KTH Informations- och
kommunikationsteknik

Written exam for
IE1204/5
Saturday 18/1 2014 14.00-18.00

General Information

Examiner: Ingo Sander.

Teacher: William Sandqvist, phone 08-790 4487 (Kista IE1204),
Fredrik Jonsson, phone 08-790 4169 (Valhallavägen IE1205),
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 10/2 2014.

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 of three varibles $f(x, y, z)$ is described with use of exor-functions:

$$f(x, y, z) = z \cdot (\overline{x} \oplus y + x \oplus y) \qquad \oplus = exorfunktion$$

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

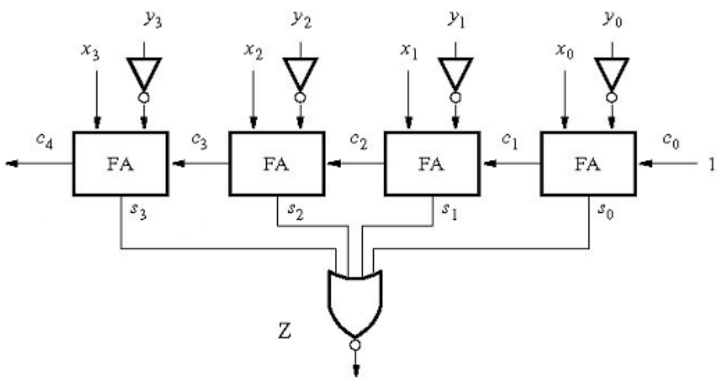
$$f(x, y, z) = \{SoP\}_{\text{normal}} = ?$$

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

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

2. 2p/1p/0p

The figure shows a circuit with four full-adders (FA). Two 4 bit integers $y = y_3y_2y_1y_0$ and $x = x_3x_2x_1x_0$ are ”added” with each other in this circuit.



a) Assume that $y = 7_{10}$ what is the value at x when the NOR gate outputs $Z = 1$? Aswer with x as the binary number $x = x_3x_2x_1x_0$.

b) what is then the value of c_4?

3. 1p/0p

Given is a Karnaugh map of a function of four variables. Answer with a that minimized function of the product-of-sums, PoS-form.

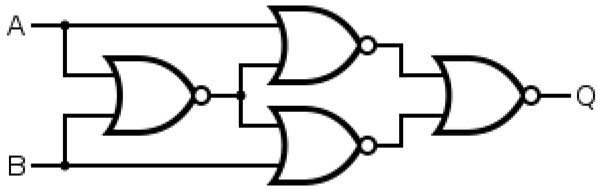
("-" in the graph stands for ”don’t care”)

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

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

4. 1p/0p

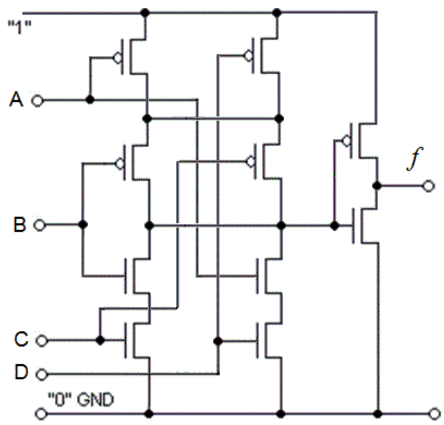
NOR logic is complete, all other gate types can be constructed with only NOR gates.
Set up a simplified expression (or name) for
$Q = f(A, B) = ?$
so that it is clear what function this is.



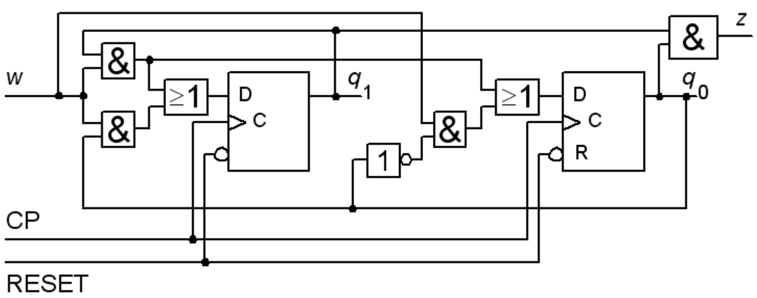
5. 1p/0p

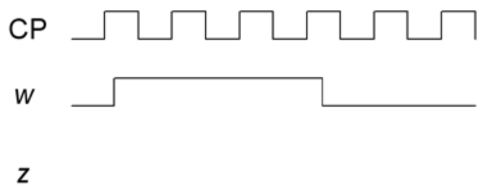
Give a simplified expression for the logical function realized by the CMOS circuit in the figure?

