EE 2310 Experiment #2: Digital Adders

(CLO2—Analyze/Design, CLO3—Comb. Logic)

Note: CLO’s in this problem set tie to ABET program-level criterion a, c, and e.

1. **Introduction:** Arithmetic circuits such as the digital adder are simple combinational logic. This lab demonstrates how to build a digital adder with such circuits.

2. **Goal of this exercise:** Familiarize students with functionality of a 74LS83 4-bit full adder. Learn to construct a 2-bit full adder from basic combinational logic.

3. **Theory of experiment:** The basic half-adder diagram is:

   ![Half-Adder Diagram](image1)

   The Boolean expression for the sum of A and B is $S = A \oplus B$, and carry is $C = A \cdot B$. The half-adder adds two single bits, A and B, but does not make a provision for carry-in. If we wish to make a full adder (an adder that provides for carry-in), it looks like:

   ![Full-Adder Diagram](image2)

   The full adder sum is: $S = (a \oplus b) \oplus c$, and carry is $C = ab + (a \oplus b)c$. The full adder accommodates three variables, two input bits and a carry.

4. **Experimental Equipment List:** The following equipment and parts are required:

   - IDL-800 Digital Lab and IDL-800 User Manual (as required)
   - SN 74LS83 Full Adder, SN 74LS08 Quad 2-input AND gate, SN 74LS32 Quad 2-input OR gate, and SN 74LS86 Quad 2-input XOR gate (all circuits are in the digital logic kit)
   - Breadboard wire connection kit

5. **Pre-Work:** Review class notes on adders and Tokheim, Chapter 8.

6. **Experimental Procedure:**

   1) **4-Bit Addition with 74LS83:**
   - Plug the 74LS83 4-bit adder into the prototype board and wire up power. **Note its special power pin connections!** See chip diagram on the last page of these instructions. Connect the output sum pins (S0-S3) to LED indicators. Connect the 8 data switches to the 8 data inputs. Make sure that you connect them in an easy-to-use order, such as switches 1-4 = A inputs, switches 5-8 = B inputs (make sure you identify most significant bits). Connect carry-in (denoted CI) to one of the pulse switches, and carry-out (denoted CO) to an LED input.
   - Make sure data switches are on 0. Turn on the power. Use the switches to input various binary numbers and check the LED’s to be sure that the sum and carry are correct. Use the momentary switch to input a carry-in as well.
• Repeat this procedure until you are familiar with the adder operation. Turn off power and disconnect the circuit when you are satisfied with your experimentation.

2) Construct a 2-bit full-adder:
• Constructing a 2-bit full adder requires XOR, OR, and AND gates. Plug one each into the board. Remember: DO NOT PLUG IN TWO LOGIC CHIPS ACROSS FROM EACH OTHER ON ADJACENT VALLEYS! YOU AUTOMATICALLY CONNECT ALL ADJACENT PINS TO EACH OTHER WHEN YOU DO THIS.
• The gates should be connected as follows (make sure power is off):

![2-bit full-adder diagram]

- REMEMBER TO CONNECT POWER INPUTS TO EACH CHIP.
- Connect inputs A1-A2 (number 1) and B1-B2 (number 2) to four of the data switches. A fifth data switch should be connected to carry-in. Note that A1 and B1 are the least significant bits of each number. The sum 1-2 and carry-out should go to three LED inputs.
- Check all connections and then turn on the power. Turn on combinations of the input switches to check that addition of two-bit binary numbers is successful, including carry out.
- Complete the following additions, noting what sum lights are on, and whether the carry-out light is on: 1+2+carry, carry +3+1, carry+3+3, 2+2+carry. Tabulate results and discuss in the project summary.

3) But can it Subtract?
• Using the information provided in Lecture #4, redesign the adder to add or subtract two positive 2-bit numbers and provide the proper sign as required. Have the TA verify your circuit functionality. Then verify subtraction of the following numbers: 3─1, 3─2, 2─1, 2─0.

7. Equipment Disassembly: Replace parts and wires in the kits and return to 2310 parts cabinet. Clean your workbench and have the TA inspect and sign your data sheet(s).

8. Laboratory Report: As usual, please follow the laboratory report form. In your write-up, discuss operation of the circuits and the verification of their correct function. Also:
- Discuss any problems with the procedure.
- Make a drawing for a 1-bit full adder without using an XOR gate. How much more complicated is this adder?
- Show the truth table of the 2-bit adder for the cases listed in part 2 of Section 5.
- Make a drawing of the 2-bit adder/subtractor you designed in part 3 of Section 5.
**Circuit Diagrams:** Here are the pin-outs for the circuit elements used in this laboratory:

- **SN 74LS08 Quad 2-input AND gate**
- **SN 74LS32 Quad 2-input OR gate**
- **SN 74LS86 Quad 2-input XOR gate**
- **SN 74LS83 4-bit full adder**

**SN 74LS83 4-bit full adder**

- **Power (+5V.) connection**
- **Ground (0V.) connection**

**74 LS XXX Outline for all chips but 74LS83**

**Physical chip outline for 74LS83**