KTH Informations- och kommunikationsteknik

Written exam for IE1204/5 Digital Design monday the 28/10 2013 9.00-13.00

General Information

Examiner: Ingo Sander.

Teacher : William Sandqvist , phone 08-790 4487 (Kista IE1204)
Exam text does not have to be returned when you hand in your writing.

Aids: No aids are allowed!
The exam consists of three parts with a total of 12 tasks , and a total of 30 points :

Part A1 (Analysis) contains eight short questions. Right answer will for six of the questions give you one point and for two of the questions one or two points. Incorrect answer will give you zero points. The total number of points in Part A1 is **10 points**. To pass the Part A1 **requires at least 6p**, *if fewer points we will not look at the rest of your exam.*

Part A2 (Methods) contains two method problems on a total of 10 points.
To pass the exam requires **at least 11 points** from A1 + A2 , *if fewer points we will not look at the rest of your exam.*

Part B (Design Problems) contains two design problems of a total of **10 points**. Part B is corrected only if there are at least 11p from the exam A- Part .

NOTE ! At the end of the exam text there is a submission sheet for Part A1 , which can be separated to be submitted together with the solutions for A2 and B.

For a passing grade (**E**) requires **at least 11 points on the exam**.

Grades are given as follows:

0 –	11 –	16 –	19 –	22 –	25
F	E	D	C	B	A

The result is expected to be announced before Monday 18/11 2013.

Part A1 (Analysis).

Only answers are needed in Part A1. Write the answers on the submission sheet for Part A1, which can be found at the end of the exam text.

1. 2p/1p/0p

A function *f*(*x*, *y*, *z*) is described on **normal form** as a product of **maxterms** (product-of-sums)

$$f(x,y,z)=\{PoS\}_{\text{normal}}=(\overline{x}+y+z)(\overline{x}+y+\overline{z})(\overline{x}+\overline{y}+\overline{z})(\overline{x}+\overline{y}+z)$$

a) write the function on its **normal form** as a sum of **minterms** (sum-of-products)!

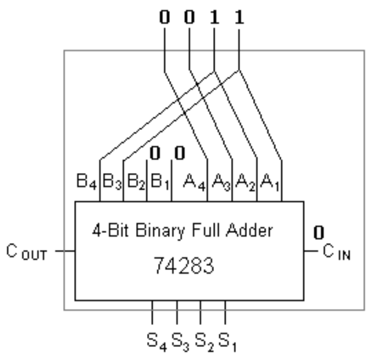
$$f(x,y,z)=\{SoP\}_{\text{normal}}=?$$

b) write the function as a **minimal** sum-of-products!

$$f(x,y,z)=\{SoP\}_{\text{min}}=?$$

2. 2p/1p/0p

The 4-bit number 0011_2 is connected to a 4-bit fulladder which is connected as shown in the figure (the adder is of the same type 74283 as you have experienced at lab).



a) What will the sum $S_4S_3S_2S_1$ be, and what will the outgoing carry-bit C_{OUT} be?

b) What signed decimal number, does $S_4S_3S_2S_1$ represent if we are using 2-complement 4-bit representation?

3. 1p/0p

The figure at right is a Karnaughmap of a function of four variables.
Write the function as a minimal sum-of-products, it's SoP-form.

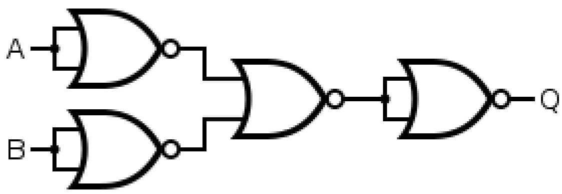
(”-” in the map stands for ”don't care”)

$$f(a,b,c,d)=\{SoP\}_{\text{min}}=?$$

ab \ cd	00	01	11	10
00	1	0	-	0
01	1	0	0	1
11	1	0	0	1
10	-	-	0	0

4. 1p/0p

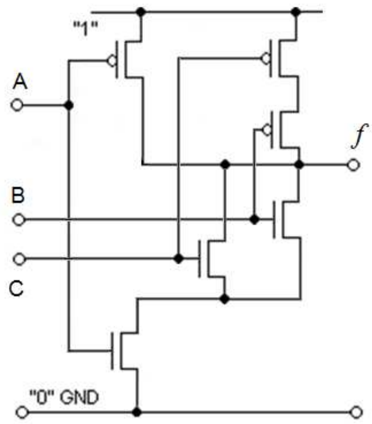
NOR is a complete logic, all other gates could be constructed with only NOR-gates.
Write a simplified expression of
$Q = f(A, B) = ?$ so that it will be clear which function it is.



