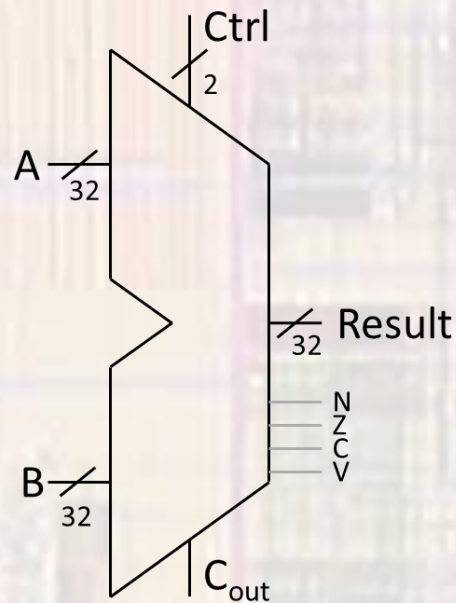# ALU
Arithmetic Logic Unit

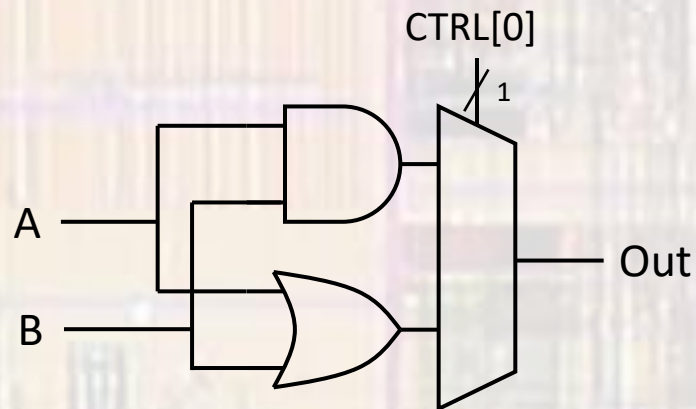Last updated 1/6/25

ALU

- ALU - Arithmetic Logic Unit
  - Calculator on the computer
  - Logical operations
  - Arithmetic operations
  - Status signals

ALU

- Logical Instructions
  - AND, OR
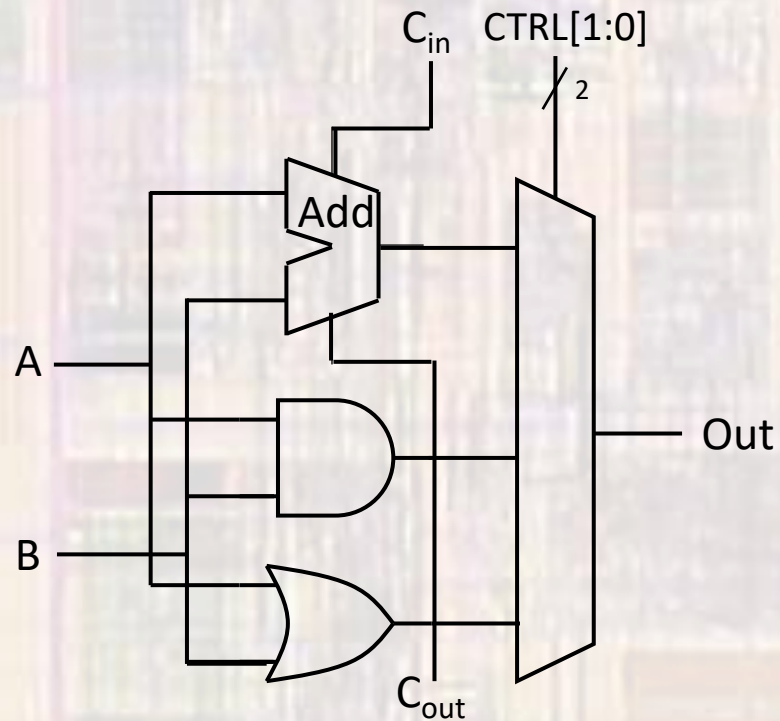   - 2 inputs A and B
    - 1 output
    - 1 bit control

CTRL[0]

