BLG222E - Computer Organization
Project 1

Design a 16-bit ALU. Your design should be able to perform the following operations:

- Arithmetic
  1. Add
  2. Add with carry
  3. Subtract
  4. Subtract with borrow
  5. Increment
  6. Decrement
  7. Transfer
- Logic
  1. AND
  2. NAND
  3. OR
  4. NOR
  5. XOR
  6. XNOR
  7. NOT
- Shift
  1. Logical shift left&right
  2. Circular shift&right
  3. Arithmetic shift&right

Detailed information of the given operations can be found in course book and lecture notes. You should start your implementation by building 1 bit logic unit and 1 bit arithmetic unit circuits that support given operations. Eventually, you should build the 16 bit ALU by using 1 bit ALU blocks in parallel together with some design for shift operations. As shown in Figure 1, ALU has A, B 16 bit parameter inputs, C_{in} carry input and S 4 bit select input. The outputs are F 16 bit result and C_{out} carry output.

You may use the Table 1 as a reference on how to use selection bits.

Implement your design in **logisim** software, upload a single compressed (zip or rar) file to ninova before the deadline. Only one student from each group should submit the project file. This compressed file should contain your design files (.circ) and a report that contains:

- the number&names of the students in the group
- list of control inputs and corresponding functions of the ALU

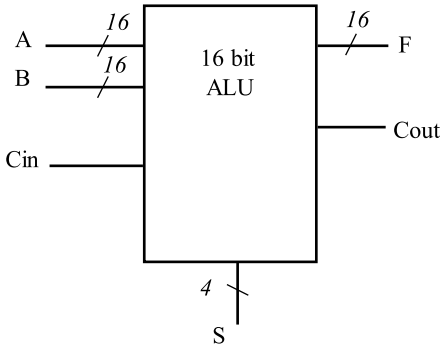

Figure 1: Inputs and outputs of the 16 bit ALU

S_3	S_2	S_1	S_0	C_{in}	Operation	Function
0	0	0	0	0	$F \leftarrow A$	Transfer A
0	0	0	0	1	$F \leftarrow A + 1$	Increment A
0	0	0	1	0	$F \leftarrow A + B$	Addition
0	0	0	1	1	$F \leftarrow A + B + 1$	Add with carry
0	0	1	0	0	$F \leftarrow A + \bar{B}$	Subtract with borrow
0	0	1	0	1	$F \leftarrow A + \bar{B} + 1$	Subtraction
0	0	1	1	0	$F \leftarrow A - 1$	Decrement A
0	0	1	1	1	$F \leftarrow A$	Transfer A
0	1	0	0	0	$F \leftarrow A \wedge B$	AND
0	1	0	0	1	$F \leftarrow \overline{A \wedge B}$	NAND
0	1	0	1	0	$F \leftarrow A \vee B$	OR
0	1	0	1	1	$F \leftarrow \overline{A \vee B}$	NOR
0	1	1	0	0	$F \leftarrow A \oplus B$	XOR
0	1	1	0	1	$F \leftarrow \overline{A \oplus B}$	XNOR
0	1	1	1	X	$F \leftarrow \bar{A}$	Complement A
1	0	0	0	X	$F \leftarrow shrA$	Logical shift right A into F
1	0	0	1	X	$F \leftarrow ashrA$	Arithmetic shift right A into F
1	0	1	X	X	$F \leftarrow cshrA$	Circular shift right A into F
1	1	0	0	X	$F \leftarrow shlA$	Logical shift left A into F
1	1	0	1	X	$F \leftarrow ashlA$	Arithmetic shift left A into F
1	1	1	X	X	$F \leftarrow cshlA$	Circular shift left A into F

Table 1: Operations of the ALU from the Lecture Notes

Group work is expected for this project. Form groups of 4 students, and design together. You might be asked to make a 10-minute demonstration of your design with a few test cases.

Make sure to connect pins (under Wiring group of logisim) to the inputs and control inputs of your design, so that different inputs and functions can be tested. Similarly connect your outputs to a "Hex Digit Display" in logisim (under Input/output group of logisim) so that the test outputs can be observed and use proper labeling to improve the clarity of your circuits.