Experiment 9: Binary Arithmetic Circuits

In-Lab Procedure and Report (30 points)

Before starting the procedure, record the table number you are working at in your lab report. Also record the EE Inventory number of any equipment that you use.

(1) Equipment. You will use the following:

- Bit Bucket digital logic breadboard system
- The usual assortment of 16 banana-plug cables, and a tub of hookup wires.

If any of these are missing or non-functional, let your lab instructor know.

(2) Obtain the required components. You will use the following:

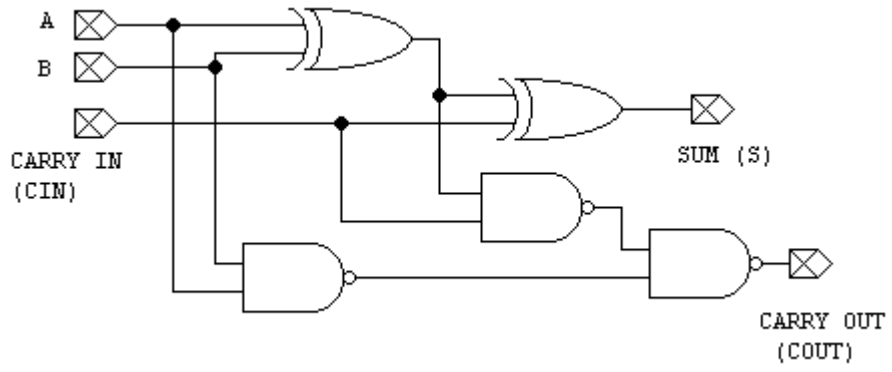
Table 1. Parts required for this experiment.

Qty	Part # or value	Description	Instructions
1	7400	Quad NAND, TTL, 14-pin IC	see included pin-out diagrams
1	7486	Quad XOR, TTL, 14-pin IC	"
1	7483	4-bit full adder, TTL, 16-pin IC	"
1	74169	4-bit up/down binary counter, TTL, 16-pin IC	"

(3) Build and test a 1-bit full adder.

(a) Construct the full-adder circuit shown in Fig. 1. Before beginning, draw a careful wiring diagram in your report showing all chips (labeled) and all pins with numbers and connections. Use toggle switches for inputs, and any convenient LED's to monitor the output bits.

Figure 1. Full adder logic circuit. The truth table is given in Table 2.



(b) The truth table for this circuit is given in Table 2. Apply all 8 input combinations and observe the outputs (S and C_{OUT}). Compare with the truth table and verify correct operation. Have your lab instructor observe your circuit in operation and initial your table of results.

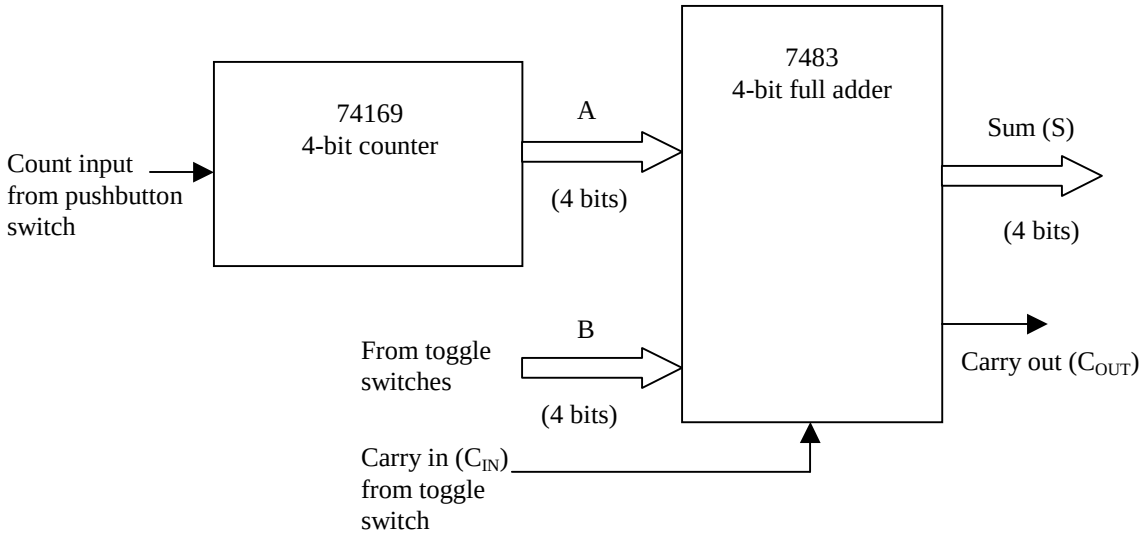
Table 2. Full adder truth table. The three input bits are the sum bits A and B, and the carry-in bit C_{IN}. The two outputs are the S (sum) and C_{OUT} (carry-out) bits.

