Practical Submission Sheet

Term: 2020-1	*Submission Date*: November 6, 2020
Lecture Date: October 30, 2020.	*Practical Number*: 10
Course Code: PHY249	*Section*: G2903
Registration Number: 11912610	*Roll No*: 03
Student Name: Aayush Arya	

Aim

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

Concepts Learnt

Learnt how to implement half subtractor, and full subtractor circuits, including those for 4-bit binary numbers (4-bit binary subtractor.)

Key Observations & Insights

The truth tables for all the circuits were verified. The boolean expressions for difference and borrow of half adder are $D = A \oplus B$ and $C = \overline{A} \cdot B$. For full subtractor, they are $D = (A \oplus B) \oplus B_{in}$ and $B_{out} = \overline{A} \cdot B + \overline{(A \oplus B)} \cdot B_{in}$

Application Areas

Binary operations are ubiquitous in digital electronics. Thus, it's essential to know how to design a circuit that can perform binary subtraction operations on single or multi-bit numbers.

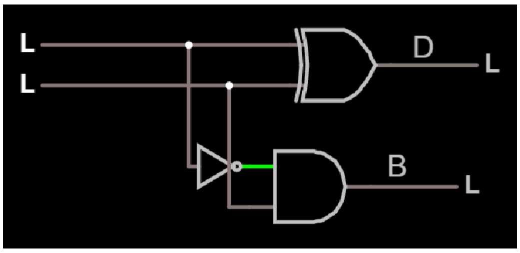
Report

A half-subtractor circuit can be used to subtract two single bit numbers. The rules for binary subtraction $D = A - B$ give us logic functions for difference and borrow in binary subtraction $D = A \oplus B$ and $B_{out} = \overline{A} \cdot B$ respectively.

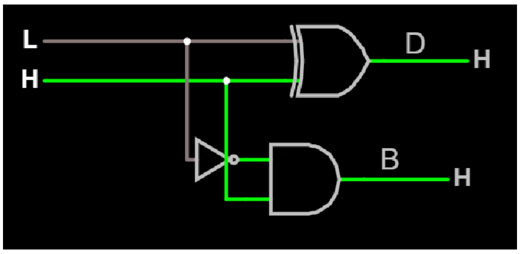
The truth table for these output functions is then

Input A	Input B	Difference (D)	Borrow (B_{out})
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

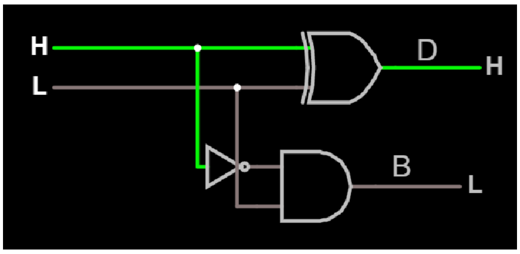
Table 1: Truth table for half-subtractor circuit.



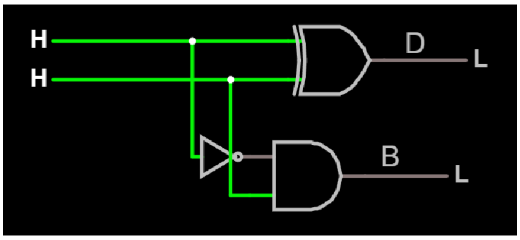
(a) $A = 0, B = 0$



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



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



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

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

A half subtractor, however, is insufficient for handling binary numbers of more than one bit. For that purpose, a *full subtractor* circuit is used.

Difference and borrow for it are defined as

$$D = (A \oplus B) \oplus B_{in}$$

and

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

The truth table for this set of logic functions is.

Input A	Input B	B_{in}	Difference (D)	Borrow (B_{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 subtractor was constructed based on the boolean expressions for D and B_{out} and its different states are shown in Figure 2.

