

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:

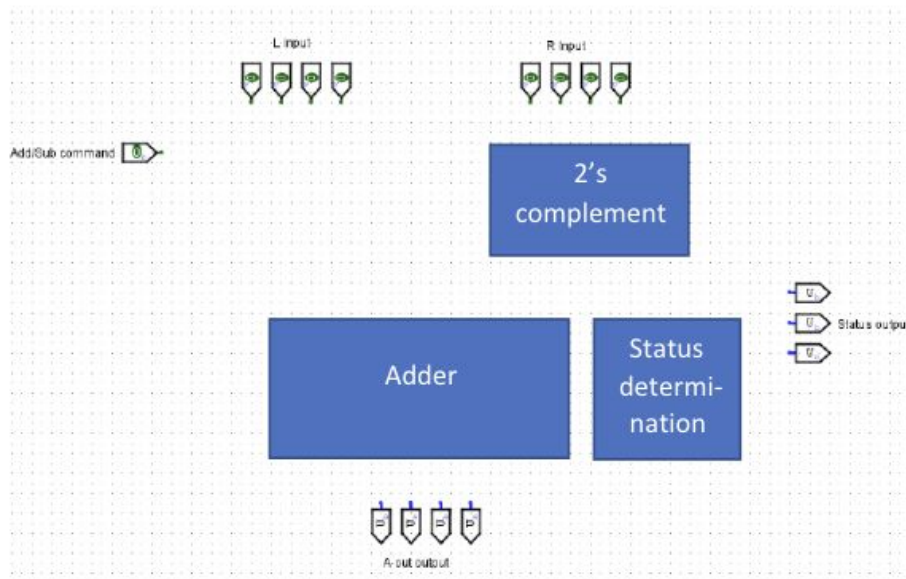


Figure 1: High-level view of ALU

- 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