# Grundlagen der Rechnerarchitektur

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## 1 Zähler

(a)

| Flanke | $state_2[t]$ | $state_1[t]$ | $state_0[t]$ | $state_2[t+1]$ | $state_1[t+1]$ | $state_0[t+1]$ |
|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| 0 | 1 | 0 | 1 | 1 | 0 | 1 |
| 0 | 1 | 1 | 0 | 1 | 1 | 0 |
| 0 | 1 | 1 | 1 | 0 | 1 | 1 |
| 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| 1 | 0 | 0 | 1 | 0 | 1 | 0 |
| 1 | 0 | 1 | 0 | 0 | 1 | 1 |
| 1 | 0 | 1 | 1 | 1 | 0 | 0 |
| 1 | 1 | 0 | 0 | 1 | 0 | 1 |
| 1 | 1 | 0 | 1 | 1 | 1 | 0 |
| 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 0 | 0 | 0 |

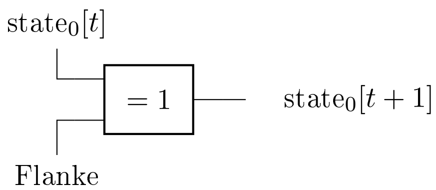
(b)

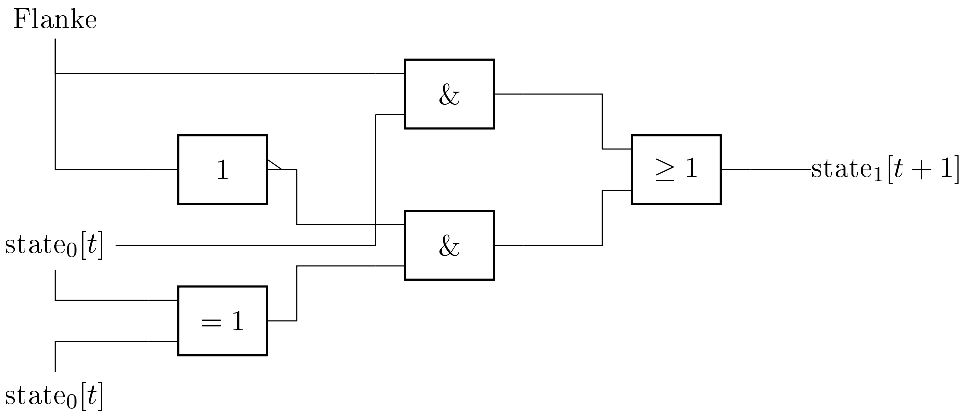
$$
\begin{aligned}
\mathrm{state}_0[t+1] &= \mathrm{Flanke} \cdot (\overline{\mathrm{state}_2[t]} \cdot \overline{\mathrm{state}_1[t]} \cdot \overline{\mathrm{state}_0[t]} + \\
&\quad \overline{\mathrm{state}_2[t]} \cdot \mathrm{state}_1[t] \cdot \overline{\mathrm{state}_0[t]} + \\
&\quad \mathrm{state}_2[t] \cdot \overline{\mathrm{state}_1[t]} \cdot \overline{\mathrm{state}_0[t]} + \\
&\quad \mathrm{state}_2[t] \cdot \mathrm{state}_1[t] \cdot \overline{\mathrm{state}_0[t]}) \\
&\quad + \overline{\mathrm{Flanke}} \cdot \mathrm{state}_0[t] \\
&= \mathrm{Flanke} \cdot \overline{\mathrm{state}_0[t]} + \overline{\mathrm{Flanke}} \cdot \mathrm{state}_0[t] \\
&= \mathrm{Flanke} \oplus \mathrm{state}_0[t]
\end{aligned}
$$