5. 1p/0p

Write the logical expression that is realized by the CMOS-circuit in the figure?

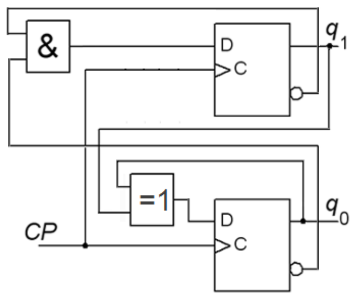
$$Y = f(A, B, C) = ?$$



6. 1p/0p

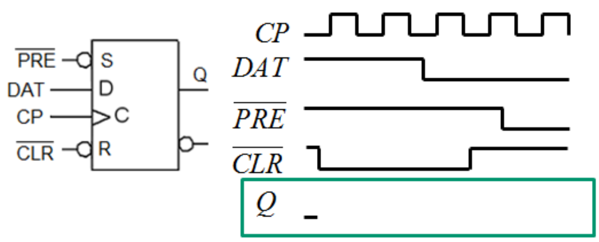
An synchronous sequential circuit starts in the state q_1q_0 00. Write the states q_1q_0 for the following three clockpulses.

$$(q_1q_0) = 00 \rightarrow ?? \rightarrow ?? \rightarrow ??$$



7. 1p/0p

Fill in Q in the time-diagram. D is a synchronous input, S and R are asynchronous inputs. You will also find the figure on the submission sheet.



8. 1p/0p

VHDL-code describes a known circuit/component. Which one is it? Choose between:
a. An EXOR-gate.
b. An EXNOR-gate.
c. A JK-flipflop.
d. A D-flipflop.
e. A T-flipflop.
f. A SR-latch.

```
entity circuit is
Port ( X     : in  std_logic;
       CLOCK : in  std_logic;
       Y     : out std_logic
      );
end circuit;

architecture Behavioral of circuit is
begin
  process(CLOCK,X)
  begin
    if (CLOCK = '1' and CLOCK'event) then
      if (X = '1')then
        Y < = NOT Y;
      else
        Y < = Y;
      end if;
    end if;
  end process;
end Behavioral;
```

Part A2 (Methods).

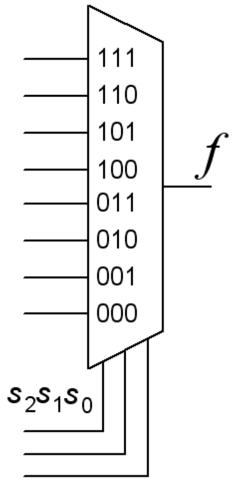
Note! Part A2 will only be corrected if you have passed part A1 (≥6p).

9. 4p

A Boolean function f of three variables $c\ b\ a$ has it's truthtable in the figure at right.

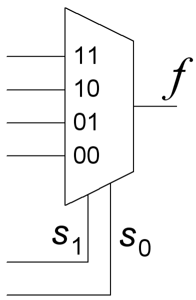
a) (1p) Show how this function can be realized with a 8:1 MUX (according to the figure).

b) (1p) Realize the function minimized with the use of only **NAND-gates**. No inverted input signals are available, all inverting must be done NAND-gates.



c	b	a	f
0	0	0	1
0	0	1	0
0	1	0	1
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	1

c) (2p) Realize the function with a 4:1 MUX. Only the input signals $c\ b\ a$ are available. Find a solution that doesn't use any inverters (and no gates).



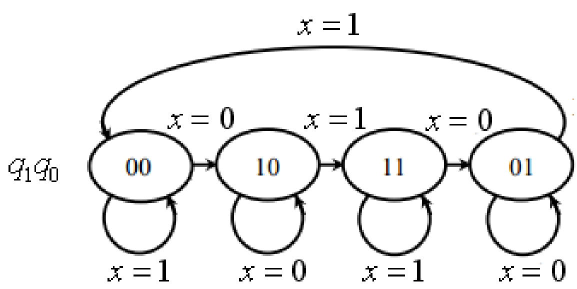
10. 6p

The figure shows a statediagram for a synchronous counter with an input x.

a) (1p) Draw the counters coded state table $q_1^+\ q_0^+ = f(q_1\ q_0\ x)$.

b) (2p) Give the functions for the next state $q_1^+ = ?\quad q_0^+ = ?$

c) (1p) Realize the counter with D-flipflops and any gates. Draw the circuit diagram.



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d) (2p) **An other synchronous sequential circuit** has the state table shown in the figure at right. Minimize the number of states and draw the **minimized state diagram**.

z is the output signal and w is the input signal, S stands for the states (A …E).

