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16-Bit
ALU and Multiplier

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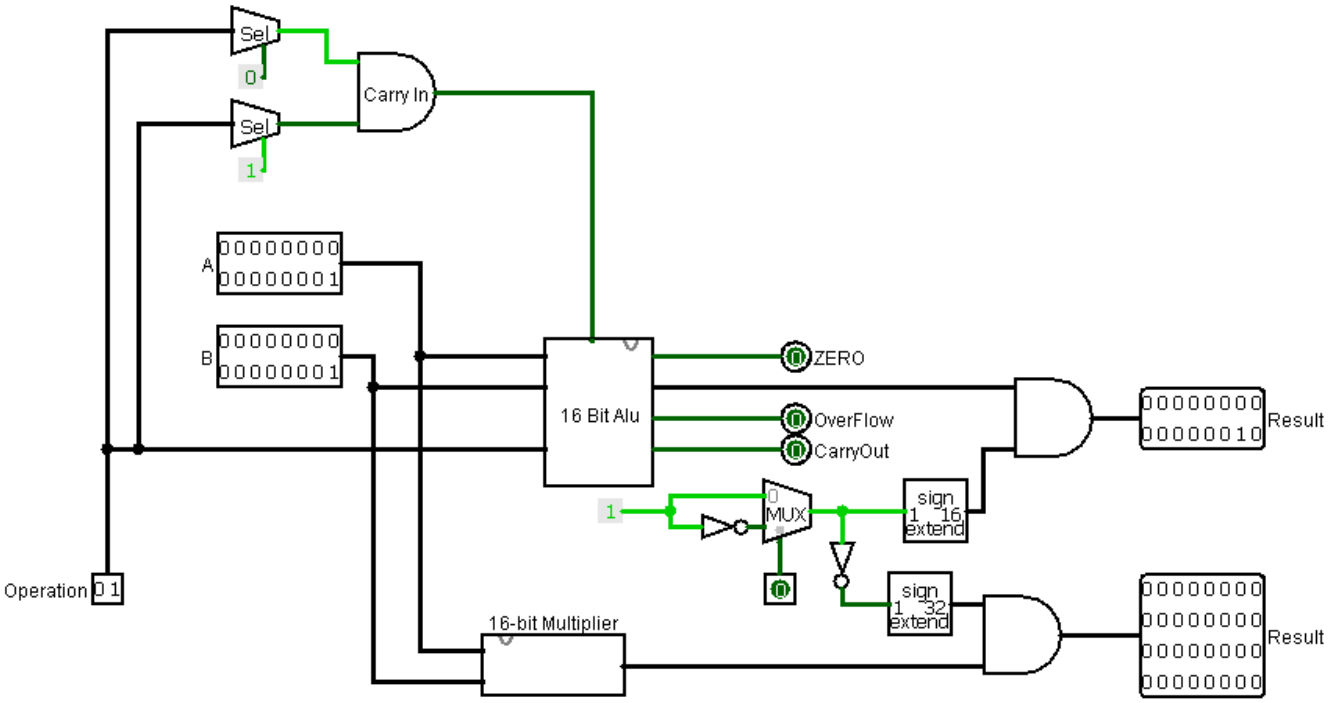
Arithmetic Logic Unit (ALU)

- Is a digital circuit that performs arithmetic and logical operations on binary numbers.
- It typically consists of several sub-components, including adders, multiplexers, logic gates, and registers.
- The ALU is responsible for operations such as addition, subtraction, bitwise logical operations (AND, OR).
- It takes input operands, performs the specified operation based on control signals, and produces the output result.