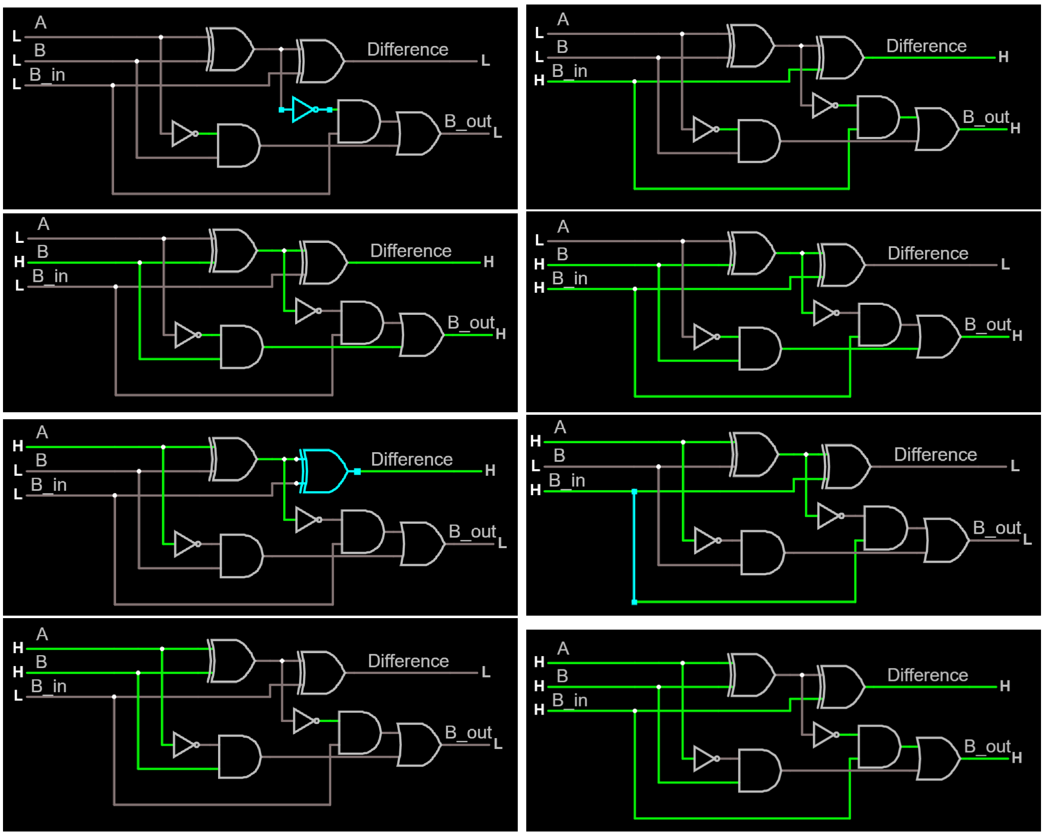


Figure 2: Different output states for a full-subtractor circuit

Using combinations of full subtractor circuits, subtractors of multi-bit numbers can be constructed. The construction for 4 bit binary subtractor and its different outputs for different inputs are shown in Figures 3 and 4.

The result of subtraction of two binary numbers $X_4X_3X_2X_1$ and $Y_4Y_3Y_2Y_1$ is $D_4D_3D_2D_1$. In Figures 3-4, the digits X_4, .. X_1 and Y_4, .. Y_1 are inputs to the full subtractors and D_1, .. D_4 are received as outputs of the "difference" function.

