

Assignment 3

16-bit ALU

Introduction: -

ALU is the fundamental building block of the processor, which is responsible for carrying out the **unsigned arithmetic**, **logic** functions, **Shift** functions and **Comparison** functions.

Specification:

- **ALU Operands** (A, B)
- **ALU Result** (ALU_OUT)
- ALU operands and output Result are of **16-bit** width.
- **ALU Result** (ALU_OUT) is registered.
- The ALU function is carried out according to the value of the **ALU_FUN** input signal stated in the table in the following page and any other value for **ALU_FUN** not stated in the table, **ALU_OUT** must equal to **16'b0**
- **Arith_flag** is activated "High" only when ALU performs one of the arithmetic operations (Addition, Subtraction, Multiplication, division), otherwise "LOW"
- **Logic_flag** is activated "High" only when ALU performs one of the Boolean operations (AND, OR, NAND, NOR, XOR, XNOR), otherwise "LOW"
- **CMP_flag** is activated "High" only when ALU performs one of the Comparison operations (Equal, Greater than, less than), otherwise "LOW"
- **Shift_flag** is activated "High" only when ALU performs one of the shifting operations (shift right, shift left), otherwise "LOW"

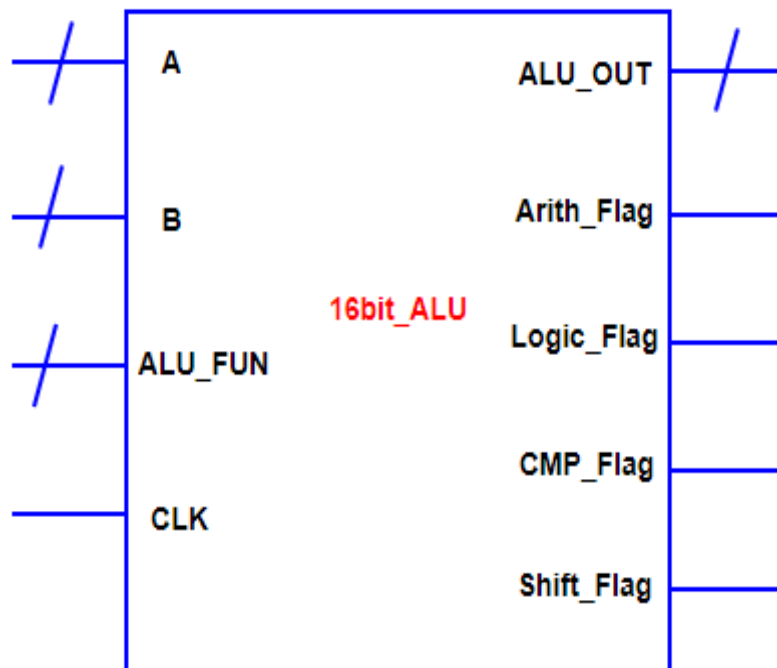
ALU_FUN Table

| ALU_FUN | Operation | ALU_OUT |
|---------|---|--|
| 0000 | Arithmetic : unsigned Addition | |
| 0001 | Arithmetic : unsigned Subtraction | |
| 0010 | Arithmetic : unsigned Multiplication | |
| 0011 | Arithmetic : unsigned Division | |
| 0100 | Logic : AND | |
| 0101 | Logic : OR | |
| 0110 | Logic : NAND | |
| 0111 | Logic : NOR | |
| 1000 | Logic : XOR | |
| 1001 | Logic : XNOR | |
| 1010 | CMP: A = B | Equal to 1 else Equal to 0 |
| 1011 | CMP: A > B | Equal to 2 else Equal to 0 |
| 1100 | CMP: A < B | Equal to 3 else Equal to 0 |
| 1101 | SHIFT: A >> 1 | |
| 1110 | SHIFT: A << 1 | |

Hint: Use Case statement to describe the behavior of this table and use default case if needed.

Hint: You can use if statement inside case branches

Block Interface



1. Write a Verilog Code to capture the above specifications as well as the synthesis diagram of your code.
2. Write a testbench to test all the ALU functions to include the following **16 test cases**: -
 - Unsigned Arithmetic Operations (Addition, Subtraction, Multiplication, Division)
 - Logical Operations (AND, NAND, OR, NOR, XOR, XNOR)
 - Compare Operations (Equal, Greater, Less)
 - Shift Operations (A shift right, A shift left)
 - NOP
3. Write a testbench to test all the ALU functions with operating clock frequency 100 KHz
4. Synthesis Diagram of your code using draw.io online tool