

TITLE: 4-Bit Versatile ALU for Arithmetic and Logical Operations

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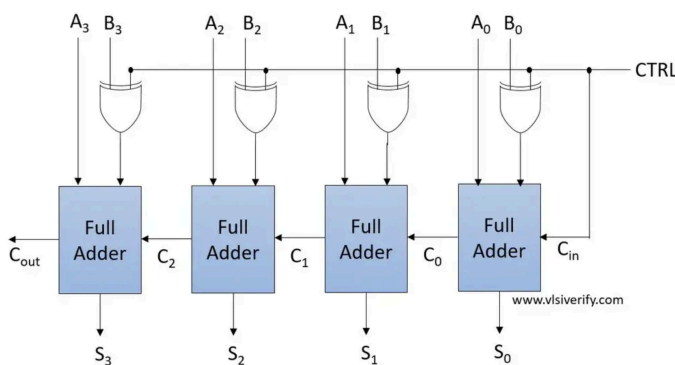
Theory/Description:

The idea of building this ALU stems from the fact that we often require some predefined macros in our schematic, for abstraction purposes. This is where our versatile ALU finds its use as it can perform addition, subtraction, multiplication and comparison of given 4-bit numbers. This greatly reduces the pain that circuit designers have to go through in defining individual adders, multipliers, etc.

The ALU is designed to handle 4-bit operands and supports the following operations, selectable using a 2-bit operation control signal (`mode[1:0]`):

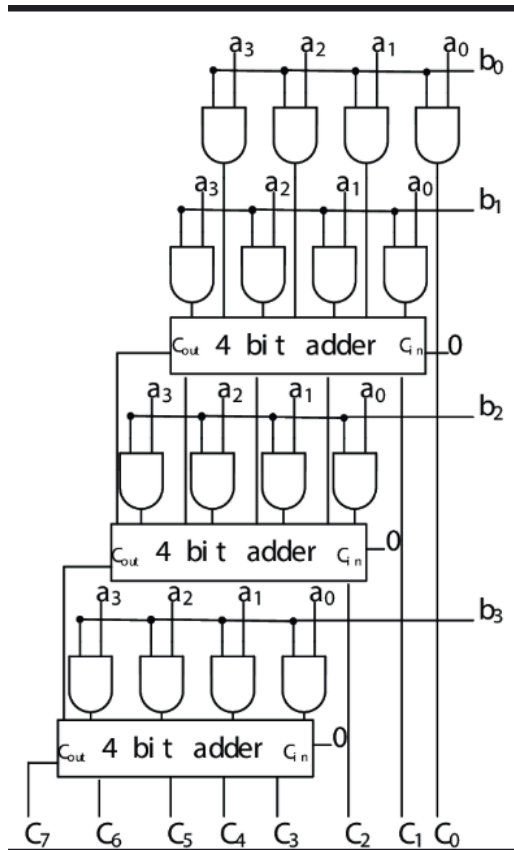
1. **Addition(mode=00)**: Performs 4-bit addition with overflow detection.
2. **Subtraction(mode=01)**: Performs 4-bit subtraction using 2's complement logic.
3. **Multiplication(mode=10)**: Computes the product of two 4-bit inputs with an 8-bit result using an array multiplier.
4. **Comparison(mode=11)**: Determines if one operand is greater than or equal to the other.

For addition and subtraction, we used an adder/subtractor circuit as shown in the figure below:

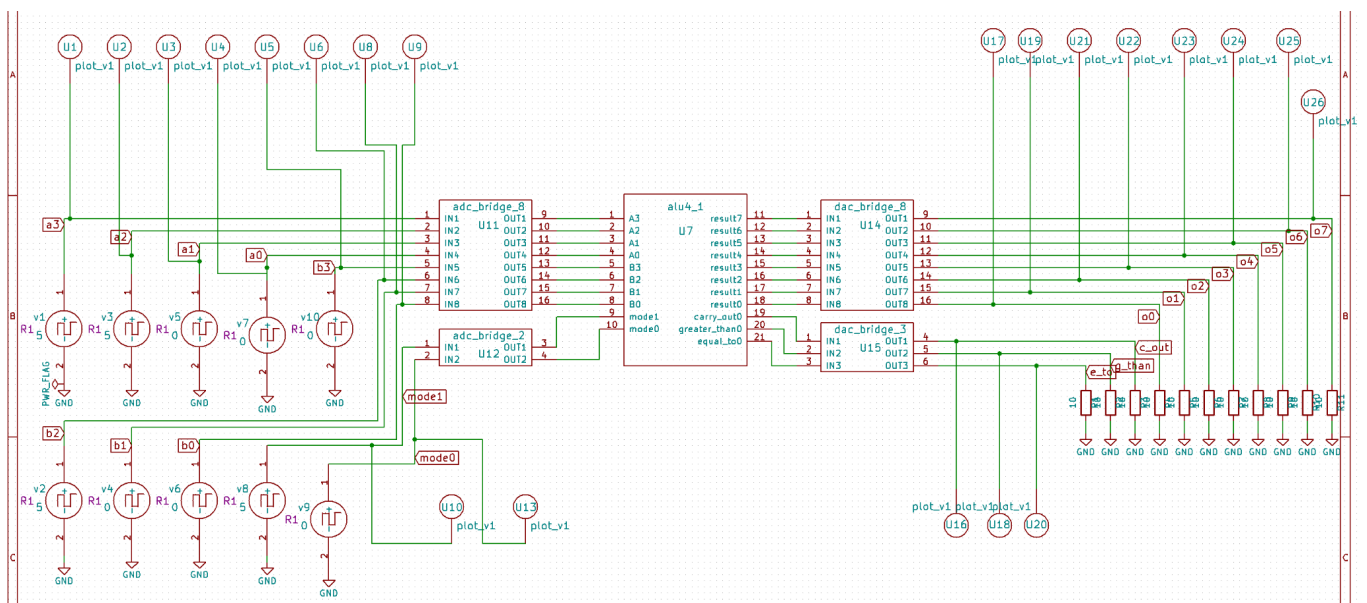


Since the result variable of the ALU is 8-bits long, the answer of sum(S) is stored in the lower 4-bits of the result variable and C_out is stored in the carry_out variable.

The multiplier uses the following logic diagram:



Circuit Diagram:

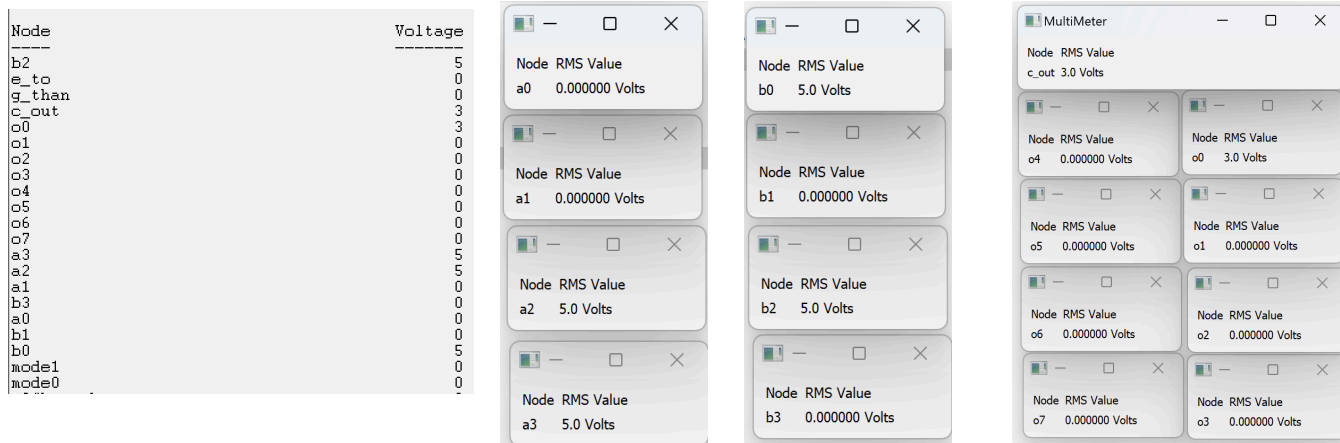


Results:

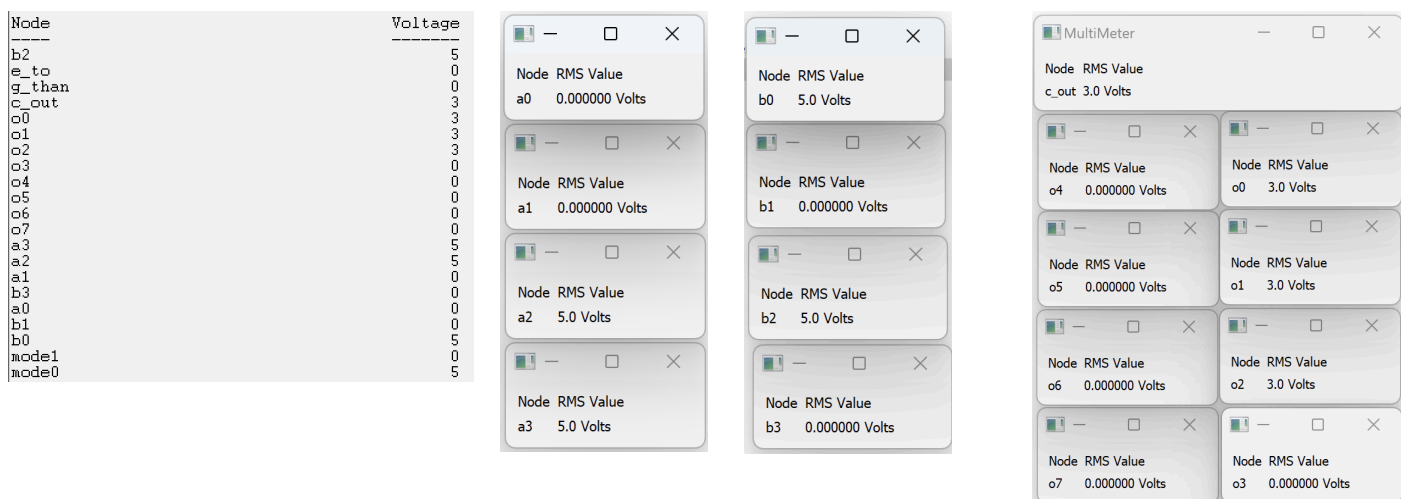
1. Addition (mode = 00) of A = 12 (1100) and B = 5 (0101)

NOTE: As explained above the lower 4-bits of the output variable contain the sum and the carry_out gives if any carry was generated.