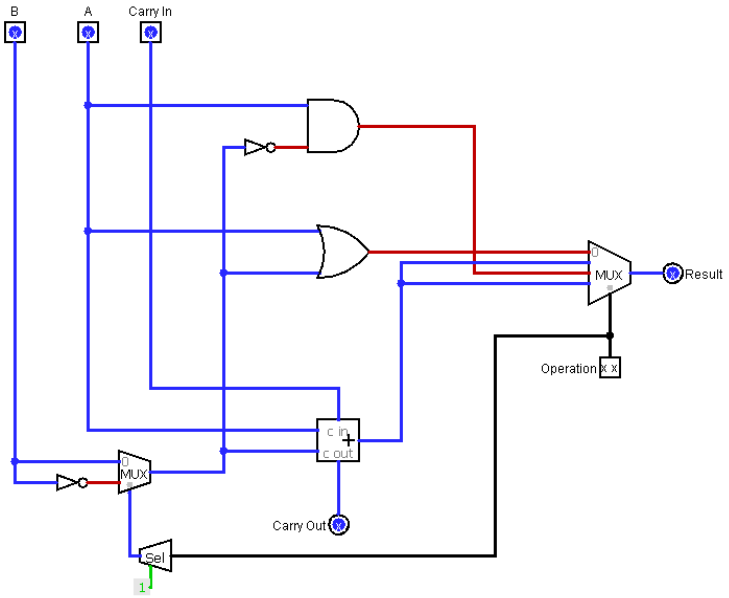


Multiplier Circuit

- Is designed specifically to perform the multiplication operation on binary numbers.
- It takes two input operands, multiplies them together using the chosen multiplication algorithm, and produces the resulting product as output.
- The complexity of the multiplier circuit depends on factors such as the bit width of the operands and the desired speed and precision of the multiplication operation.

First: 16-Bit ALU

Consists of 2 levels:



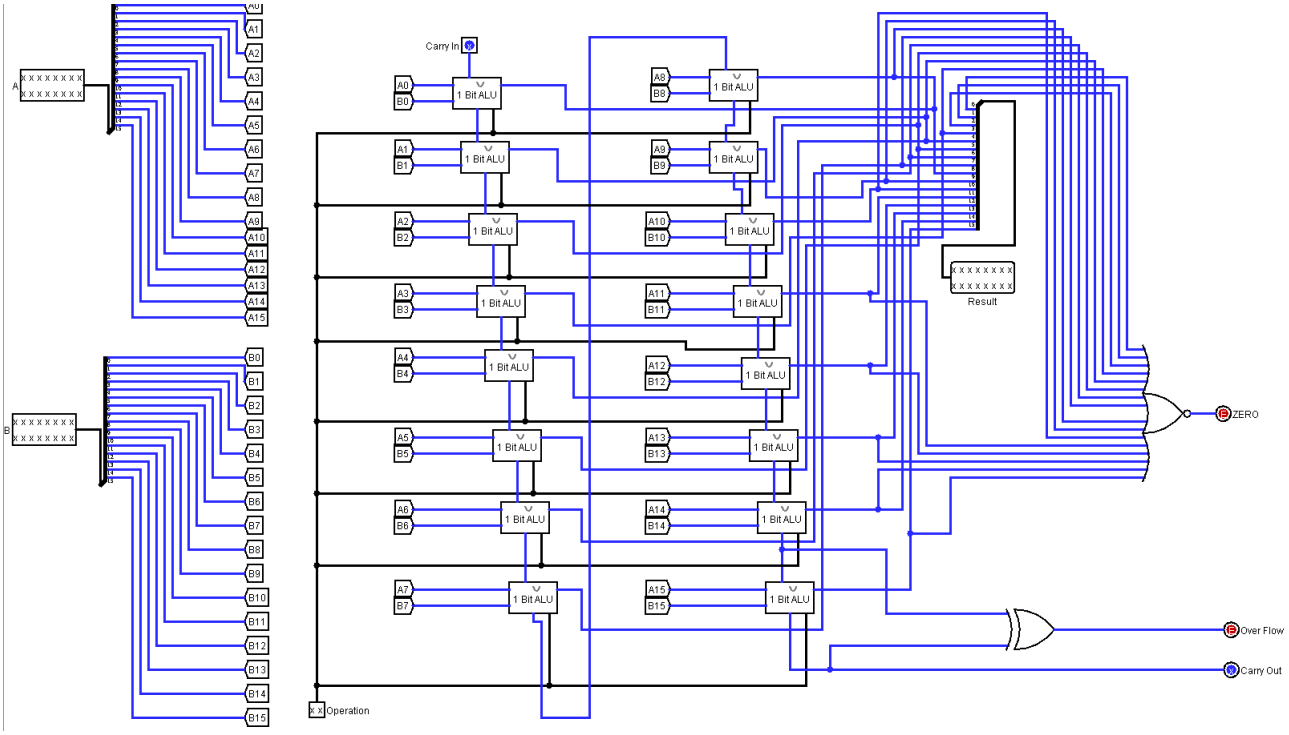
level 1: Basic ALU

- **AND** connected to 2 i/p A,B.
- **OR** connected to 2 i/p A,B.
- **ADD/SUB** connected to 2 i/p A,B using a multiplexer to switch between +B/-B for SUB.
- **Operational multiplexer** to choose between them.

