The University of Azad Jammu & Kashmir, Muzaffarabad

Computer Architecture & Logic Design

Lab 05: Types of Combinational Circuit

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Course Code:	CS-1206
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LAB Objective

The primary objective of this lab is to design, analyze, and understand the working principles of Adder and Subtractor circuits in digital electronics. Through this practical work, students will gain both theoretical knowledge and hands-on experience in implementing arithmetic operations using combinational logic.

Importance in Digital Systems

- **Core Functionality**: Used in ALUs (Arithmetic Logic Units), microprocessors, and DSP systems.
- **High-Speed Operations**: Essential for real-time computation in embedded and high-performance applications.
- **Scalability**: Can be cascaded to handle multi-bit operations in larger data paths.

Full Adder

A Full Adder extends the half adder's functionality by including a carry-in (Cin) input. This allows it to add three inputs: two significant bits (A and B) plus a carry from a previous addition. The outputs are:

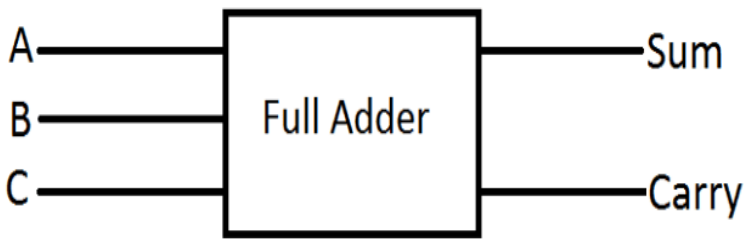
- Sum – final result of the addition.
- Carry-out (Cout) – carry generated for the next stage.

Logic:

$$\textbf{Sum (S)} = A \oplus B \oplus Cin$$

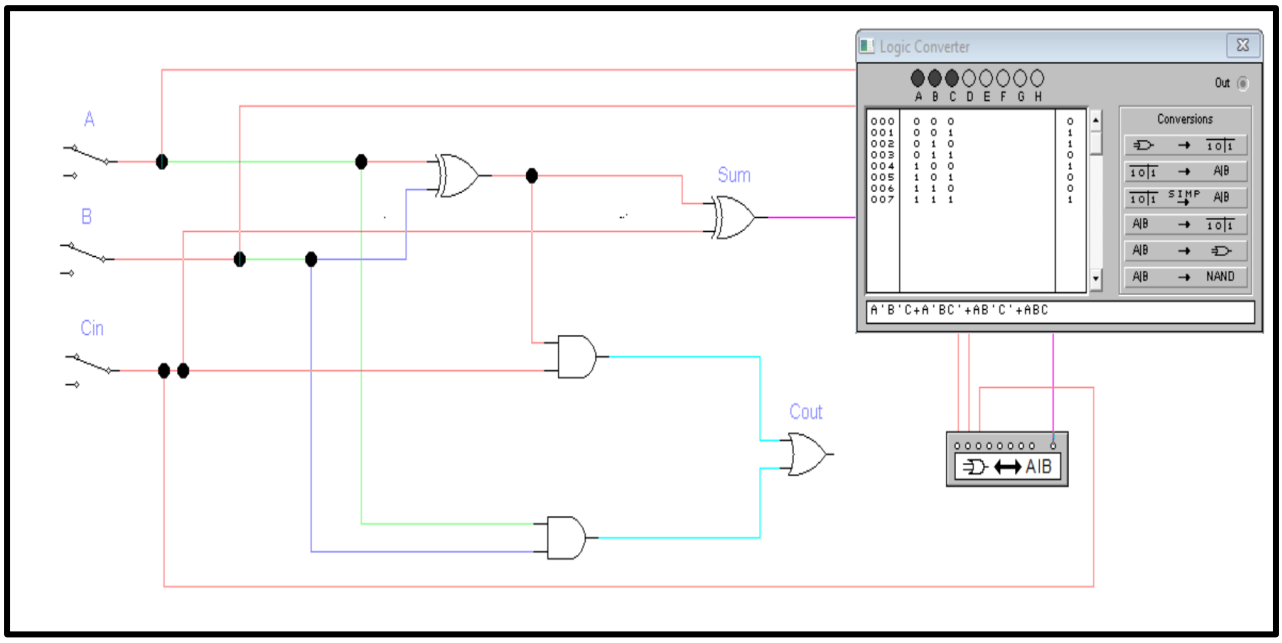
$$\textbf{Cout} = (A \cdot B) + (Cin \cdot (A \oplus B))$$