Inputs				**Binary Outputs**	
A	**B**	**C_{IN}**	**Base 10 Sum of A+B+C_{IN}**	**C_{OUT}**	**S**
0	0	0	0	0	0
0	0	1	1	0	1
0	1	0	1	0	1
0	1	1	2	1	0
1	0	0	1	0	1
1	0	1	2	1	0
1	1	0	2	1	0
1	1	1	3	1	1

(4) Build and test a 4-bit adder.

Use the 7483 to add two 4-bit binary numbers. One of the 4-bit numbers (we will designate it *A*) will come from a 74169 counter. The other (called *B*) will come from toggle switches. This is illustrated in Fig. 2.

FIGURE 2. Block diagram of 4-bit full adder circuit.



(a) Draw the wiring diagram carefully for your report. Label all pin numbers and show all the connections. You can use one hex display on the bit bucket to show the value of input A, and the other to show the sum S.

(b) Build the circuit. Test it by filling in a table like the one below (Table 3). Use the exact inputs given. Put this table in your report. Have your instructor observe your circuit in operation and initial the table in your report. For reference, Table 4 provides decimal, binary, and hex equivalents from 0D through 31D.

Table 3. Test results for the 4-bit full adder circuit. Values of A, B, and S are in hex.

Inputs			Calculated Outputs		Actual Outputs		
A	**B**	**C_{IN}**	**S**	**C_{OUT}**	**S**	**C_{OUT}**	**Correct?**
0	0	0					
0	0	1					
1	0	0					
7	7	1					
8	7	0					
8	8	0					
F	F	0					
F	F	1					

(5) Cleanup

DO NOT PUT CHIPS OR ANY OTHER COMPONENTS IN THE WIRE TUBS.

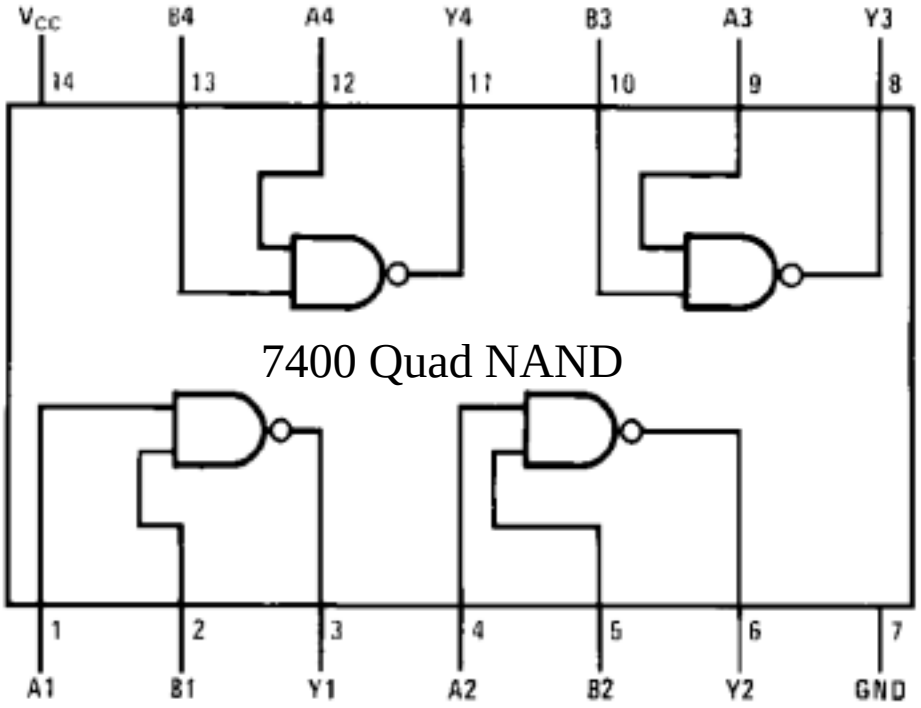
(a) Turn off the power to the Bit Bucket.
(c) Disassemble your circuit and place all wires back in the wire tub.
(d) Put all chips and other components back in the proper bins.
(e) Clean up your workstation and discard any trash.

