Computer Architecture and Programming Languages
Jacobs University Bremen
Dr. Kinga Lipskoch

Course: CO20-320241
September 23rd, 2019

Homework 3 - Logic Circuits and Flip-Flops

- Template file for submitting the solutions:
  https://grader.eecs.jacobs-university.de/courses/320241/2019_2/lectures/template_hw.tex
- The TAs are grading solutions to the problems according to the following criteria:
  https://grader.eecs.jacobs-university.de/courses/320241/2019_2/Grading_Criteria_CAPL.pdf

Problem 3.1 *Simplifying expressions* (3 points)

Simplify the following logic expressions using rules/theorems of the Boolean algebra. At every step of the simplification refer to specific rules/theorems you apply by using some kind of labels (e.g., $R1$, $R2$, $R3$ or similar). Do not forget to write down the mapping between your labels and rules.

(a) $\mathtt{x} = (\mathtt{M} + \mathtt{N})(\overline{\mathtt{M}} + \mathtt{P})(\overline{\mathtt{N}} + \overline{\mathtt{P}})$

(b) $\mathtt{z} = \overline{\mathtt{A}}\mathtt{B}\overline{\mathtt{C}} + \mathtt{A}\mathtt{B}\overline{\mathtt{C}} + \mathtt{B}\overline{\mathtt{C}}\mathtt{D}$

(c) $\mathtt{x} = \overline{(\mathtt{M} + \mathtt{N} + \mathtt{P})\mathtt{Q}}$

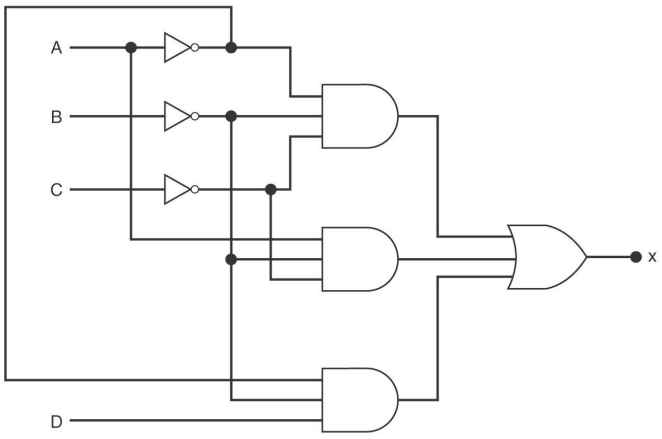
(d) $\mathtt{z} = \overline{\mathtt{A}\mathtt{B}\mathtt{C} + \mathtt{D}\mathtt{E}\mathtt{F}}$

(e) $\mathtt{z} = \overline{\mathtt{A}\overline{\mathtt{B}} + \mathtt{C}\overline{\mathtt{D}} + \mathtt{E}\mathtt{F}}$

(f) $\mathtt{z} = \overline{\overline{\mathtt{A} + \mathtt{B}\overline{\mathtt{C}}} + \mathtt{D}\overline{(\mathtt{E} + \overline{\mathtt{F}})}}$

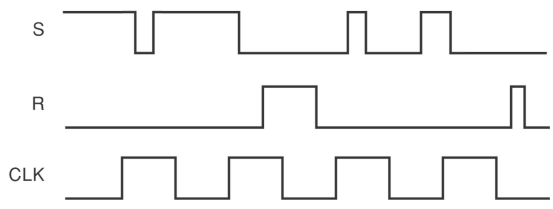
Problem 3.2 *A logic circuit* (3 points)

Determine the output expression of the circuit in the figure below and simplify it using Karnaugh-maps. Shortly describe your steps, such that one can follow.



Problem 3.3 *S-R flip-flop I* (2 points)

Apply the waveforms of the figure below to an S-R flip-flop that triggers on positive going transition and determine the waveform of $\mathtt{Q}$. Assume that $\mathtt{Q} = 1$ initially. Write down the corresponding state table of the flip-flop.

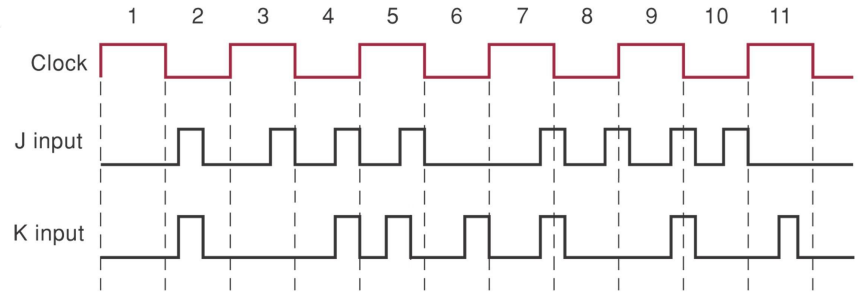


Problem 3.4 *S-R flip-flop II* (2 points)

Apply the waveforms of the figure from **Problem 3.3** to an S-R flip-flop that triggers on negative going transition and determine the waveform for `Q`. Assume that `Q` $= 0$ initially. Write down the corresponding state table of the flip-flop.

Problem 3.5 *J-K flip-flop I* (2 points)

Apply the waveforms of the figure below to a J-K flip-flop that triggers on positive going transition and determine the waveform for `Q`. Assume that `Q` $= 1$ initially. Write down the corresponding state table of the flip-flop.



Problem 3.6 *J-K flip-flop II* (2 points)

Apply the waveforms of the figure from **Problem 3.5** to a J-K flip-flop that triggers on negative going transition and determine the waveform for `Q`. Assume that `Q` $= 0$ initially. Write down the corresponding state table of the flip-flop.

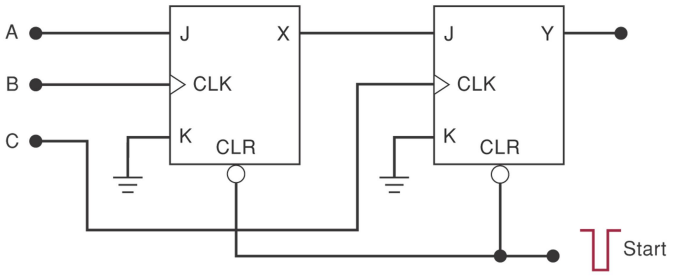
Problem 3.7 *A circuit* (2 points)

In the circuit below the inputs `A`, `B` , `C` are all initially `LOW`. The output `Y` is supposed to go `HIGH` only if `A`, `B` , `C` go `HIGH` in a certain sequence.

(a) Determine the sequence that will make `Y` go `HIGH`.

(b) Explain why the `START` pulse is needed/can be used for.

(c) Modify this circuit equivalently by using D flip-flops instead of J-K flip-flops.



How to submit your solutions

You can submit your solutions via *Grader* at **`https://grader.eecs.jacobs-university.de`** as a generated PDF file from the given template TEX file.
If there are problems with *Grader* (but only then), you can submit the file by sending mail to `k.lipskoch@jacobs-university.de` **with a subject line that starts with CO20-320241**.

Please note, that after the deadline it will not be possible to submit solutions. It is useless to send solutions by mail, because they will not be graded.

This homework is due by Monday, September 30$^{\text{th}}$, 23:00.