PASS – Computer Systems

Week 4

1. Tips for Week 4 exam

    1) Truly understand every question in the prac exam – what the right answer is and why.
    2) Study the revision quiz (in MyUni module)
    3) Review your notes, make sure you understand all the key concepts like canonical representation, binary representation (min, max, conversion, overflow), binary arithmetic, ALU, etc
    4) Time yourself during the exam – e.g., 45 min for 25 questions ➔ 1.8 min/question.

2. What is the smallest number of NOR gates required to implement an AND chip?

    3

3. C++ has the following bitwise operators, **&** (and), **|** (or) and **~**(not) and a left shift operator **<<**.

    What is the decimal value of the expression, **(1<<3|1<<1)**, if all numbers are represented in 8-bit two's complement. Your answer must start with an initial sign, **+** or **-**. The rest of your answer must only contain decimal digits.

    00001010
    00000010

    00001010 $0+2^1+0+2^3$
    $= 10$

    When shifting a signed value, the **>>** operator is an ***arithmetic shift***. What is the decimal value of the expression, **(-128>>3|1>>1)**, if all numbers are represented in 8-bit two's complement. Your answer must start with an initial sign, **+** or **-**. The rest of your answer must only contain decimal digits.

    +16

-128 : 1000 0000
>> 3 : 0001 0000
1>>1 : 00000000 OR = +16

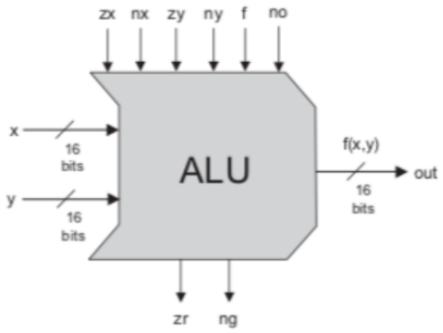
4. Write down the canonical representation for the **sum** and **carry** output of the **HalfAdder** boolean function. (use !, &, + operators to represent not, and, or)

a	**b**	**sum**	**carry**
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Sum =	$\bar{a} \cdot b + a \cdot \bar{b}$
Carry =	$a \cdot b$

5. ALU

The following diagram shows the interface to the Hack ALU and the effect of the six control inputs zx, nx, zy, ny, f and no.



zx	nx	zy	ny	f	no

if zx==0 then
x1=x
else
x1=0
	if nx==0 then
	x2=x1
	else
	x2=!x1
		if zy==0 then
		y1=y
		else
		y1=0
			if ny==0 then
			y2=y1
			else
			y2=!y1
				if f==0 then
				fout=x2&y2
				else
				fout=x2+y2
					if no==0 then
					out=fout
					else
					out=!fout

Notes:

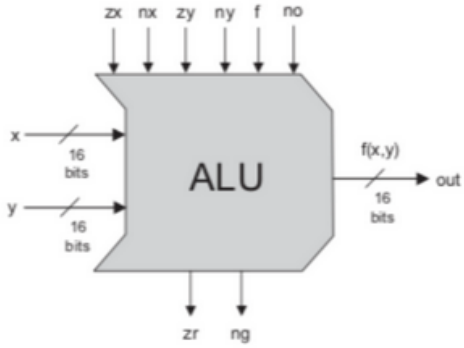
- The values of **x1**, **x2**, **y1**, **y2**, **fout** and **out** must be expressed as simplified arithmetic expressions and may include a single **x**, a single **y**, a single digit (**0**, **1** or **2**) and the operators, **+** and **-**.
- If an expression starts with **-**, all operators must be **-**.
- If an expression is **0**, it may be expressed as **0** or **zero**.
- The values of **zr** and **ng** must be expressed as **true** or **false**.
- Your answers must not include any spaces.