Review and Report Completion

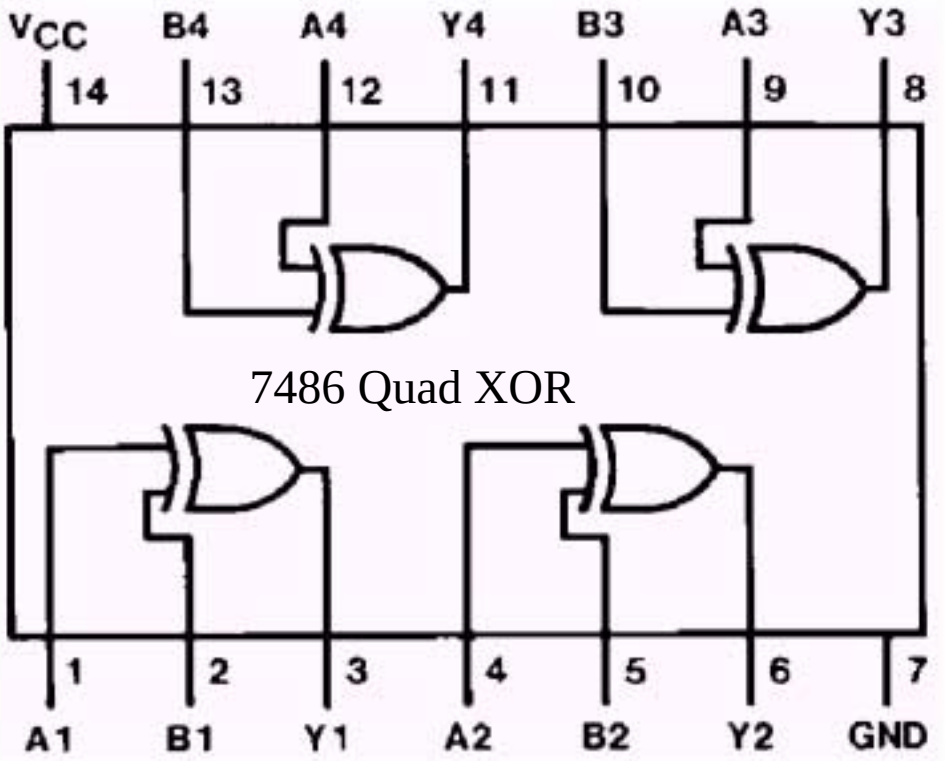
Finish writing your lab report, following the outline given in the Course Information. Submit your lab report to your instructor before leaving the lab.

Table 4. Decimal, binary, and hexadecimal conversion chart.

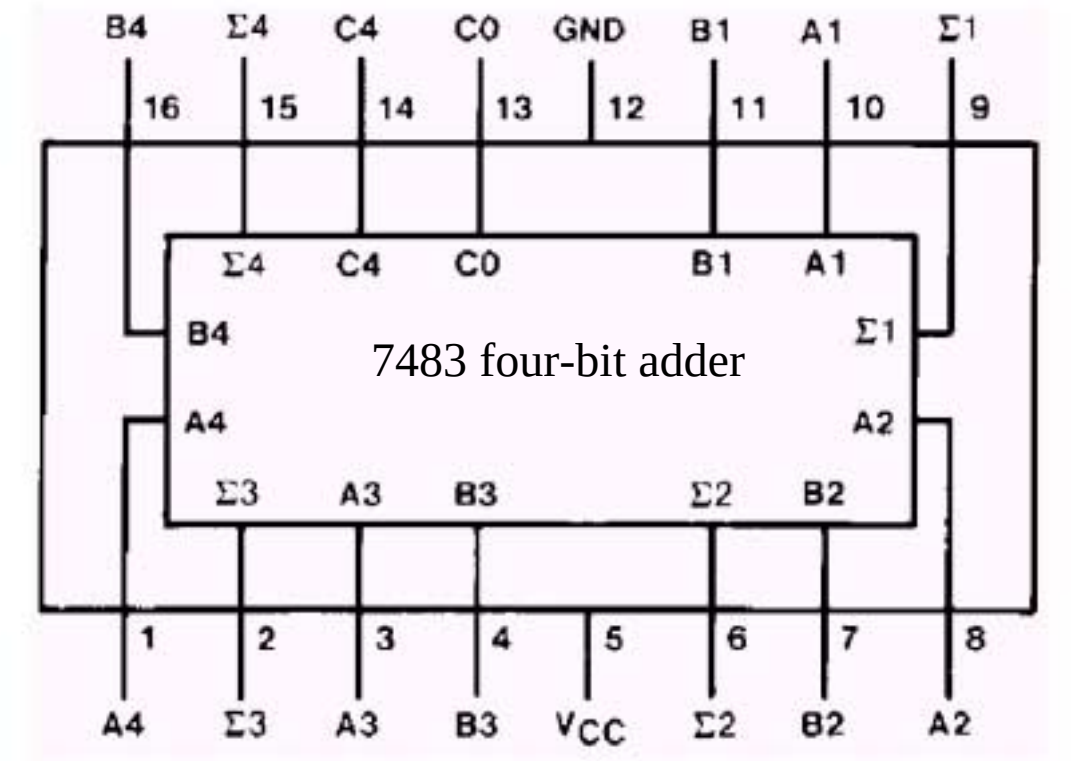
Decimal (base 10)	Binary (base 2)	Hex (base 16)
0	0000	0
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9
10	1010	A
11	1011	B
12	1100	C
13	1101	D
14	1110	E
15	1111	F
16	1 0000	10
17	1 0001	11
18	1 0010	12
19	1 0011	13
20	1 0100	14
21	1 0101	15
22	1 0110	16
23	1 0111	17
24	1 1000	18
25	1 1001	19
26	1 1010	1A
27	1 1011	1B
28	1 1100	1C
29	1 1101	1D
30	1 1110	1E
31	1 1111	1F