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



6. 1p/0p





Sequence network starts in the state $q_1 = q_0 = 0$. Analyze the circuit and fill in the output z in the timing diagram. A copy of the diagram is also available on the *submission sheet*.

7. 1p/0p

Studying the sequence network in task 6. Calculate the minimum time which may follow between clock pulses CP, without the risk for malfunctioning. Draw "the critical path" in the figure on the *submission sheet* (the path you have based your calculation on).

The following times are given for the components [ns]:

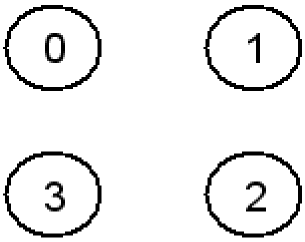
$t_{\text{AND}} = 0{,}4 \quad t_{\text{OR}} = 0{,}4 \quad t_{\text{NOT}} = 0{,}1$

$t_{\text{Setup}} = 0{,}3 \quad t_{\text{Hold}} = 0{,}2$

8. 1p/0p

This VHDL code describes a sequence circuit.
Draw the state transitions (with conditions) between the four states in the state diagram on the *submission sheet*.

```
CASE state IS
   WHEN 0 => nextstate = 1;
   WHEN 1 =>
     IF ( k=0) THEN
        nextstate = 2;
     ELSE
        nextstate = 3;
     END IF;
   WHEN 2 => nextstate = 0;
   WHEN OTHERS nextstate =0;
END CASE;
```

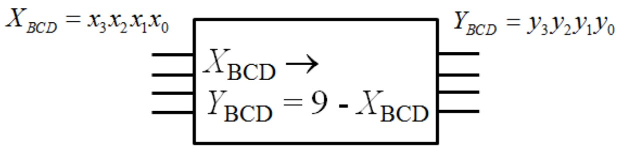


Part A2 (Methods).

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

9. 5p

Construct a transcoder that transforms BCD code (same as binary, though only the numbers 0 ... 9 are used) to the 9's complement of the BCD code. Ex. number 3 (0011_{BCD}) has the 9's complement 6 (0110_{BCD}) because 9 - 3 = 6.

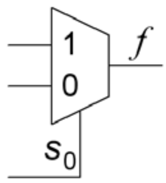


a) (1p) Set up the truth table $y_3y_2y_1y_0 = f(x_3x_2x_1x_0)$, use the don't cares.

b) (2p) Minimize the functions y_3, y_2, y_1, y_0, use the don't cares.

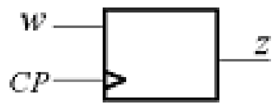
c) (1p) Draw the circuit diagrams for the functions using gates of optional type. You may assume that all variables are also available in inverted form.

d) (1p) Draw the circuit diagram for the function y_2 with the only use of a 2:1 multiplexer. (Se figure). All variables are also available in inverted form.

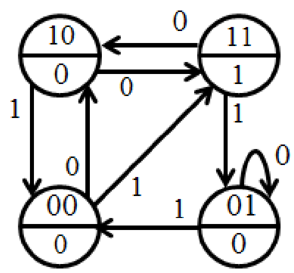


10. 5p

A synchronous Moore machine has four states coded as q_1q_0 00, 10, 11, 01. In state 11, the output z = 1, otherwise 0. The state machine has an input signal w.



a) (1p) Set up the encoded state table $q_1^+q_0^+ = f(q_1q_0, w)$.