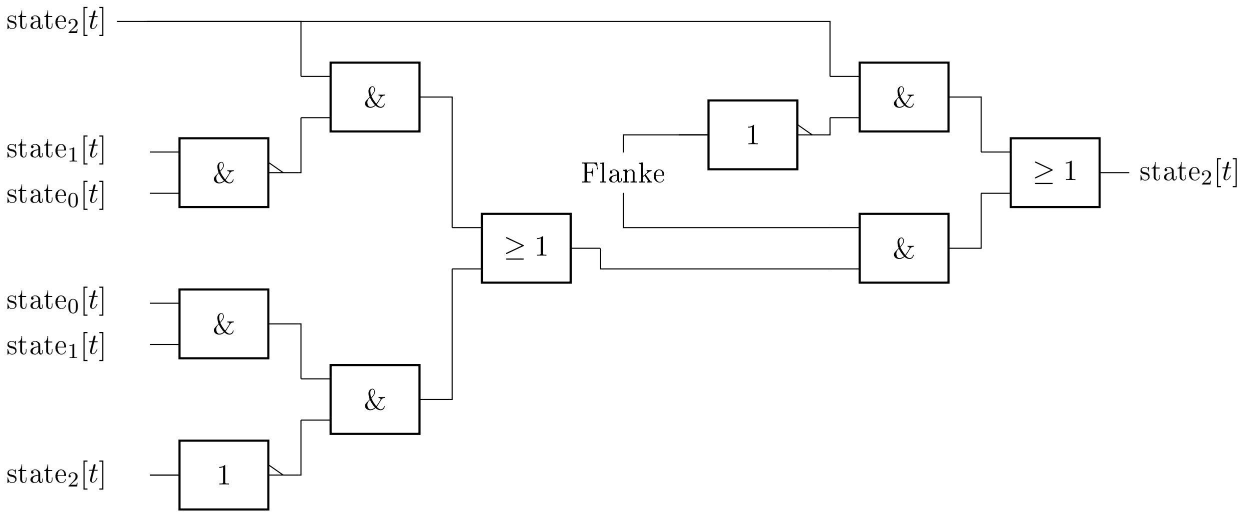
$$
\begin{aligned}
\mathrm{state}_1[t+1] &= \mathrm{Flanke} \cdot (\overline{\mathrm{state}_2[t]} \cdot \overline{\mathrm{state}_1[t]} \cdot \mathrm{state}_0[t] + \\
&\quad \overline{\mathrm{state}_2[t]} \cdot \mathrm{state}_1[t] \cdot \overline{\mathrm{state}_0[t]} + \\
&\quad \mathrm{state}_2[t] \cdot \overline{\mathrm{state}_1[t]} \cdot \mathrm{state}_0[t] + \\
&\quad \mathrm{state}_2[t] \cdot \mathrm{state}_1[t] \cdot \overline{\mathrm{state}_0[t]}) \\
&\quad + \overline{\mathrm{Flanke}} \cdot \mathrm{state}_1[t] \\
&= \mathrm{Flanke} \cdot (\mathrm{state}_1[t] \oplus \mathrm{state}_0[t]) + \overline{\mathrm{Flanke}} \cdot \mathrm{state}_1[t]
\end{aligned}
$$

$$
\begin{aligned}
\mathrm{state}_2[t+1] &= \mathrm{Flanke} \cdot (\overline{\mathrm{state}_2[t]} \cdot \mathrm{state}_1[t] \cdot \mathrm{state}_0[t] + \\
&\quad \mathrm{state}_2[t] \cdot \overline{\mathrm{state}_1[t]} \cdot \overline{\mathrm{state}_0[t]} + \\
&\quad \mathrm{state}_2[t] \cdot \overline{\mathrm{state}_1[t]} \cdot \mathrm{state}_0[t] + \\
&\quad \mathrm{state}_2[t] \cdot \mathrm{state}_1[t] \cdot \overline{\mathrm{state}_0[t]}) \\
&\quad + \overline{\mathrm{Flanke}} \cdot \mathrm{state}_2[t] \\
&= \mathrm{Flanke} \cdot (\overline{\mathrm{state}_2[t]} \cdot \mathrm{state}_1[t] \cdot \mathrm{state}_0[t] + \\
&\quad \mathrm{state}_2[t] \cdot \overline{\mathrm{state}_1[t] \cdot \mathrm{state}_0[t]}) + \\
&\quad \overline{\mathrm{Flanke}} \cdot \mathrm{state}_2[t]
\end{aligned}
$$

(c)






## 2 Addierer und Subtrahierer

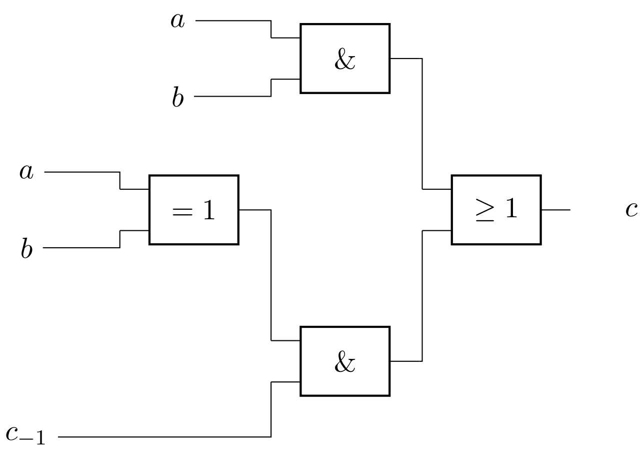
(a)