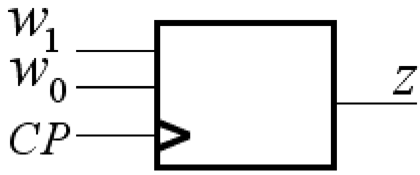
z	S	S^+ $w=0$	S^+ $w=1$
0	A	A	B
1	B	C	D
1	C	A	E
1	D	C	B
1	E	E	A

Part B (Design Problems).

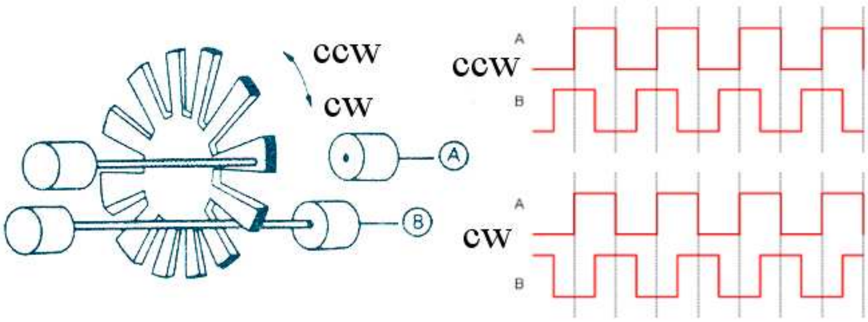
Note! Part B will only be corrected if you have passed part A1+A2 (≥11p).

11. 5p

A synchronous Moore-machine has two input signals w_1w_0 and one output signal z. For the input sequence w_1w_0 10, 11 the output signal should be z =0. For the input sequence w_1w_0 01, 11 the output signal should be z =1. For w_1w_0 01, 10 the output sigmal w should change it's value. For all other input sequences the output signal should remain the same.
Present the Moore-machine's **state table**, **minimize it** as far as possible. Draw the minimized **statediagram**.



12. 5p



ccw										
A:	0	0	1	1	0	0	1	1	0	…
B:	0	1	1	0	0	1	1	0	0	…
U:	0	0	0	0	0	0	0	0	0	…

cw										
A:	0	1	1	0	0	1	1	0	0	…
B:	0	0	1	1	0	0	1	1	0	…
U:	0	0	**1**	0	0	0	**1**	0	0	…

An optical **pulsesensor** (as in your computer mouse) consists of two fotocell's ***A*** and ***B*** and a disk that interrupts the light for the sensor according to how the disk is rotated.

You should construct an asynchronous Moore-compatible statemachine with two inputs ***A*** and ***B*** and one output ***U***, which will have ***U*** = 1 if, and only if, the **three latest input signals** being exactly ***AB***: 00 10 11.
(This sequence will appear when the disc is rotating in clockwise direction, cw, se the figure above. The figure also shows that this sequence will *not* appear when the disc is rotating in the counterclockwise, **ccw,** direction).
Your answer should contain a **statediagram**, a **flowtable**, a suitable **state code**, an **exitation table** free from race conditions, and **equations for the next state** without hazards, and an output function. You don't have to draw the actual circuit diagram.

Good luck!

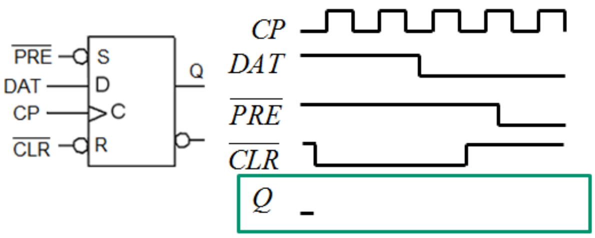
Submission sheet for Part A1 **Sheet 1**

(remove and hand in together with your answers for part A2 and part B)

Last name: ______________________ **Given name:** ______________________

Personal code number: ______________________

Write down your answers for the questions from Part A1 (1 to 8)

Question	Answer
1 2/1/0	**a**) $f(x,y,z) = \{SoP\}_{\text{normal}} = ?$ **b**) $f(x,y,z) = \{SoP\}_{\text{min}} = ?$
2 2/1/0	**a**) $S_4S_3S_2S_1$? och C_{OUT}? **b**) $S_4S_3S_2S_1$ Decimal number with sign?
3 1/0	$f(a,b,c,d) = \{SoP\}_{\text{min}} = ?$
4 1/0	$Q = f(A,B) = ?$ (name?)
5 1/0	$Y = f(A,B,C) = ?$
6 1/0	$(q_1q_0) = 00 \rightarrow ?? \rightarrow ?? \rightarrow ??$
7 1/0	
8 1/0	Name of the circuit (a, b, …, f):

This table is completed by the examiner!

Part A1	**Part A2**		**Part B**		**Total**	
Points	9	10	11	12	Sum	Grade