Practical Submission Sheet

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Course Code: PHY249
Registration Number: 11912610
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Practical Number: 9
Section: G2903
Roll No: 03

Aim

To design half-adder, full adder and 4-bit binary adder circuits using any gate combination.

Concepts Learnt

Learnt the implementation of binary adder circuits such as half, full and multi-bit (in this case, 4) adders.

Key Observations & Insights

The truth tables for all the circuits were verified. The boolean expressions for sum and carry in case of half adder are $S = A \oplus B$ and $C = A \cdot B$. For full adder, they are $S = (A \oplus B) \oplus C_{in}$ and $C_{out} = A \cdot B + (A \oplus B) \cdot C_{in}$

Application Areas

Binary adders are used everywhere in digital electronics, which is used in most modern electronic circuits in devices ranging from classical computers to internet of things devices (e.g. Arduino).

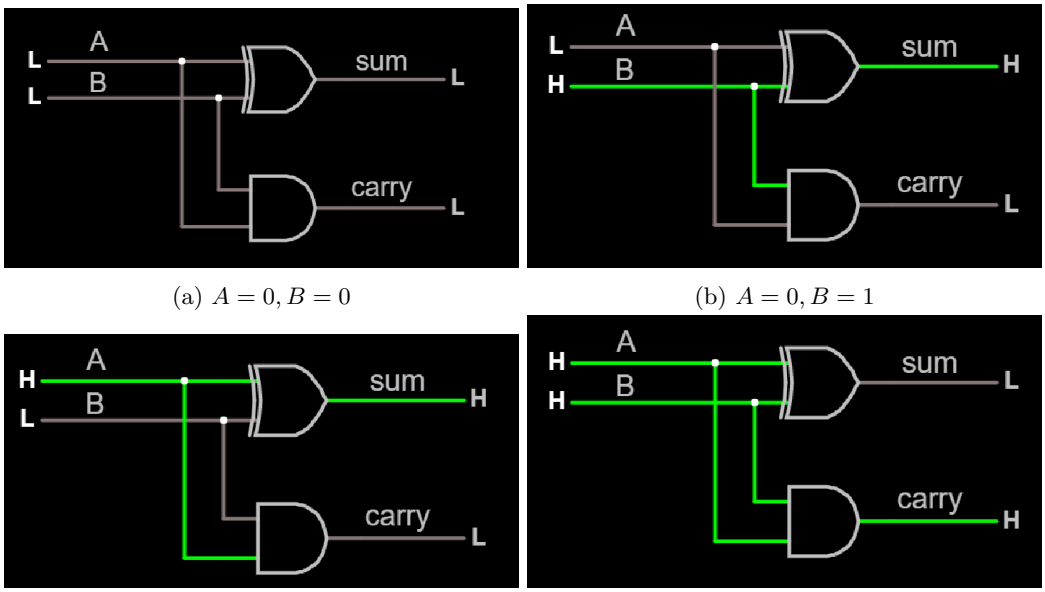
Report

A half-adder circuit can be used to add two single bit numbers. It can be easily constructed using standard logic gates such as XOR and AND, as depicted in Figures 1-4. The rules for binary addition suggest that sum and carry are defined as $S = A \oplus B$ and $C = A \cdot B$ respectively.

The truth table for these output functions is then

Input A	Input B	Sum (S)	Carry (C)
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Table 1: Truth table for half-adder circuit.



(a) $A = 0, B = 0$ (b) $A = 0, B = 1$

(c) $A = 1, B = 0$ (d) $A = 1, B = 1$

Figure 1: Different output states for a half-adder circuit

The problem with a half-adder circuit is that, it can't deal with multi-bit numbers. One might want to input the carry of the sum of the rightmost two bits to another adder. For this, a *full adder* circuit is used.

