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Exercises for
Rechnerstrukturen
Winter Semester 2015

Exercise Sheet 7 (Block B - 3)

(16 points)

Submission until Wednesday, 9th December 2015, 16:00 pm
Discussion begins on Monday, 14th December 2015

Please see notes at the end of the document for the submission.

7.1 Development of a complete sequential circuit (16 points; 3+4+8+1)

In the context of an exchange program You are working on a klingon spaceship. On a field mission on an alien planet You must carry a klingon laser blaster. Unfortunately the control module is broken and You must replace it. You can find all necessary components in the toolbox, but You do not have a construction plan. All You have got is the manual for the blaster.

You receive the following “interesting” klingon manual with notes for earthlings:

Klingon Laser-Blaster model WS1516

1. There are 4 modes: `Idle`, `Load`, `Knockout`, `Kill`.
2. There are 4 input buttons: *Pause*, *Charge*, *Stun*, *Shoot*.
   (The assignment to the 4 modes is the same ordering.)
3. Always start with the mode `Idle`.
4. From `Idle` You can reach: `Idle`, `Load` and `Knockout`.
5. From `Knockout` You can reach: `Knockout`, `Idle` and `Kill`.
6. From `Kill` You can reach: `Kill`, `Knockout` and `Load`.
7. From `Load` You can reach: `Load`, `Idle` and `Knockout`.

Important tips for earthlings:

on 1.) In `Idle` the weapon is locked. In `Load` the superconducting crystals inside of the blaster are charged. The `Kill` mode is for shooting. The `Knockout` mode is only rarely used by klingons, but it can be used for stunning.
on 2.) The 4 buttons are hard to press, but not for klingons.
on 3.) In `Idle` mode the blaster is on and has enough power from the battery.
on 4.) Pressing `Shoot` in `Idle` does nothing. Safety first! Although many klingons circumvent this safety feature by leaving the blaster in `Kill` mode...
on 5.) If you press *Charge* here, first go to `Idle`.
on 6.) If you press *Pause* here, the blaster goes into steady shooting. To reach `Idle`, you must first change to `Knockout` or `Load`.
on 7.) *Charge* and *Shoot* stay in `Load` to not short the battery.

Tips for the output: Good outputs are the states of the machine: Idle, Load, Knockout and Kill.

Steps to develop the plan

a. **Develop a Moore machine**, which simulates the unit. Choose meaningful labels for the input alphabet (Σ), output alphabet (Δ) and for the states of the machine (Q), e.g. the labels of the instruction manual. Draw the graph belonging to Your Moore machine.

b. **Write down the transition function** (in form of a table) for the moore machine by using the following columns:

$q \in Q$	$w_i \in \Sigma$	$\delta(q, w_i)$	$\lambda(\delta(q, w_i))$
$\vdots$	$\vdots$	$\vdots$	$\vdots$

c. Encode Your transition table. **Choose appropriate binary encodings for Your input signals and the states.** To encode a set of 4 symbols, You must use 2 Bits.

To save the current status of Your circuit use JK-Flip-Flops. **Write down the necessary number of JK-Flip-Flops.**

Extend Your transition table with the inputs for the JK-Flip-Flops (the following state) by using the following transition table for JK-Flip-Flops. Please do not use the JK-Flip-Flops as D-Flip-Flops, but trigger the control inputs (J and K) separately.

