CCE1013 – Computer Logic I

Practical 3

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Design of an ALU

Objectives

- To design, build and test a 1-bit ALU as a combinational logic circuit.

1. Before coming to the lab session

- Make sure you read the slides on the ALU.
- Go over this document thoroughly.

2. Developing a combinational circuit for an ALU

The inputs into the ALU are the two operands, *A* and *B* and the control inputs, which consist of the C_{in} and the instruction code (Opcode). The outputs from the ALU are the result and the control outputs, which are the flags generated by the ALU. The operands and the outputs are 1-bit, while the Opcode is 2-bit.

You will be implementing the same ALU architecture that we saw in class (Figure 1).

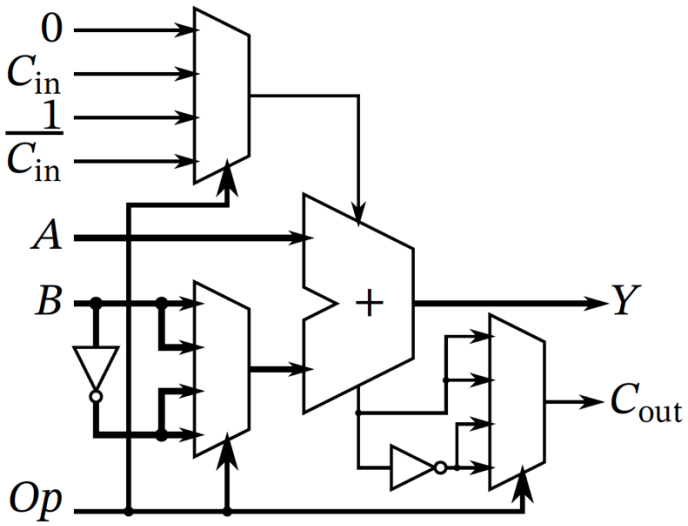

Figure 1 – Combinational logic circuit diagram for an ALU (from lecture slides).

A list of the possible Opcodes, and the corresponding instruction that should be received by the ALU is shown in Table 1. Four arithmetic operations are supported.

Opcode	Instruction	Y	Adder inputs $A+B+C_{\text{in}}$
00	ADD	$A+B$	$A+B+0$
01	ADDC (with carry)	$A+B+C$	$A+B+C$
10	SUB	$A-B$	$A+\overline{B}+1$
11	SUBB (with borrow)	$A-B-C$	$A+\overline{B}+\overline{C}$

Table 1 – Behaviour of ALU for different Opcodes.

You are to now implement the schematic provided through an electric circuit using the following components:

- A breadboard
- A 5V DC Power Supply
- An 8-way DIP switch, of which
  - 3 inputs will be used for A, B and C_{in};
  - 2 inputs will be used for the Opcode.
- Seven 1 kΩ resistors
  - 2 for the LEDs;
  - 3 for each of the A, B and C_{in} DIP switch inputs;
  - 2 for each of the Opcode switch inputs.
- Two LEDs to indicate the outputs Y and C_{out}
- Three 74153 Dual 4-to-1 multiplexer ICs
- A 7483A 4-bit full adder IC
- A 7404 Hex inverter gate IC

As you will build a 1-bit ALU, we only need to use the LSB inputs and outputs of the 4-bit full adder. The next output bit from the adder can be used as the flag (which then serves an input into the final multiplexer).

Logic ‘0’ is produced by connecting the input to the ground rail, while logic ‘1’ is produced by connecting the input to the power supply rail.

Switch ON the power supply, and verify that your circuit works as expected by trying all the combinations of the A, B, C_{in} and Opcode input switches.

Note: if you are using Tinkercad, then you will need to build your own 4-to-1 multiplexer from scratch, using 2 inverters, 4 triple-input AND gates and 3 dual-input OR gates. Make sure you test out your first multiplexer before going on to build the other two. You may use a breadboard for each multiplexer.

3. Deliverable

Your report should include a photo of the developed circuit, as well as a truth table and photos of the results obtained (i.e. LEDs ON or OFF) for each possible combination of operands, C_{in} and Opcodes.

The deadline for the deliverable is 22 January 2021.