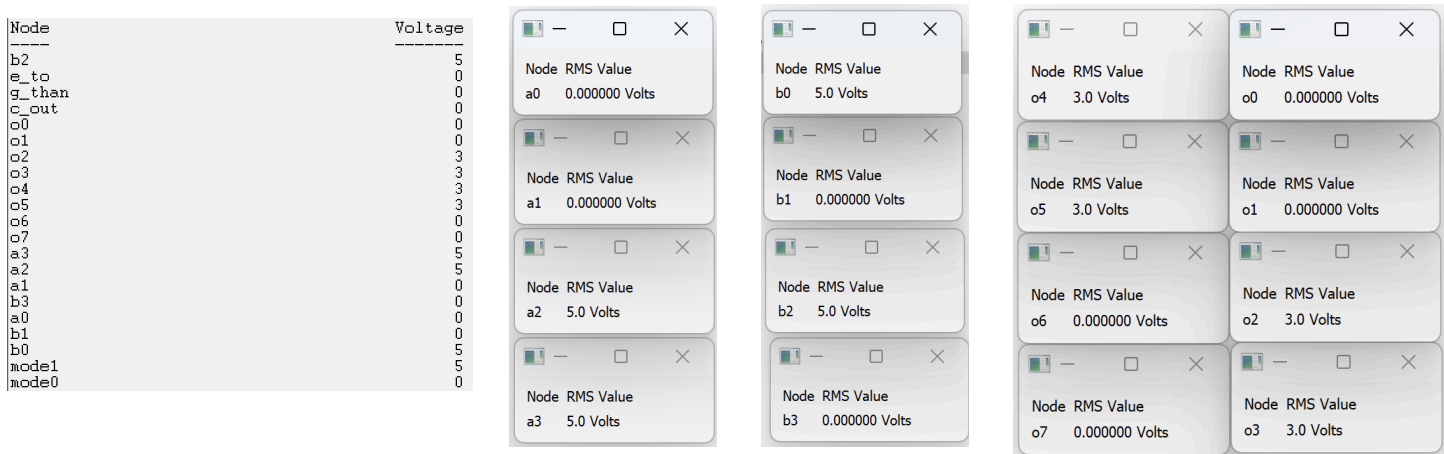
So, to understand the result, take the lower four bits of the “o” variable and attach the c_out variable to the left most position which in this case gives - 10001 i.e. 17.



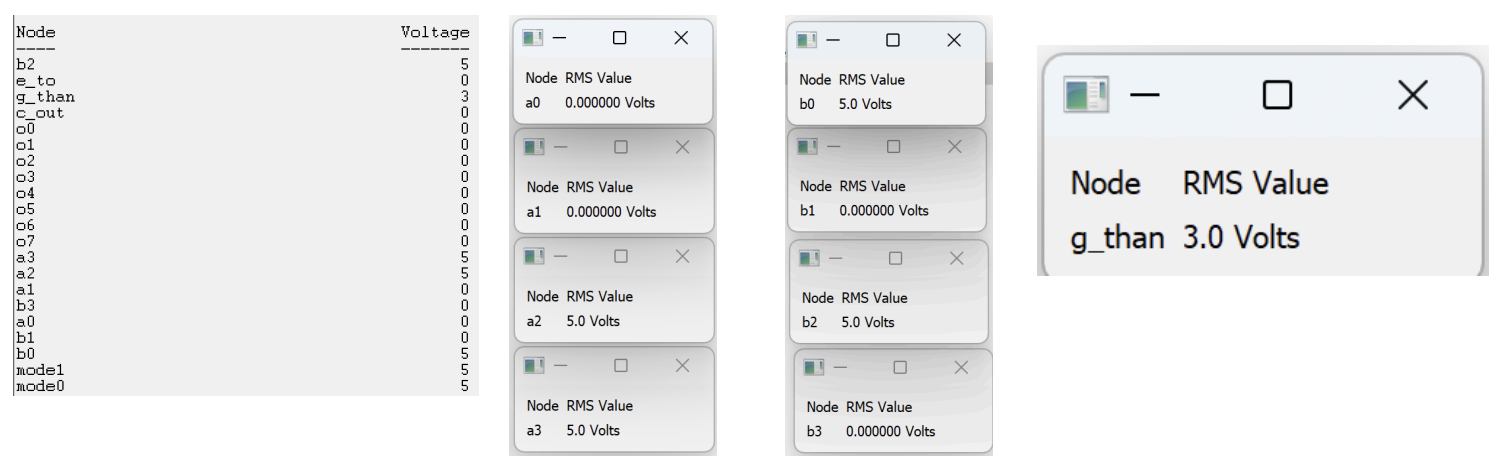
2. Subtraction (mode = 01) of A = 12 (1100) and B = 5(0101)



3. Multiplication (mode = 10) of A = 12 (1100) and B = 5(0101)



4. Comparison (mode = 11) of A = 12 (1100) and B = 5(0101)



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Reference:

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