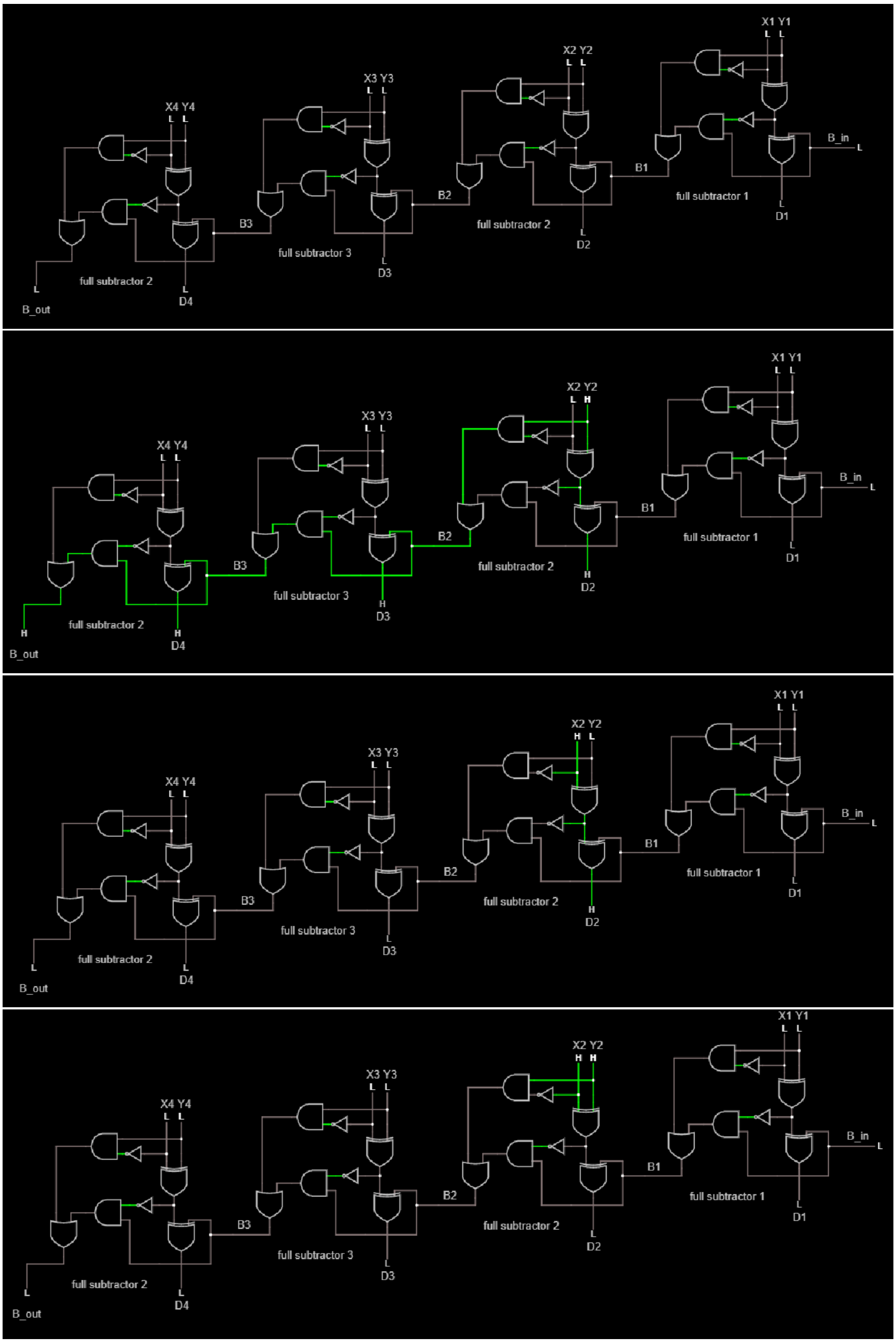


Figure 3: 4-bit subtractor circuit

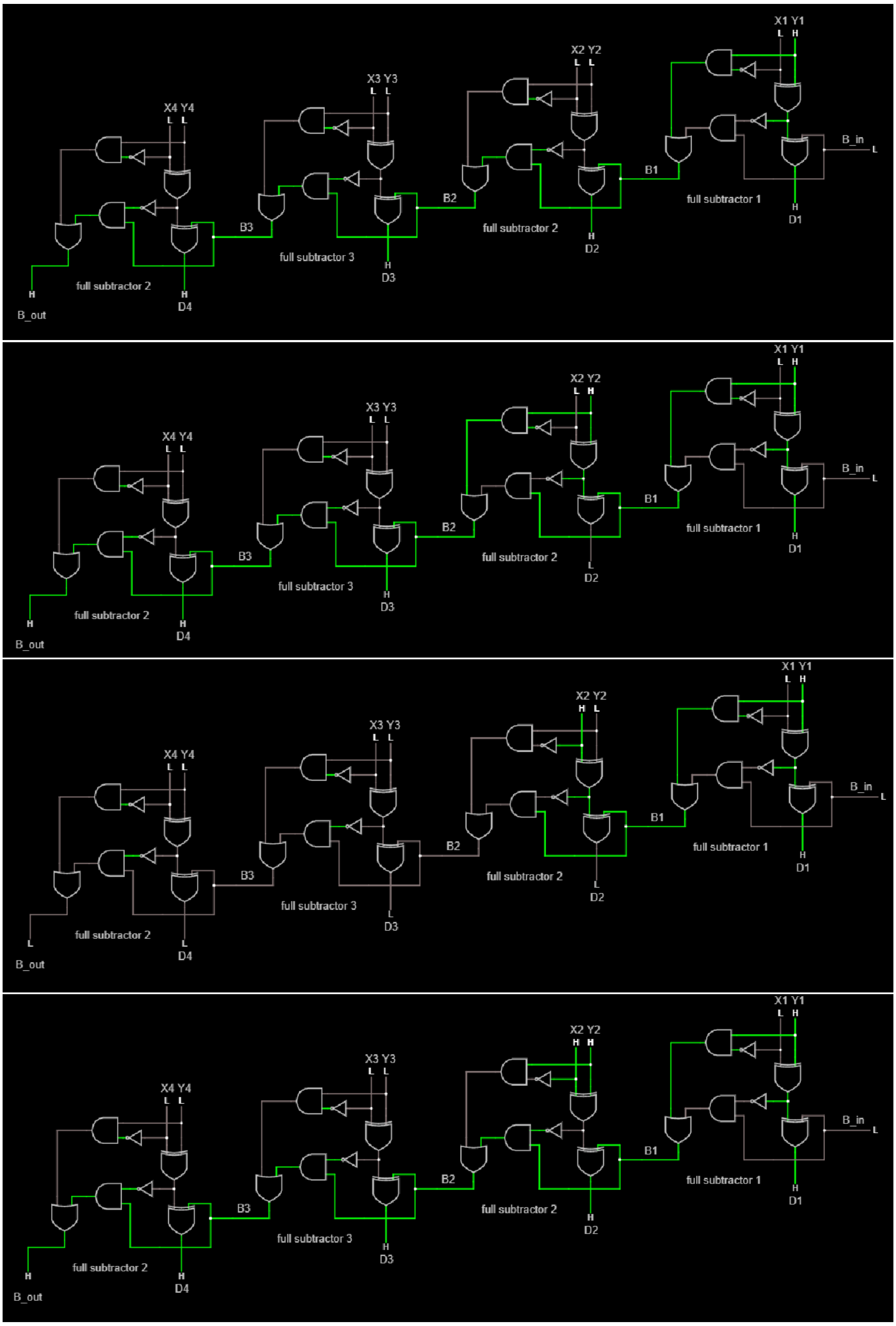


Figure 4: (Cont.) 4-bit subtractor circuit.