Block Diagram:

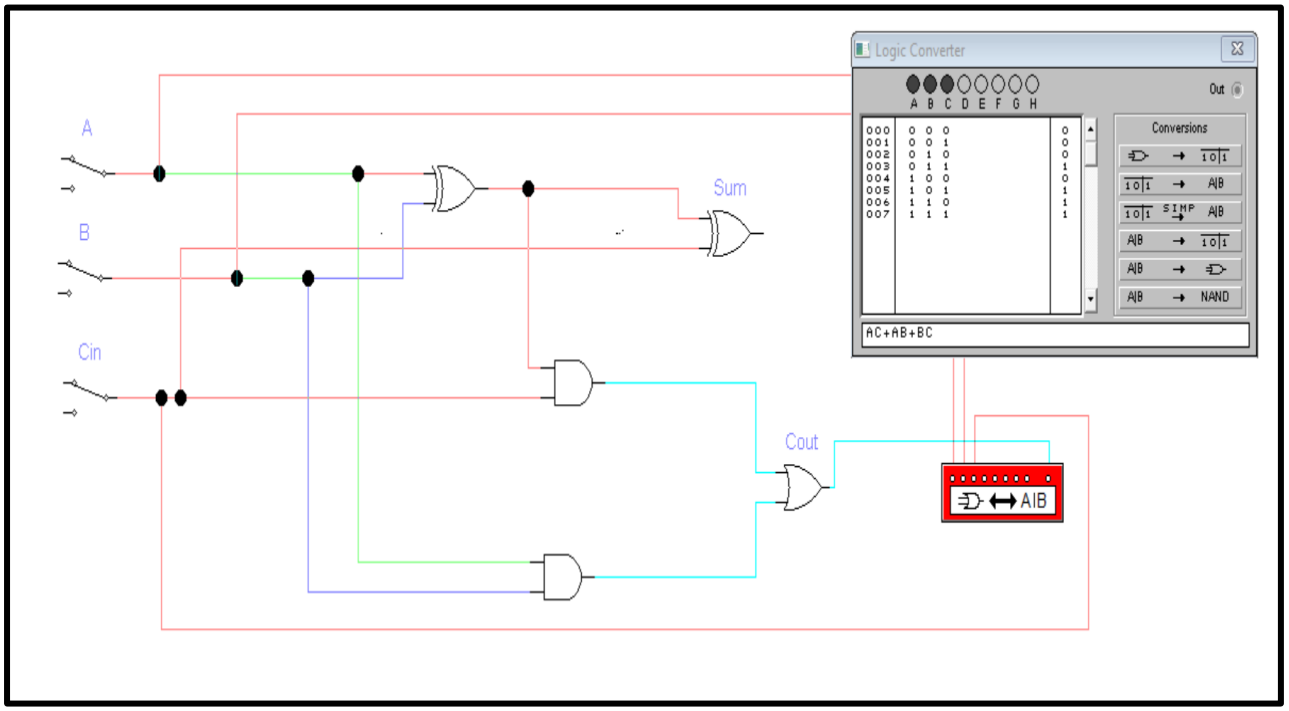


Implementations in EWB

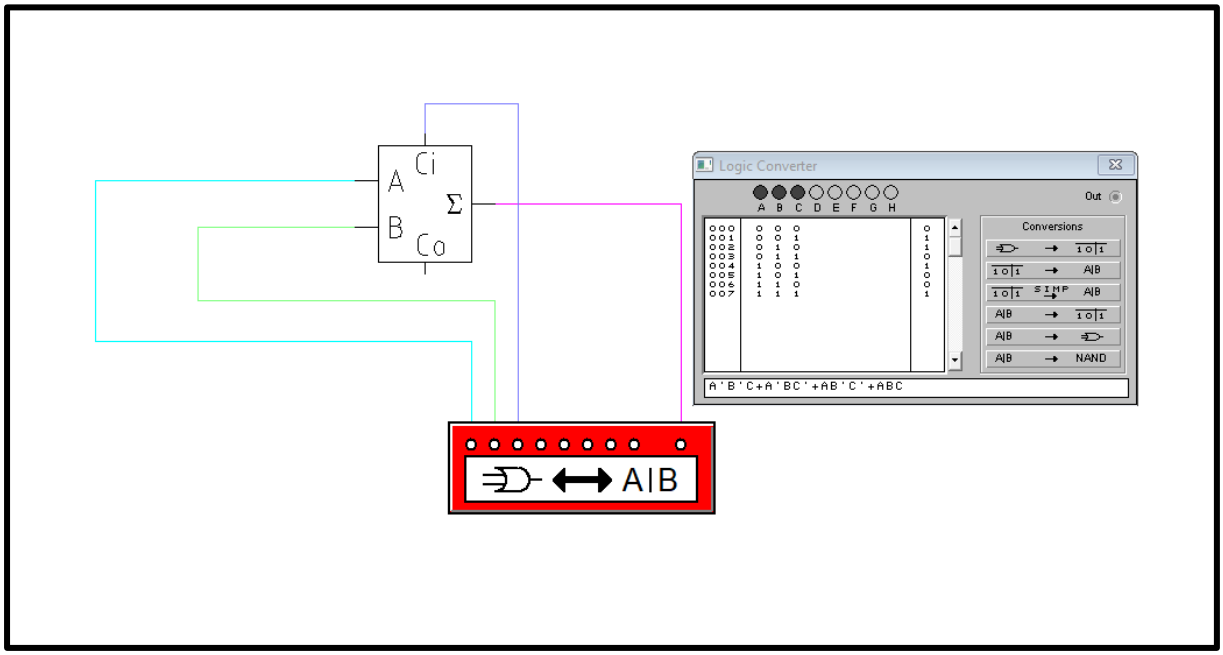
Sum with Truth Table:



CARRY:



Implementation using Built in Circuit



2. Half Subtractor

A Half Subtractor is used for subtracting two binary bits (A - B). It has two outputs:

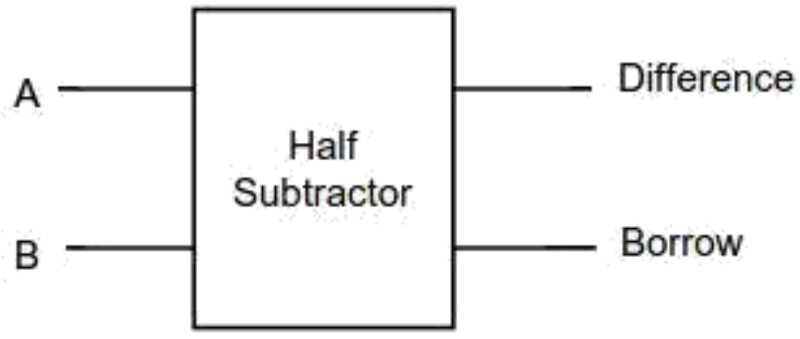
- Difference (D) – result of the subtraction.
- Borrow (Bo) – indicates if borrowing is needed from the next higher bit.

It is called "half" because it does not handle a borrow from a previous stage.