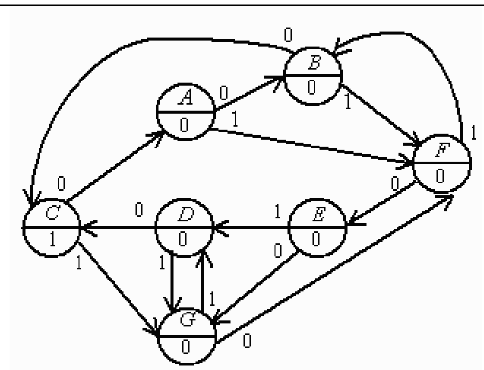


b) (1p) Give minimized functions for the next states and the output:
$q_1^+ = f(q_1q_0, w)$ $q_0^+ = f(q_1q_0, w)$ $z = f(q_1q_0)$

c) (1p) Construct the state machine with D flip-flops and optional gates. Draw a complete diagram of the circuit.

---

d) (2p) Another synchronous state machine have the state diagramme according this figure. Minimize the number of states and draw the minized state diagram.

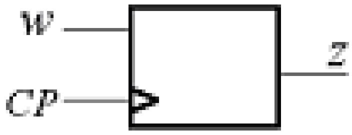


Part B (Design Problems).

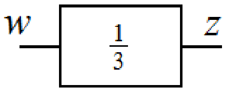
Note! Part B will only be corrected if you have passed part A1+A2 (≥11p).

11. 4p

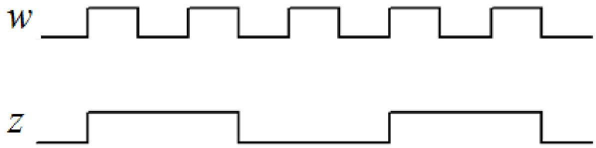
A synchronous Moore-machine has an input signal *w* and an output signal *z*. For the input sequence $w = 1$ followed by $w = 1$ the output signal should be $z = 1$. For the input sequence $w = 0$ followed by $w = 0$ the output signal should be $z = 0$. For all other input sequences the output signal should remain the same. Present the Moore-machine's **state table**, **minimize it** as far as possible. Draw the minimized **statediagram**



12. 6p



$f_z = \frac{1}{3} f_w$



Construct an asynchronous Moore-compatible state machine that will frequency divide a symetric squarewave *w* to a similar symetric squarewave *z* but with the third of the orginal frequency, as seen in the figure.

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!

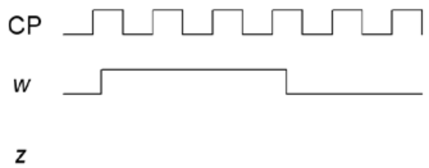
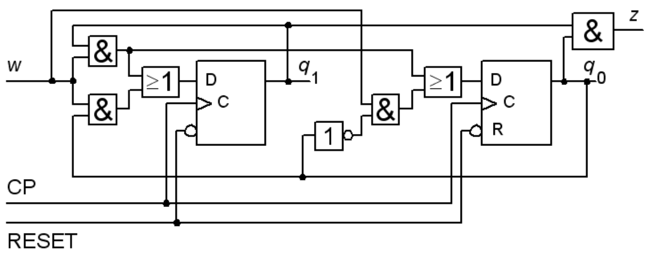
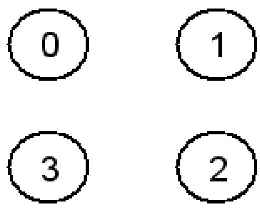
Submission sheet for Part A1 Sheet 1

(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**) $f(x,y,z) = \{SoP\}_{\min} = ?$
2 2/1/0	**a**) x binary number $x_3x_2x_1x_0$? **b**) c_4? The value of the bit?
3 1/0	$f(a,b,c,d) = \{PoS\}_{\min} = ?$
4 1/0	$Q = f(A,B) = ?$ (name?)
5 1/0	$Y = f(A,B,C,D) = ?$
6 1/0	
7 1/0	 Fill in the "critical path" in the figure. (the path you have based your calculation on). Minimum time between clock pulses: t [ns] = ?
8 1/0	

This table is completed by the examiner!

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