Note: a one-selector selects 2nd bit of operation input so mux selects this bit

Level 2: multi connected ALU

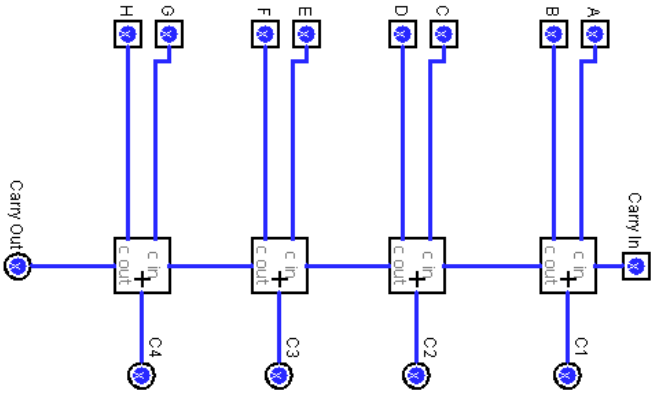
- Input Every ALU is connected with 2-bits from both the 16-bit input A and B , carry in of previous alu, the operation bits.
- Output Result of sum, carry out to next alu.
- Checkers Zero checker if all result is zero, overflow checker if both MSB and carry out are diff.



Second: 16-Bit Multiplier

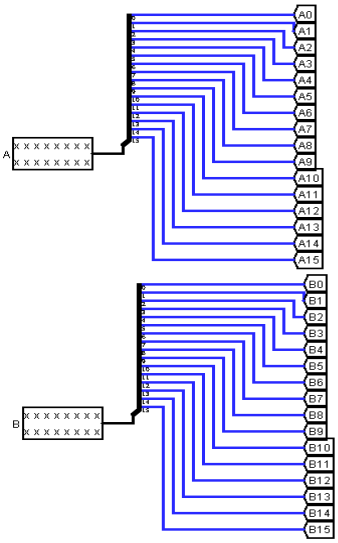
Consists of 3 levels:

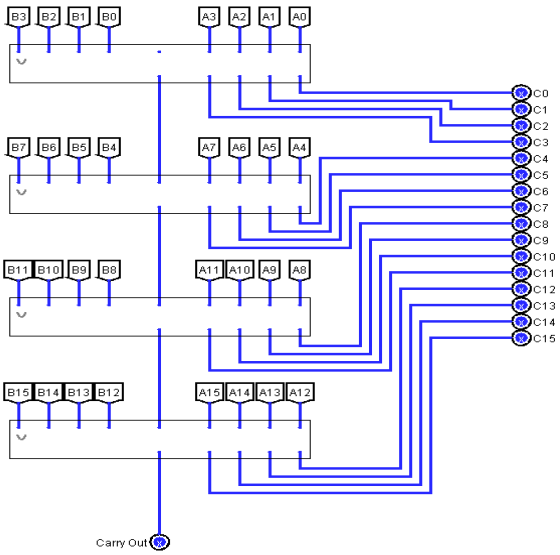
Level 1: 4-bit parallel adder 4 connected single adder.



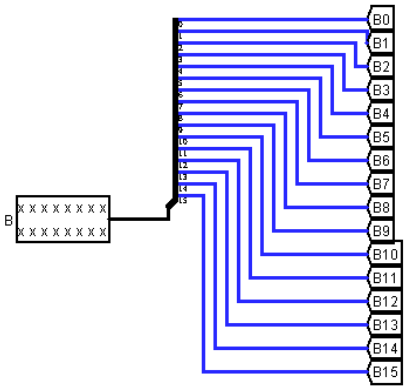
Level 2:

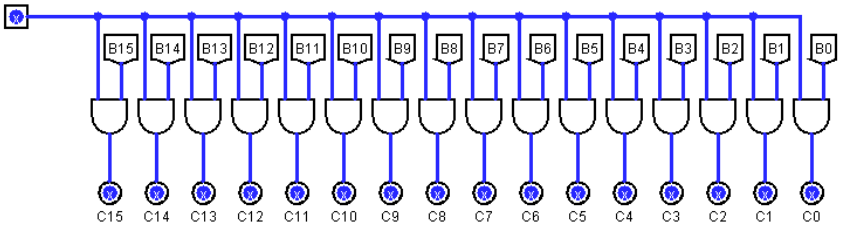
- ***16-bit parallel adder*** 4 connected 4-bit adders.