7400 Quad NAND



7486 Quad XOR



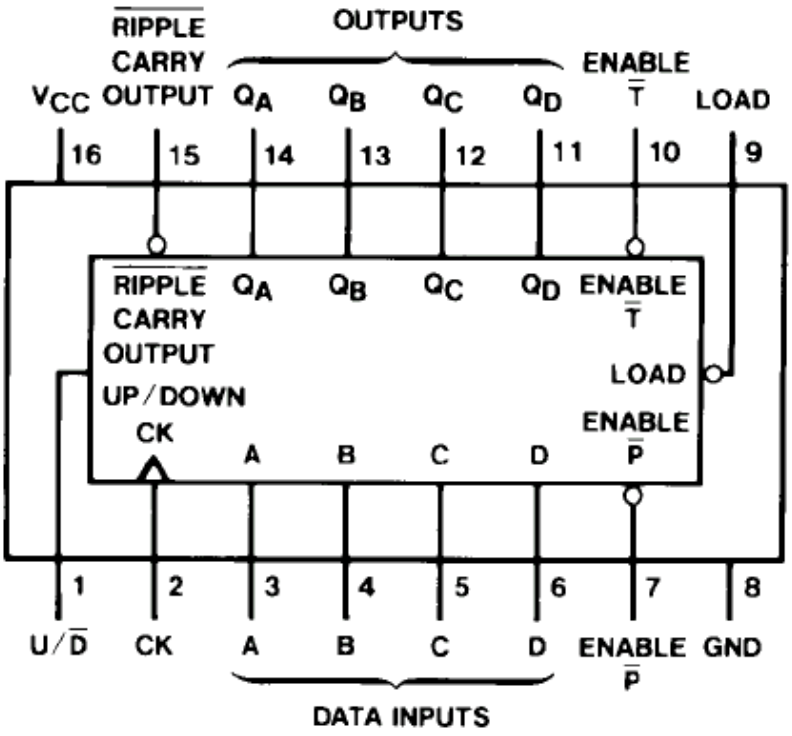
7483 Pin Description

Label	Pin #	Description
A4	1	MSB of input A
A3, A2, A1	3, 8, 10	other bits of input A
B4	16	MSB of input B
B3, B2, B1	4, 7, 11	other bits of input B
Σ4	15	MSB of sum output
Σ3, Σ2, Σ1	2, 6, 9	other bits of sum output
C0	13	Carry in
C4	14	Carry out
VCC	5	Power (+5 V)
GND	12	Ground

74169 Up/Down 4-bit Binary Counter

DM74ALS169B

Connection Diagram



Mode Select Table

LOAD	$\overline{EP}$	$\overline{ET}$	U/$\overline{D}$	Action on Rising Clock Edge
L	X	X	X	Load ($P_n \rightarrow Q_n$)
H	L	L	H	Count Up (Increment)
H	L	L	L	Count Down (Decrement)
H	H	X	X	No Change (Hold)
H	X	H	X	No Change (Hold)