Logic:

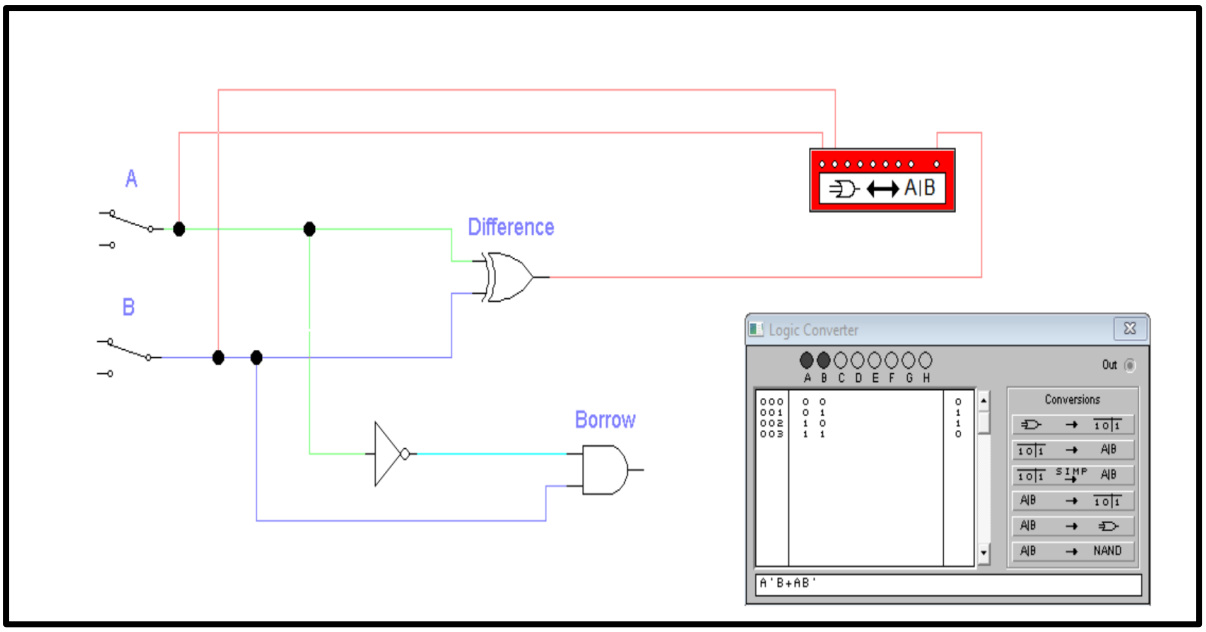
- **Difference (D) = A ⊕ B**
- **Borrow (Bo) = $\overline{A}$ · B**

Block Diagram:

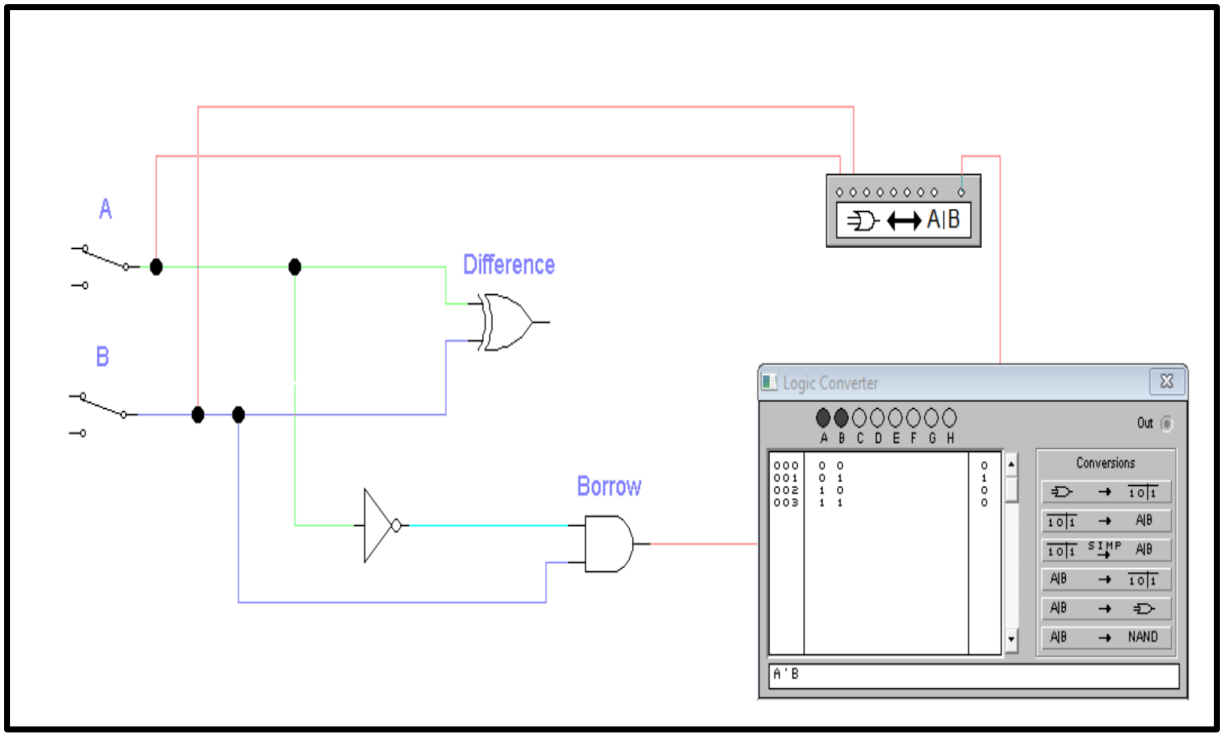


Implementation in EWB

Difference:



Borrow:



Full Subtractor

A Full Subtractor performs the subtraction of two binary bits with an additional borrow-in (Bin) input. This allows it to handle multi-bit subtraction by cascading multiple stages. It produces:

- Difference (D) – result of subtraction.
- Borrow-out (Bout) – borrow passed to the next stage.

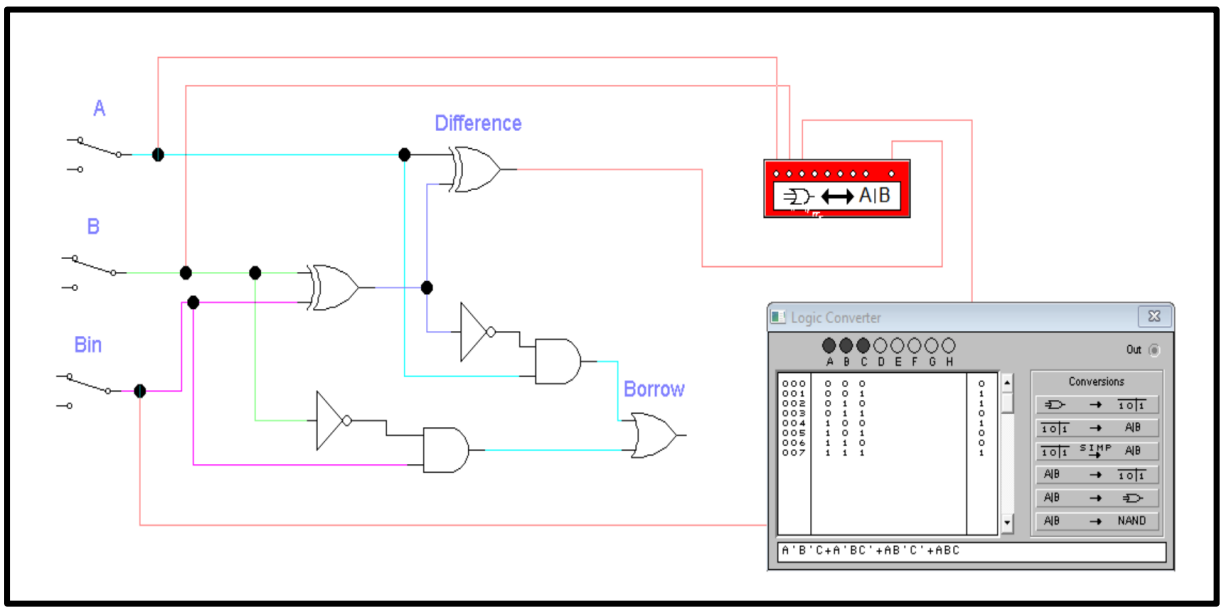
Logic:

- **Difference (D) = A ⊕ B ⊕ Bin**
- **Bout = (B · Bin) + ($\overline{A}$ · B) + ($\overline{A}$ · Bin)**

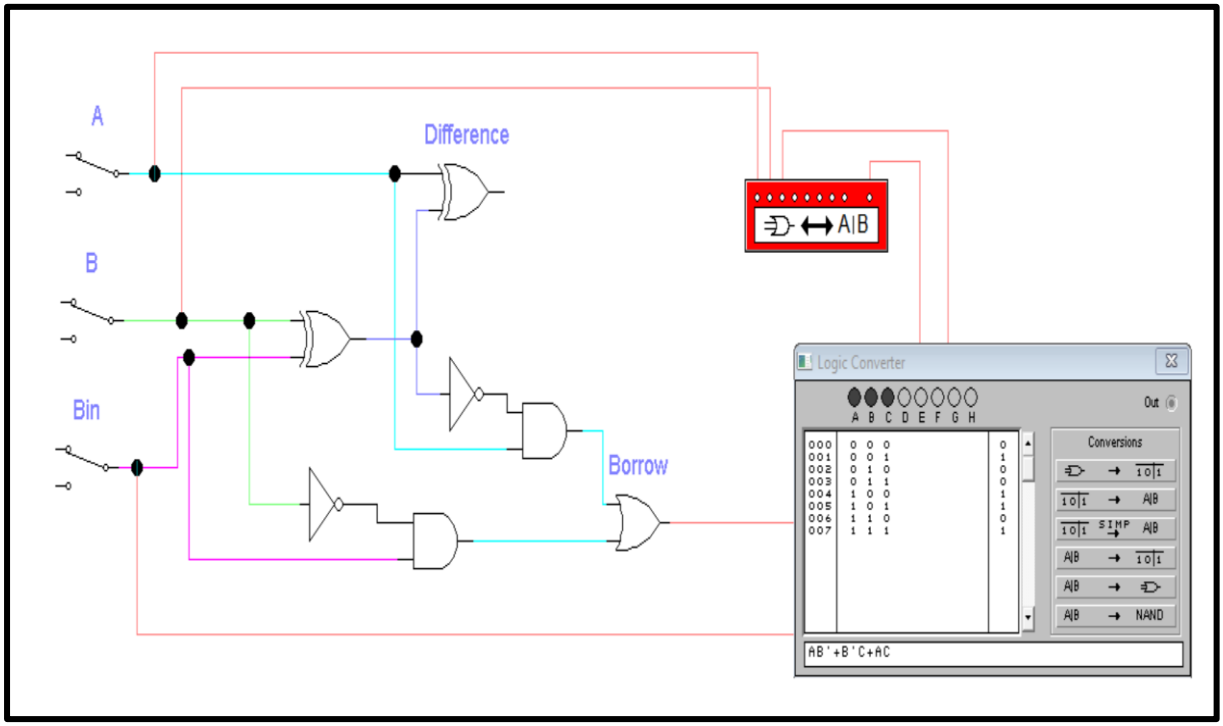
Block Diagram:

Implementation in EWB

Difference:



Borrow:



LAB CONCLUSION WITH TRUTH TABLES

Full Adder Final Truth Table:

A	B	Cin	Sum	Cout
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

HALF Subtractor Final Truth Table:

A	B	Difference	Borrow
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

Full Subtractor Final Truth Table:

A	B	Bin	Difference	Bout
0	0	0	0	0
0	0	1	1	1
0	1	0	1	1
0	1	1	0	1
1	0	0	1	0
1	0	1	0	0
1	1	0	0	0
1	1	1	1	1