- ***16-bit AND Circuit*** every bit of the 16 is ANDed with a single bit



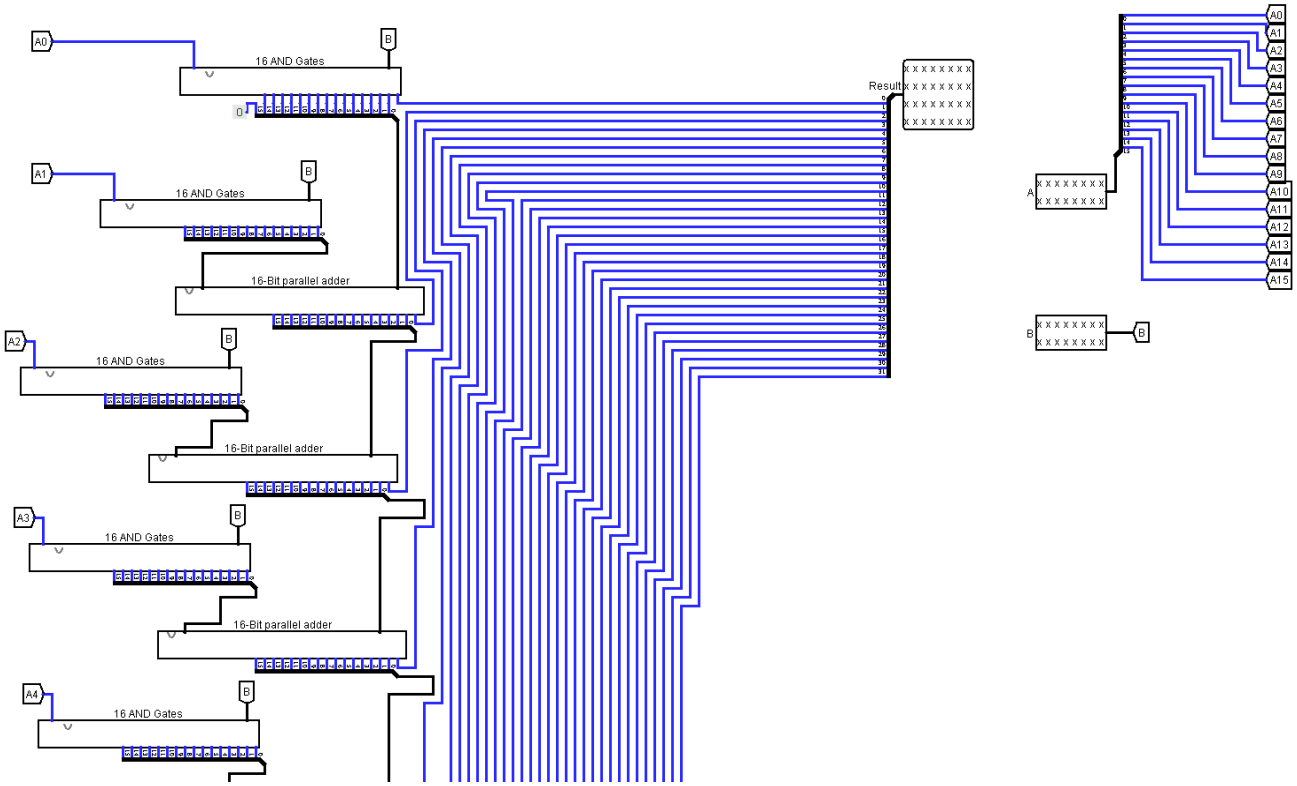


Level 3: 16-bit Multiplier circuit

It works with the same principle of this simple 2-bits multiplication but on large scale

