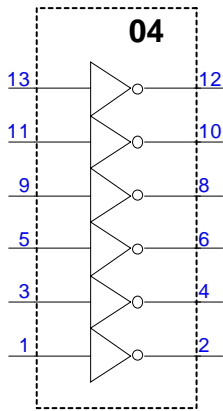
- **Note: Remember that you are building an adder to add positive numbers; these numbers are NOT two's complement.**
- Add 85 (01010101) and 42 (00101010) with no carry-in and then with carry-in.
- Add 128 (10000000) and 127 (01111111) with no carry-in and then with carry-in. How do you display the carry out?
- Have your TA verify your results.

7. Equipment Disassembly: The experimental procedure is complete. Please disassemble the circuit wiring, replace in the wiring kit box, and replace parts in the logic circuit kit. Make sure that your work area is clean.

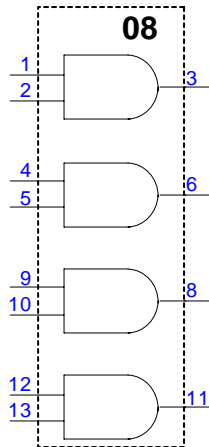
8. Laboratory Report: As usual, your laboratory report should follow the on-line form. In your write-up, discuss the operation of the circuits and the verification of the function of each. Also include the following items:

- Discuss your experience in the laboratory and any problems with the procedure.
- Show the circuit hook-up for your complete design. Use circuit schematics and show the pin numbers. You do NOT need to show the connections to Power and Ground.
- Discuss any insights gained from the exercises.

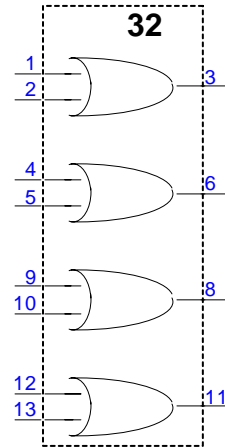
9. Circuit Diagrams: On the following pages are the pin-outs for the circuit elements needed in this laboratory:



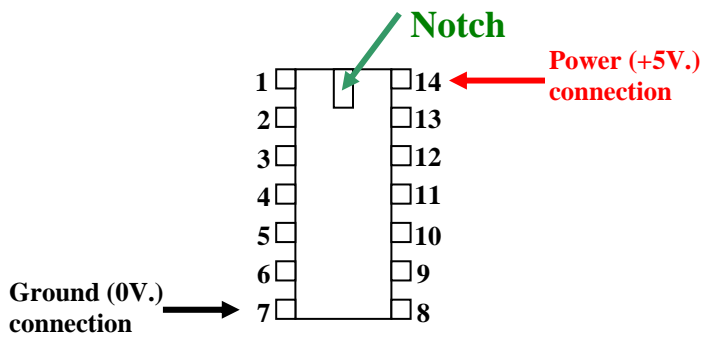
SN 74LS04 Hex inverter gate



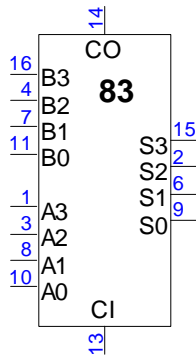
SN 74LS08 Quad 2-input AND gate



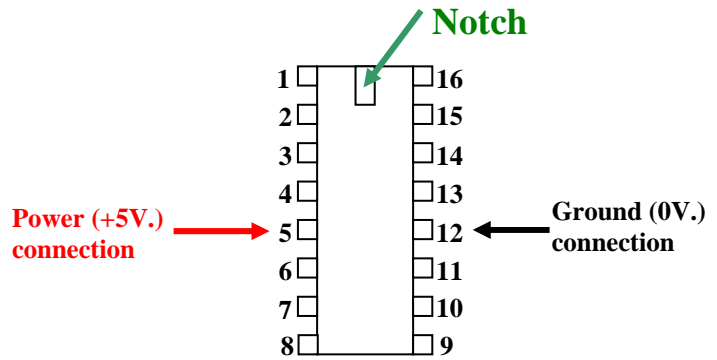
SN 74LS32 Quad 2-input OR gate



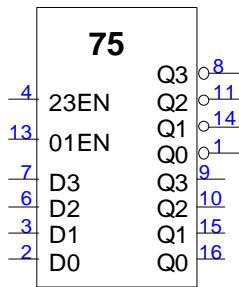
74 LS XXX 14-Pin Chip Outline



SN 74LS83 4-bit full adder pin-outs.



Physical chip outline for 74LS83 & 74LS75



SN 74LS75 4-bit latch pin-outs – Note: Input pin 4 is the clock for inputs D3 and D4, and pin 13 is the clock for inputs D1 and D2.

The 74LS75 4-bit latch
Has both Q and \bar{Q} outputs.
Note that the Q outputs are pins 16, 15, 10, and 9, and the inverted outputs are 1, 14, 11, and 8.