Sum and carry for it are defined as

$$S = (A \oplus B) \oplus C_{in}$$

and

$$C_{out} = A \cdot B + (A \oplus B) \cdot C_{in}$$

The truth table for it is

Input A	Input B	C_{in}	Sum (S)	Carry (C_{out})
0	0	0	0	0
0	1	0	1	0
1	0	0	1	0
1	1	0	0	1
0	0	1	1	0
0	1	1	0	1
1	0	1	0	1
1	1	1	1	1

Table 2: Truth table for full adder.

The circuit for a full adder was constructed based on the boolean expressions for S and C_{out} and its different states are shown in Figure 2.

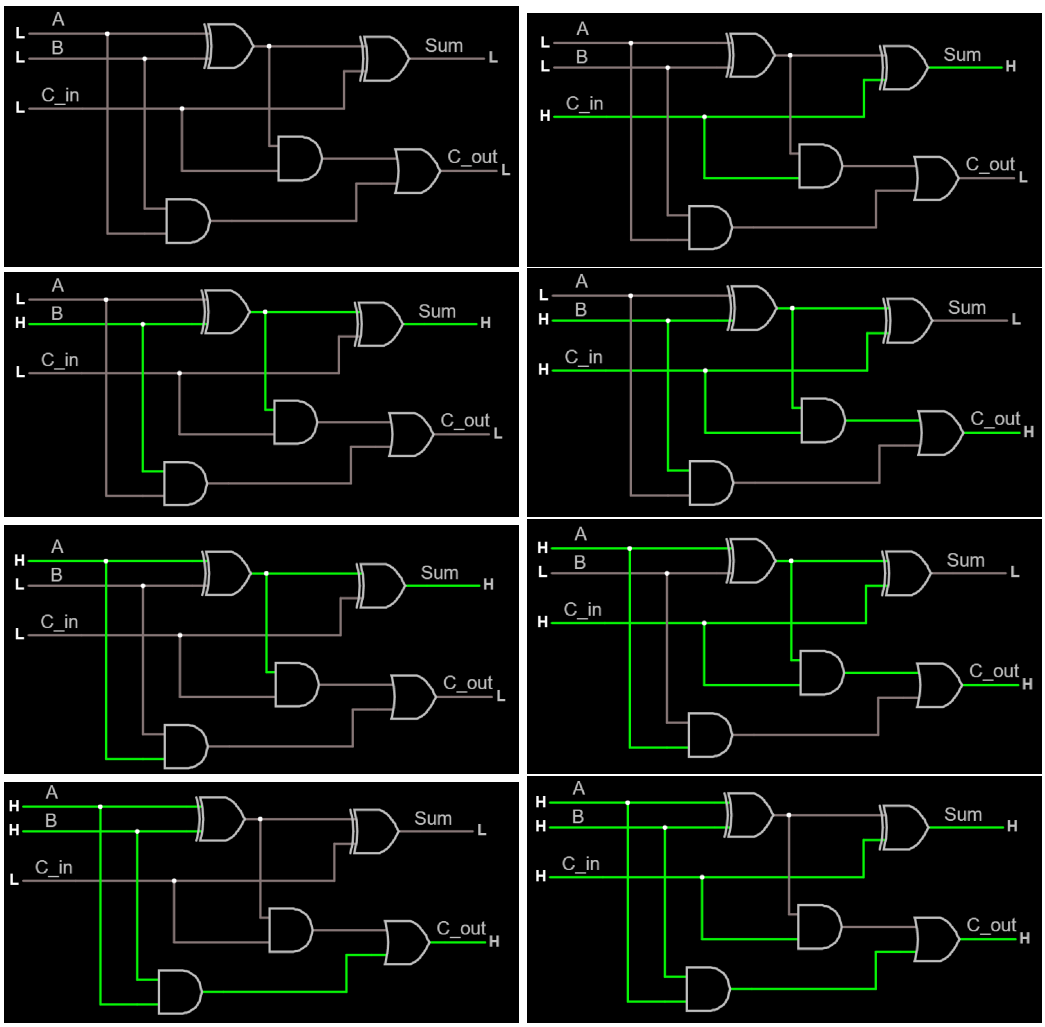


Figure 2: Different output states for a full-adder circuit

Using combinations of full adder circuits, adders of multi-bit numbers can be constructed. The construction for 4 bit binary adder is shown in Figures 3 and 4.