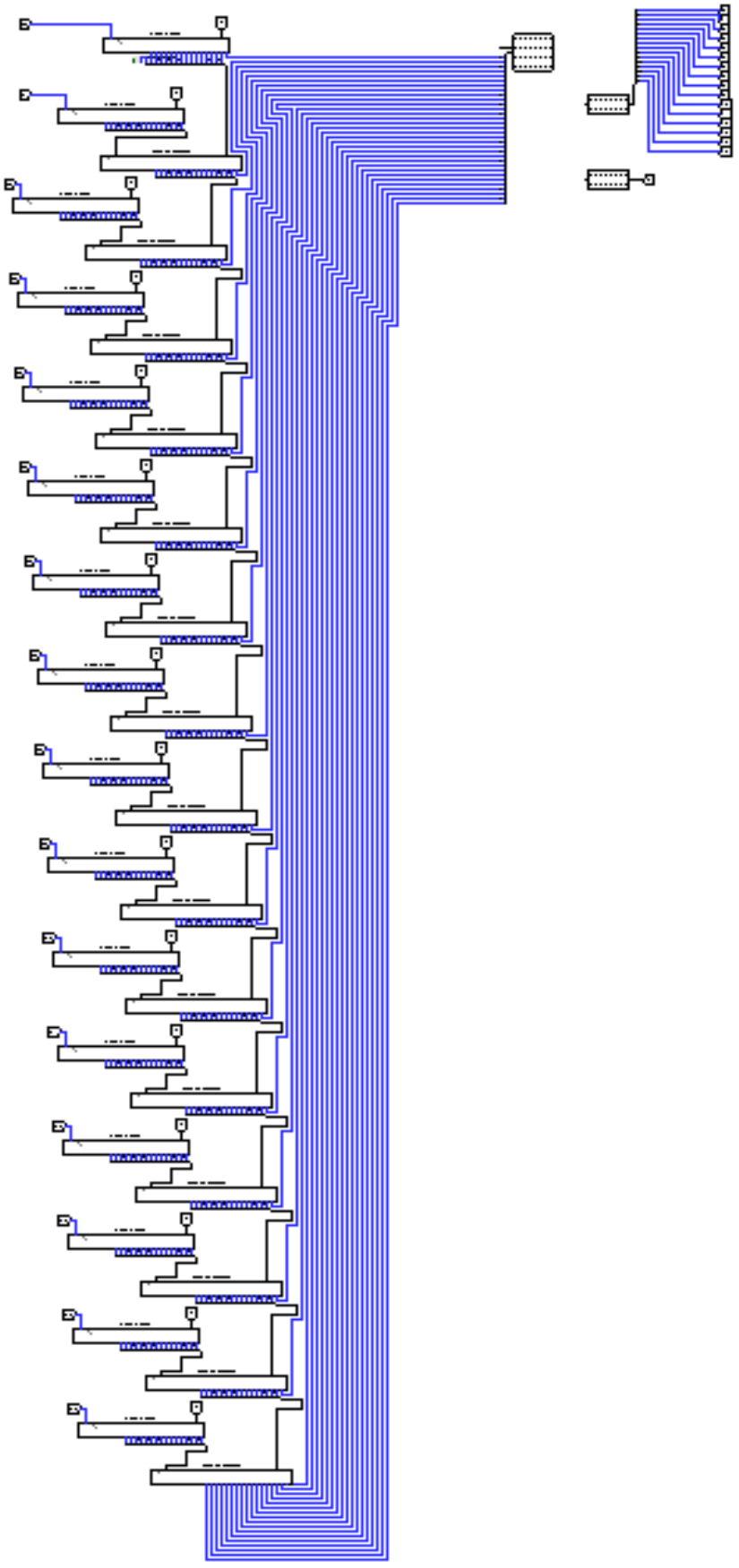
$$
\begin{array}{cccc}
 & & B_1 & B_0 \\
 & & A_1 & A_0 \\
\hline
 & & A_0B_1 & A_0B_0 \\
 & A_1B_1 & A_1B_0 & \\
\hline
C_3 & C_2 & C_1 & C_0
\end{array}
$$

Personally I don't recommend you to see its full circuit image. Here is a sample of its circuit…



If you are still curious to see it, then… you will find it in the next slide.

Here you are!...



Finally heres a truth table for operations:

Input Operation Control		What it does
0	0	OR
0	1	SUM
1	0	AND
1	1	SUB

Circuit Control	What it does
0	ALU
1	Multiplier

Note:
If circuit control is changed from/to ALU/Multiplier the result is automatically becomes all zeros in the unused circuit.