1

A
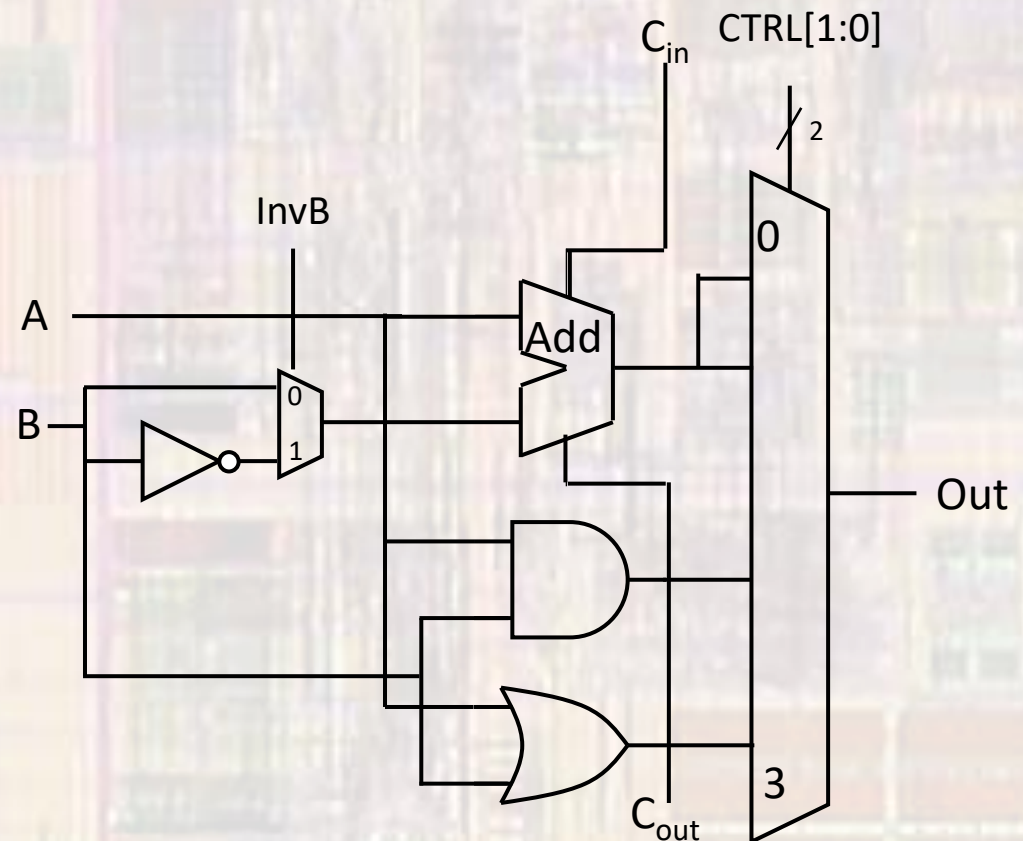
B

Out

ALU

- Arithmetic Instructions
  - ADD
    - Inputs: A, B, C_{in}
    - Outputs: Out, C_{out}
    - 2 control inputs