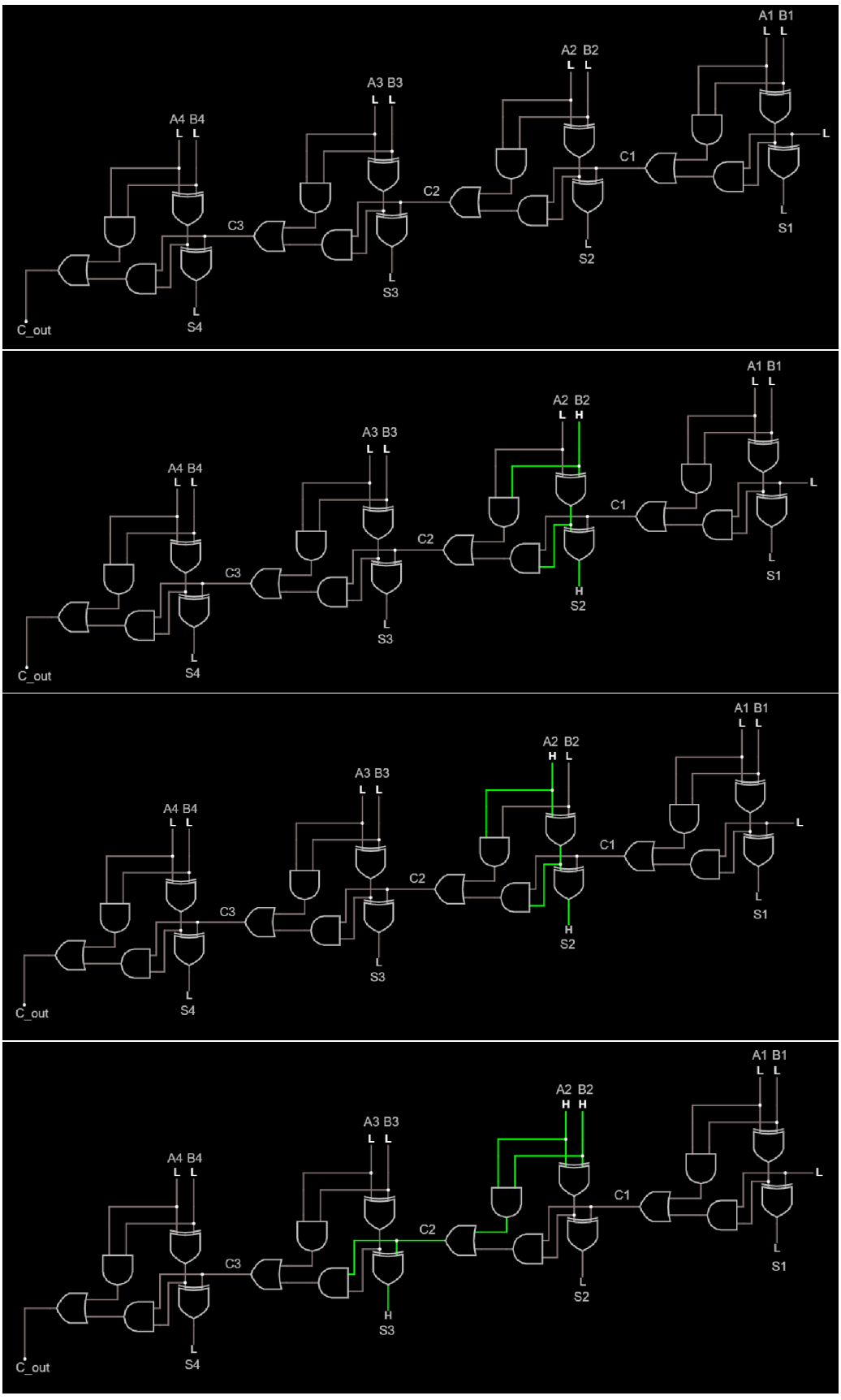


Figure 3: 4-bit adder circuit