What are the values x1, x2, y1, y2, fout and **out** when the ALU control inputs have the following values?

if **zx** == 0 then x1 =	x	, then if **nx** == 0 then x2 =	x
if **zy** == 1 then y1 =	0	, then if n**y** == 1 then y2 =	-1
If **f** == 1 then fout =	x-1		
If **no** == 0 then out =	x-1		
What values would be output on the **zr** and **ng** wires if the values of x and y are as follows?			
If x == 1 and y == 2 then **zr** =	true		
If x == 2 and y == 3 then **ng** =	false		

6. Another ALU question

The following diagram shows the interface to the Hack ALU and the effect of the six control inputs zx, nx, zy, ny, f and no.



zx	nx	zy	ny	f	no

if zx==0 then
x1=x
else
x1=0
	if nx==0 then
	x2=x1
	else
	x2=!x1
		if zy==0 then
		y1=y
		else
		y1=0
			if ny==0 then
			y2=y1
			else
			y2=!y1
				if f==0 then
				fout=x2&y2
				else
				fout=x2+y2
					if no==0 then
					out=fout
					else
					out=!fout

Notes:

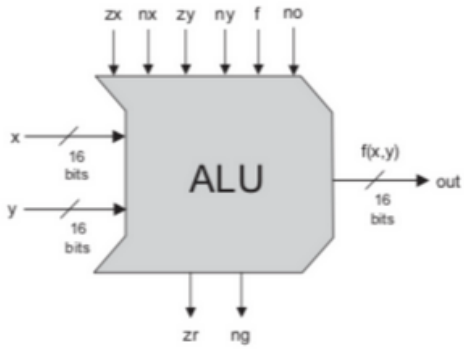
- The values of **x1**, **x2**, **y1**, **y2**, **fout** and **out** must be expressed as **true**, **false** or as simplified boolean expressions.
- Boolean expressions may include a single **x**, a single **y** and the operators **&**, **|** and **!**.
- The values of **zr** and **ng** must be expressed as **true** or **false**.
- Your answers must not include any spaces.

What are the values **x1**, **x2**, **y1**, **y2**, **fout** and **out** when the ALU control inputs have the following values?

if **zx** == 0 then x1 =	x	, then if **nx** == 0 then x2 =	x
if **zy** == 1 then y1 =	0	, then if n**y** == 1 then y2 =	−1
If **f** == 0 then fout =	x & −1		
If **no** == 0 then out =	x | −1		
What values would be output on the **zr** and **ng** wires if the values of x and y are as follows?			
If x == true and y == false then **zr** =	1x−1 = −1 false		
If x == true and y == true then **ng** =	1x−1 = −1 true		

7. More ALU

The following diagram shows the interface to the Hack ALU and the effect of the six control inputs zx, nx, zy, ny, f and no.



zx	nx	zy	ny	f	no

if zx==0 then
x1=x
else
x1=0
	if nx==0 then
	x2=x1
	else
	x2=!x1
		if zy==0 then
		y1=y
		else
		y1=0
			if ny==0 then
			y2=y1
			else
			y2=!y1
				if f==0 then
				fout=x2&y2
				else
				fout=x2+y2
					if no==0 then
					out=fout
					else
					out=!fout

Notes:

- The values of **x1**, **x2**, **y1**, **y2**, **fout** and **out** must be expressed as **true**, **false** or as simplified boolean expressions.
- Boolean expressions may include a single **x**, a single **y** and the operators **&**, **|** and **!**.
- The values of **zr** and **ng** must be expressed as **true** or **false**.
- Your answers must not include any spaces.

What are the values **x1**, **x2**, **y1**, **y2**, **fout** and **out** when the ALU control inputs have the following values?

if **zx** == 0 then x1 =	x	, then if **nx** == 0 then x2 =	x
if **zy** == 0 then y1 =	y	, then if n**y** == 0 then y2 =	y
If **f** == 0 then fout =	x & y		
If **no** == 1 then out =	!x | !y		
What values would be output on the **zr** and **ng** wires if the values of x and y are as follows?			
If x == true and y == false then **zr** =	0 + 1 = 1 false		
If x == true and y == true then **ng** =	0 + 0 = false		