C_{in} CTRL[1:0]
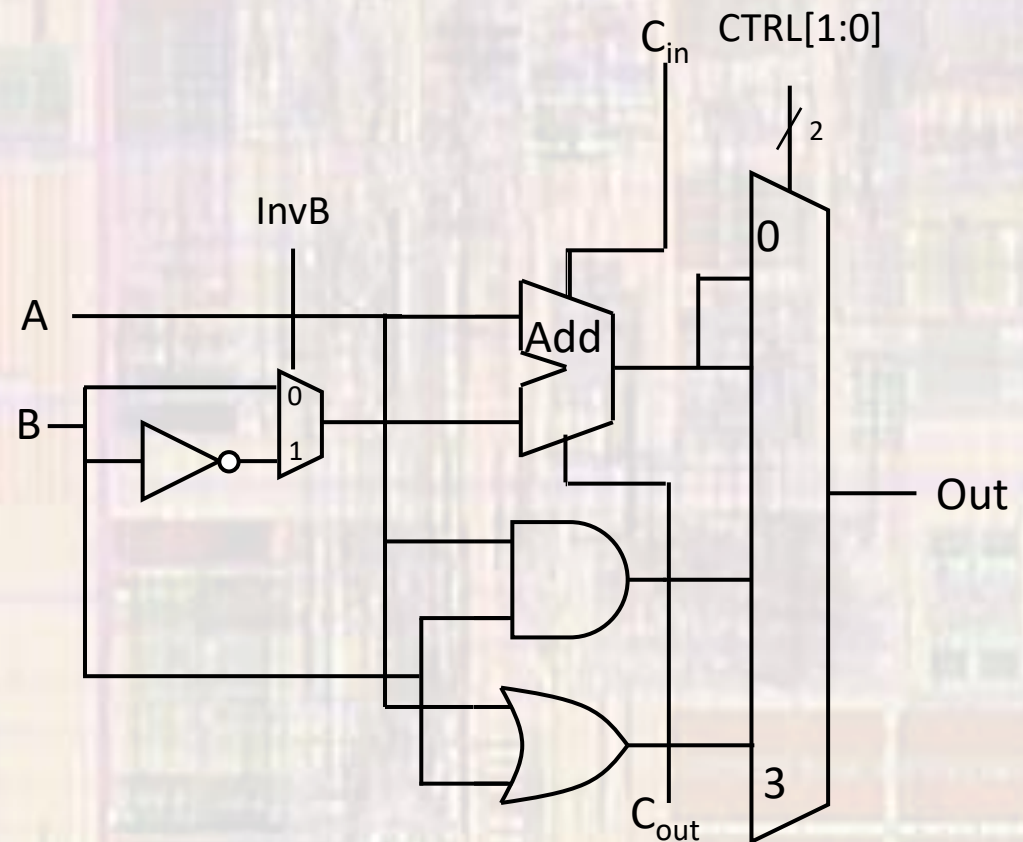
/2

Add

A

Out

B

C_{out}

ALU

- Arithmetic Instructions – cont'd
  - Subtract
    - A + (-B)
      - Negate (invert) B
      - Carry-in = 1
    - Inputs: A, B, C_{in} = 1
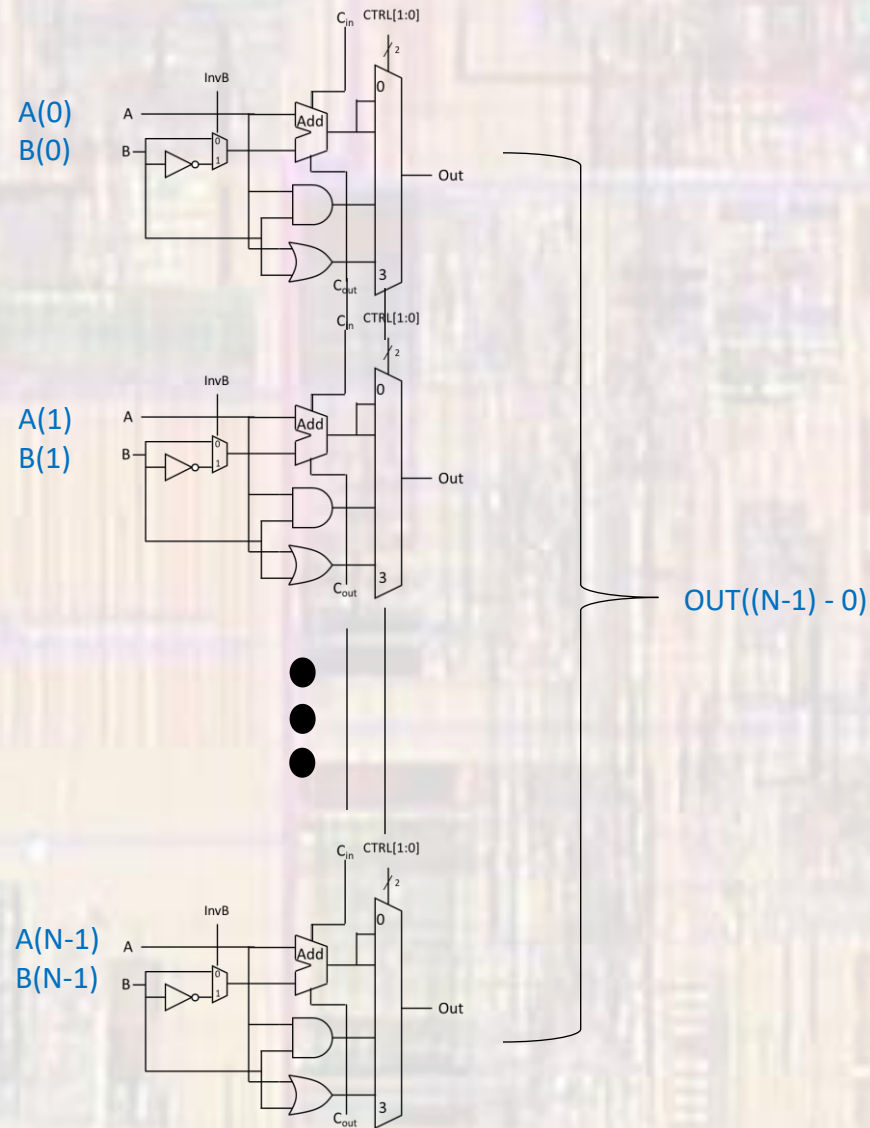   - Outputs: Out, C_{out}
    - 2 control inputs

