15-348: Embedded Systems
Fall 2022
Lab 2: Two-Bit Adder
Due: Beginning of lab time on Thursday, August 18, 2022

Part	Quantity
Breadboard	1
SN74LS86AN (XOR)	1
SN74LS08N (AND)	1
SN74LS32N (OR)	1
8-pin DIP Switch	1
1KΩ Resistor	4
LED	3
330Ω Resistor	3

Introduction

The purpose of this lab is to introduce you to building circuits that include integrated circuits. You will build a two-bit adder using logic gates.

Your final circuit will be evaluated based on both its functionality and the cleanness of the circuit layout and wiring.

Two-Bit Adder

A two-bit adder is a circuit the adds together two, 2-bit numbers. The first number, A, can be representing using bits a1 and a0. The second number, B, is similarly represented.

The output consists of the sum of A and B, represented as two bits (s1 and s0) and one carry bit (c). A truth table for a 2-bit adder is as follows:

| Inputs				Outputs		
a1	**a0**	**b1**	**b0**	**c**	**s1**	**s0**
0	0	0	0	0	0	0
0	0	0	1	0	0	1
0	0	1	0	0	1	0
0	0	1	1	0	1	1
0	1	0	0	0	0	1
0	1	0	1	0	1	0
0	1	1	0	0	1	1
0	1	1	1	1	0	0
1	0	0	0	0	1	0
1	0	0	1	0	1	1
1	0	1	0	1	0	0
1	0	1	1	1	0	1
1	1	0	0	0	1	1
1	1	0	1	1	0	0
1	1	1	0	1	0	1
1	1	1	1	1	1	0

Circuit

The input consists of two 2-bit numbers – A and B – that should be provided using the DIP switch as shown in class. You should input the binary representation of the numbers using pins 1 (a1) and 2 (a0) for number A and pins 7 (b1) and 8 (b0) for number B.

You should implement the following circuit:
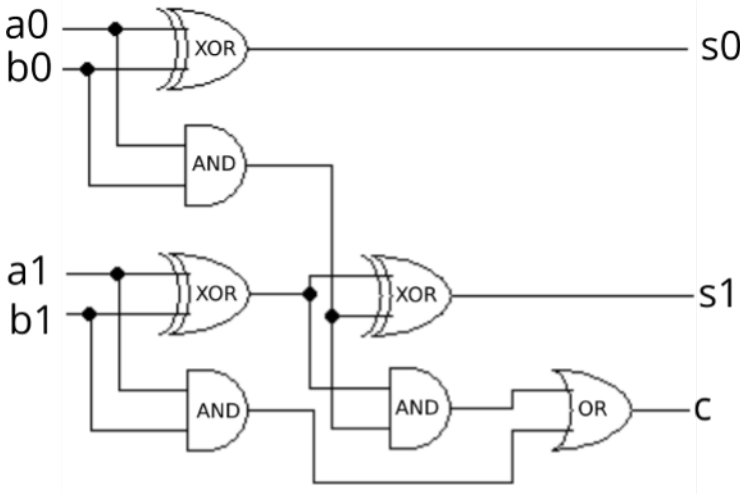
Hints

1. To build your circuit you should use the XOR, AND, and OR gates. Read the datasheets to find the pinouts.

XOR	SN74LS86AN	https://www.ti.com/lit/gpn/sn54s86
AND	SN74LS08N	https://www.ti.com/lit/gpn/SN54LS08
OR	SN74LS32N	https://www.ti.com/lit/gpn/sn54ls32-sp

2. To obtain the input pins (a0,a1,b0,b1) connect the DIP switch with a pull-down resistor (1K) as shown in class.

3. You should display the outputs s0, s1, and c using 3 LEDs.

4. Build your circuit in two parts. First, build a one bit half adder with a0, and b0, and then a full adder with a1, b1, and the carry bit of the half adder. The output of the half adder will be s0, and the output of the full adder will be s1, and c. Both adders are connected using the carry bit of the half adder as shown below. Note that the logic circuit shown below is exactly the same as the one shown above.
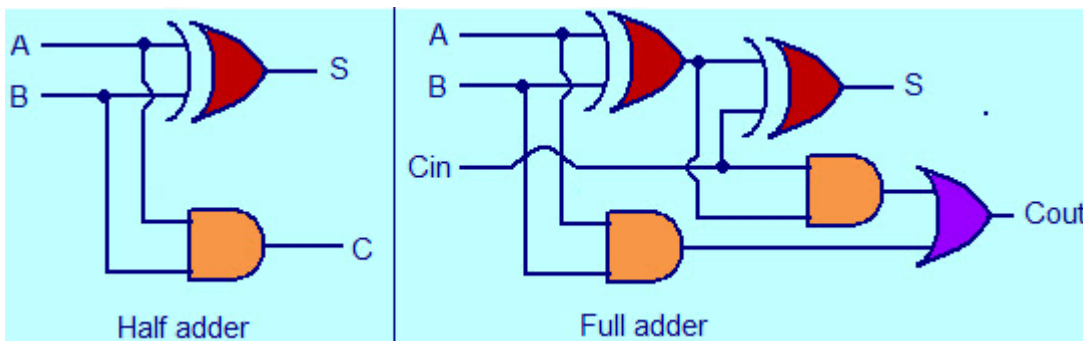
Make sure that the half adder works as expected before building the full adder.

Additional Remarks:

1. The logic gates need to be placed in the middle of the breadboard with each pin in different rows that are not connected.

2. Be careful with the ICs. You might need to slightly bend the pins to make them fit in the breadboard.

3. Ensure that the power supply is OFF when you are building the circuit. A mistake in the wiring could accidentally burn one of the logic gates

4. Leave some space between the s0 and s1 LEDS and the c LED to clearly see the output.

5. Minimize your time spent debugging: use the multi-meter to check all inputs and outputs of the ICs.