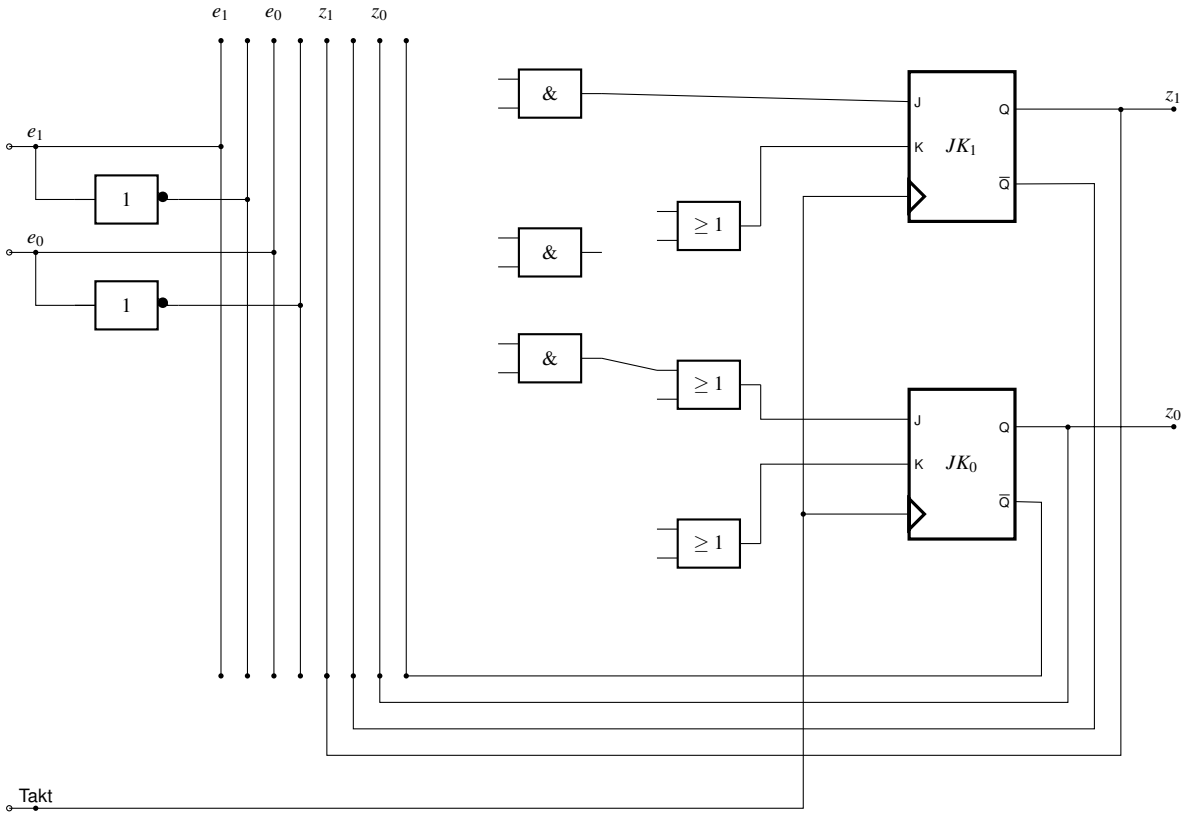
z	z'	j	k
0	0	0	-
0	1	1	-
1	0	-	1
1	1	-	0

The resulting transition table should consist of 16 rows (without table head). Please use the following columns, where (e_1, e_0) is the encoded input, (z_1, z_0) is the encoded current state, (z'_1, z'_0) is the encoded following state, j_i, k_i the necessary control inputs of the JK-Flip-Flops and a is the output:

e_1	e_0	z_1	z_0	z'_1	z'_0	j_1	k_1	j_0	k_0	a
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$

Draw 4 KV diagrams and infer the minimal functions for the JK control inputs. The inputs j and k depend on the input and the current state.

d. **Complete the following synchronous sequential circuit** with logic gates and wires, so that Your inferred functions from exercise c) trigger the JK-Flips-Flops. You must not create a circuit for the output. Please use logic symbols according to the lecture.



Notes:
Submission until Wednesday, 9th December 2015, 16:00 pm in the mailbox number 46 at Otto-Hahn-Straße 12.

You can find the mailboxes in the first floor of the Otto-Hahn-Straße 12 near the transition to the ground floor of the Otto-Hahn-Straße 14. The mailboxes are labeled with “Rechnerstrukturen”, the exercise group number and time/place of the exercise. The English exercise group is number 30 and the mailbox is number 46.

Please write your **name**, your **student registration number** and your **exercise group number** at the top right corner of your submission. You can make submissions in teams with up to two more students. To make a team submission put names, student registrations numbers and group numbers of all members of the team on the submission. Only one submission per team has to be made.

Tack you submission. Please do not fold your submission and do not put it into an envelope. Use the correct mailbox, you will need your exercise group number for that.

In total there are 12 exercises in 3 blocks (A, B, C). In each block you have to achieve at least 30 points of 64 possible ones to get access to the exam.