ALU

- Control
  - CTRL[1:0]
    - 0,0 → subtract
    - 0,1 → add
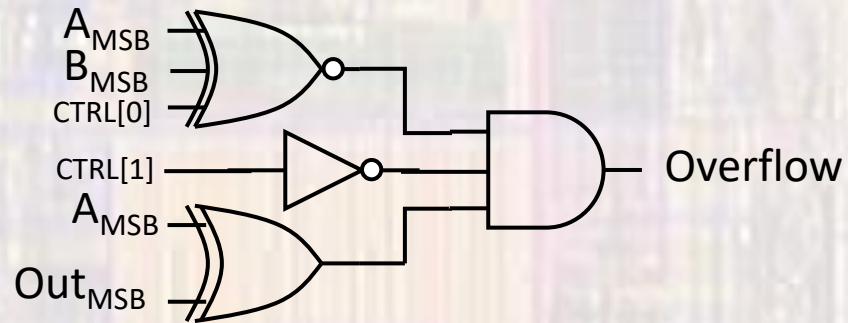   - 1,0 → AND
    - 1,1 → OR

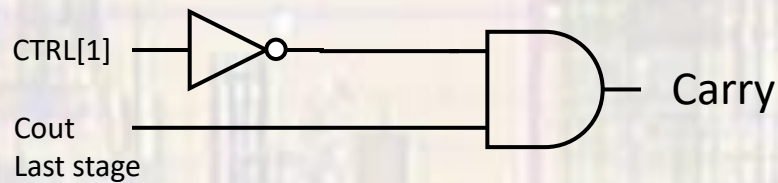   - CTRL[1] = 1 → logical

ALU

- N-bit ALU

A(0)
B(0)

A(1)
B(1)

OUT((N-1) - 0)

A(N-1)
B(N-1)

ALU

- Status Signals
  - Overflow Flag (v)

  - Carry Flag (c)

ALU

- Status Signals – cont'd
  - Zero Flag (z)

$$\text{OUT} \xrightarrow{\quad n \quad} \quad \text{Zero}$$

  - Negative Flag (n)

$$\text{OUT}_{MSB} \quad \text{Negative}$$

ALU

- Control revisited

Operation	invB	Cin	Ctrl[1]	Ctrl[0]
AND	x	x	1	0
OR	x	x	1	1
ADD	0	0	0	0
SUB	1	1	0	1

Operation		Cin	Ctrl[1]	Ctrl[0]
AND			1	0
OR			1	1
ADD			0	0
SUB			0	1

ALU

- Enhanced Adder
  - Replace the carry chain adder with an efficient adder/subtractor

ALU

- 32 bit representation

Ctrl
2

A
32

Result
32

N
Z
C
V

B
32

C_out