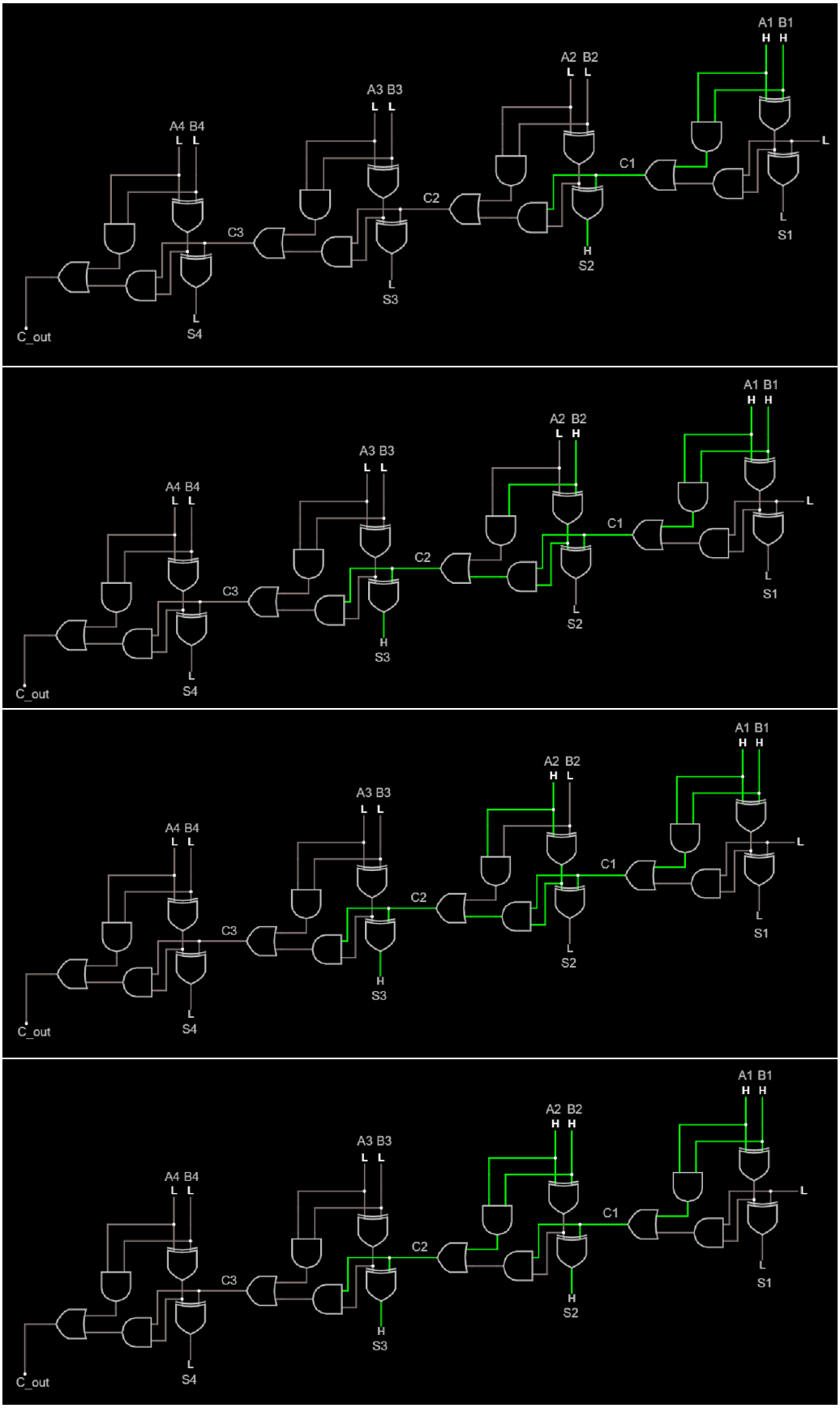


Figure 4: (Cont.) 4-bit adder circuit.