

ALU

COMP 273 Assignment 6

Due: March 15, 2024, on myCourses

Submission instructions

All work must be your own and must be submitted to myCourses. Include your name and student number in a comment at the top of your Logisim circuits. **Submit only one file: a6.circ.** Do not use a zip archive. Check your submission by downloading it from myCourses and checking that it was correctly submitted. You will not receive marks for work that is incorrectly submitted.

Purpose

- Learning about the basic circuitry in the ALU.
- To get used to 2's complement.
- To get used to using flags.

Helpful

- A5 should be completed before you start this assignment.
- The lectures on ALU.
- The lecture notes on ALU.
- Tutorial E is also useful.

Overview

In this assignment you will build an Integer ALU. This includes the Left and Right registers, the Status register and the A-out register. This ALU will only perform addition and subtraction. All numbers are signed using the 2's complement technique. You will need a 2's complement circuit for the Right register only. The output of the Left and Right register will go into an Adder circuit. The output of the Adder circuit will populate the A-Out register and the status register. **Your status register will only test for Zero, Negative, and magnitude overflow (except when subtracting).** This is the simple overflow case.

Implementation

Using Logisim Evolution create the circuit for the following problem:

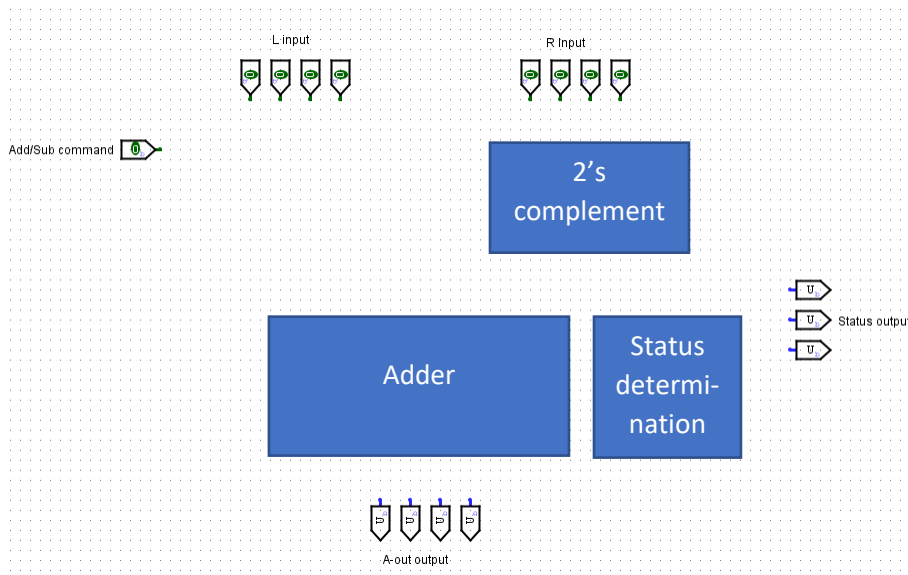


Figure 1: High-level view of ALU

- **Task:** Build the circuit of figure 1.
- **Inputs:** L and R (nibble sized register, 4 pins each), and Add/Subtract command pin.
- **Outputs:** A-out (nibble sized register, 4 pins) and Status (3 pin register)
- **Circuits:** 2's complement circuit, adder circuit, and status output circuits. Plus, a CLOCK.

NOTE: Your final circuit does not need to look exactly like figure 1. However, the input and output pins must look like figure 1.

NOTE 2: Your final circuit must use designs we covered in class. You cannot use any outside (other sourced) circuit designs.

NOTE 3: You must build the circuit from the following components ONLY: **wires, D-flip-flop, clock, AND, OR, NOT, XOR, and pins**. You **CANNOT** use: any prebuilt adder circuits, or any other prebuild items from Logisim. Optionally you **can** use tunneling and "adding a circuit" from the project menu.

Steps

- Begin by placing the input and output pins onto the circuit. These pins will be used to enter values.
- The Adder circuit assumes two 2's compliment inputs from L and R. The L input goes directly into the Adder without modification. The R input goes either through the 2's complement circuit or passes unchanged. The solution to the addition is outputted to the A-out pins.
- The 2's complement circuit is controlled by the command pin and will negate the value in the R register when it is set to 1. When the commanded pin is set to 0, R is passed to the Adder unchanged. When the command pin is 1 the ALU is performing a subtraction. When it is 0 it is performing an addition.

- The Status register's flag bits are updated by the result stored in A-out. **Bit 0 = negative, Bit 1 is zero, and bit 3 is magnitude overflow.**
- A clock must control the execution of this circuit.

Execution

Your ALU circuit must be able to do the following:

1. Add and subtract two 4-bit 2's complement integer numbers (Left O Right, where O is + or -).
2. $0 - 0 = 0$
3. $1 - 1 = 0$
4. $1 - (-1) = 2$
5. $2 - 1 = 1$
6. $1 - 2 = -1$
7. Overflow

Note: The TA will input the numbers into the L and R pins in 2's complement by hand.

Marking

- Deductions
 - -10% per day late with max 2 late days.
 - -3 points for not following instructions.
 - -5 points for not using the clock.
 - Assignment must execute to be graded.
- Points Awarded (maximum 20 points)
 - +6 : Adder circuit
 - +6 : 2's complement circuit
 - +5 : Status determination circuits
 - +3 : Registers & pins/probes