Practice test for Pearl 000 of Computer Science (202001021)

9 September 2021

- You are allowed to use one A4-sized sheet of paper with your own notes at this exam, and a *simple* calculator.
- Scientific or graphical calculators, laptops, cell phones, books etc. are not allowed. ***Put them in your bag right now!***
- The number of points per question is indicated in the margin.
- The real test, next week, will be partially multiple-choice; however, the kind of questions will be the same. See also previous year's tests on Canvas.

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1. Binary numbers

(a) Convert hexadecimal ABC to binary. [8]

(b) Convert the 2-complement binary number 10101 to decimal. [8]

(c) Suppose you have an (unsigned) binary number and you move all bits 1 position to the left, and insert a 0 at the right-most position. What computation is this? Explain your answer. [9]

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2. Boolean logic

(a) In the lecture on datapath and control we saw so-called switches (or selectors), which select one from several inputs and pass it to the output. Consider a switch, with 2 data inputs called A and B, each 1 bit wide, and a control input C that determines which of the inputs will be passed on to the output D: if C=0, A will be passed on to D, otherwise B.
Give the truth table of such a switch. [9]

(b) Simplify the following Boolean formula such that no '+' sign remains: $\overline{C} \cdot A + C \cdot B$ [8]

(c) Sketch how you would realise the following formula with only NAND gates: $\overline{\overline{CA} \cdot \overline{CB}}$ [8]

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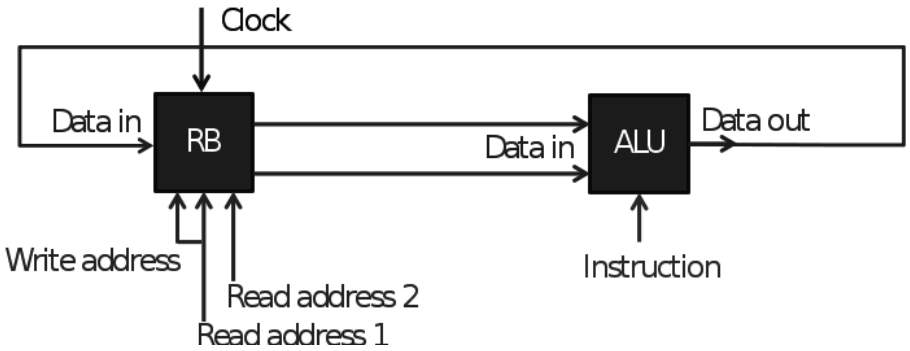
3. A processor



The ALU of the processor above has two instructions: 0 = add and 1 = multiply. Furthermore it has four 1-bit registers, called R0 through R3. The starting value for register R3 equals 0. Give for this processor the program for the following computation: R3 = R1 $\times$ (R1 + R2)

	read address 1 / write address	read address 2	instruction
Timeslot 0			
Timeslot 1			
Timeslot 2			
Timeslot 3			
Timeslot 4			
...			

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4. An AVR program

Given the following AVR program ("BRNE" means "BRanch if Not Equal", "INC" means "INCrement (increase by 1)" and "SUB" means "Subtract"):

```
LDI    R16, $0
LDI    R17, $80
LDI    R18, $03
ADD    R17,R16
INC    R16
MOV    R19, R16
SUB    R19, R18
BRNE   -5
```

After this program has been executed, what are the contents (in decimal) of registers R16, R17, R18 and R19 ?

And how long will this program take? Each instruction takes 1 clock cycle, except BRNE. If the jump to a different address is indeed performed, BRNE takes 2 clock cycles; otherwise 1.

Hint: The best approach for this exercise is to make a table, in which you fill in after every instruction what the contents of the registers are.

R16	R17	R18	R19	explanation
0				

And so on, you'll need more rows then the above.

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5. Problem 5

What is the mathematical function that is computed by the code below?
Write as a function of X and Y, e.g. f(X, Y) = X + Y.
Assumption: X and Y are larger than 0 and the result is available in R20.

```
LDI   R17, $X
LDI   R18, $Y
LDI   R19, $00
LDI   R20, $00
MOV   R19, R18
ADD   R20, R17
DEC   R18
BRNE  -3
ADD   R20, R19
DEC   R17
BRNE  -3
```