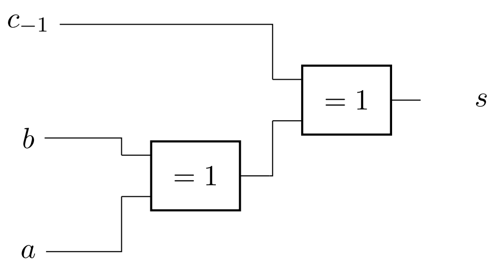
| $a$ | $b$ | $c_{-1}$ | $c$ | $s$ |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 0 | 1 | 0 | 0 | 1 |
| 1 | 0 | 0 | 0 | 1 |
| 1 | 1 | 0 | 1 | 0 |
| 0 | 0 | 1 | 0 | 1 |
| 0 | 1 | 1 | 1 | 0 |
| 1 | 0 | 1 | 1 | 0 |
| 1 | 1 | 1 | 1 | 1 |

$$
\begin{aligned}
c &= a \cdot b \cdot \overline{c_{-1}} + \overline{a} \cdot b \cdot c_{-1} + a \cdot \overline{b} \cdot c_{-1} + a \cdot b \cdot c_{-1} \\
&= a \cdot b + c_{-1} \cdot (\overline{a} \cdot b + a \cdot \overline{b}) \\
&= a \cdot b + c_{-1} \cdot (a \oplus b)
\end{aligned}
$$

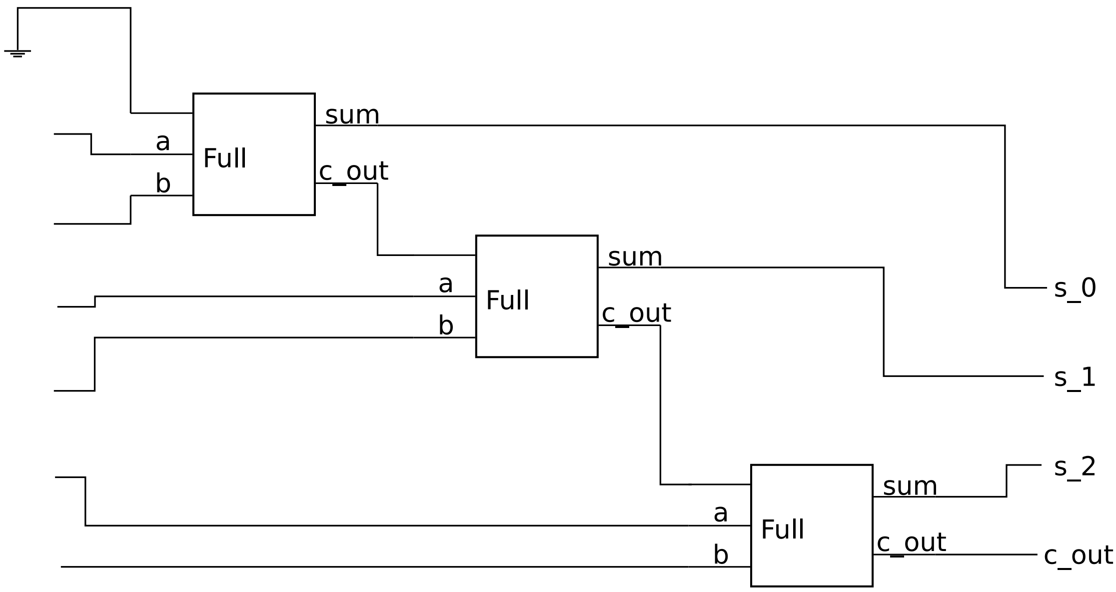
$$
\begin{aligned}
s &= \overline{a} \cdot b \cdot \overline{c_{-1}} + a \cdot \overline{b} \cdot \overline{c_{-1}} + \overline{a} \cdot \overline{b} \cdot c_{-1} + a \cdot b \cdot c \\
&= \overline{a} \cdot (b \cdot \overline{c_{-1}} + \overline{b} \cdot c_{-1}) + a \cdot (\overline{b} \cdot \overline{c} + b \cdot c) \\
&= \overline{a} \cdot (b \oplus c_{-1}) + a \cdot \overline{(b \oplus c_{-1})} \\
&= a \oplus b \oplus c_{-1}
\end{aligned}
$$

(b)




(c) Schaltbild des 3-Bit-Addierers:




(d) Schaltbild des 3-Bit-Addierers mit Subtraktionsfunktion. Die Schaltung aus der vorherigen Aufgabe wurde hier als Blockschaltbild verwendet: