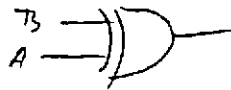
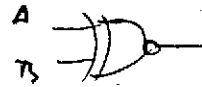


exclusive or - xor
non-equivalence



exclusive nor xnor



	c	b	a	f
0	0	0	0	0
1	0	0	1	1
2	0	1	0	1
3	0	1	1	0
4	1	0	0	0
5	1	0	1	0
6	1	1	0	1
7	1	1	1	0

$$f = \bar{c}\bar{b}a + \bar{c}b\bar{a} + cb\bar{a}$$

SOP - DNF
izveš

	$\overline{a}$				b
	0	1	0	1	
c	0	0	0	1	

a, b, c v bīdri
pārskatī

- prom. s mīksti vākus
blīvē u tabulā
- tālā xācīnāji pordup

$$f = \Sigma(1, 2, 6)$$

hdyly u mape pordzeny a, b
skavē indexy

	$\overline{a}$				b
	0	2	3	1	
c	4	6	7	5	

Loobadava mapa

	$\overline{a}$				b
	0	1	1	0	
c	0	0	1	0	

$$a \cdot 1 = a$$

$$(\overline{a+b}) = \bar{a} \cdot \bar{b}$$

$$a \cdot 0 = 0$$

$$(\overline{ab}) = \bar{a} + \bar{b}$$

$$a + 1 = 1$$

$$a + 0 = a$$

$$a \cdot a = a$$

$$a + a = a$$

$$a \cdot \bar{a} = 0$$

$$a + \bar{a} = 1$$

$$a + ab = a(1+b) = a$$

$$a(a+b) = a+ab = a$$

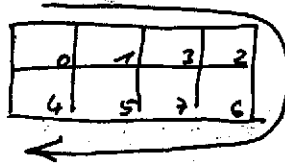
$$a + \bar{a}b = a+b$$

$$a \cdot (\bar{a} + b) = ab$$

Grayův kód

	c	b	a
0	0	0	0
1	0	0	1
3	0	1	1
2	0	1	0
6	1	1	0
7	1	1	1
5	1	0	1
4	1	0	0

vždy se mění jen jedna číslice
syntaxe a něj K. mapa



minimalizace fce

$$f = a\bar{b}\bar{c} + \bar{a}b$$

algebraicky:

$$f = a\bar{b}\bar{c} + \bar{a}b\bar{c} + \bar{a}b c = a\bar{b}\bar{c} + \bar{a}b(c + \bar{c}) = a\bar{b}\bar{c} + \bar{a}b$$

minterm - rovnice popisující právě jednu jednotku
(obsahuje všechny reáln. proměnné)

max. 1. tabulka

konjunktivní forma - CNF

$$f = (c + b + a) \cdot (c + \bar{b} + \bar{a}) \cdot (\bar{c} + b + a) \cdot (\bar{c} + \bar{b} + \bar{a}) \cdot (\bar{c} + \bar{b} + \bar{a}) =$$

maxterm

popisují se řádky s 0 a všechno negovaný

$$= (c + \underbrace{\bar{c}\bar{b} + \bar{c}\bar{a} + b\bar{c} + b\bar{a} + a\bar{c} + \bar{a}b}_{\bar{c}\bar{c}\bar{a} + c\bar{a} = c(\bar{a} + \bar{a}) = c}) \cdot \dots$$

$$= (c + \bar{b}\bar{a} + \bar{b}a) \cdot (\bar{c} + b + a) \cdot (\bar{c} + \bar{b} + \bar{a}) \cdot (\bar{c} + \bar{b} + \bar{a}) =$$

$$= (c + \bar{b}\bar{a} + \bar{c}\bar{b}\bar{a} + \bar{b}\bar{a} + \bar{c}\bar{b}a + \bar{b}a) \cdot \dots =$$

$\bar{b}\bar{a}(\bar{c} + 1) = \bar{b}\bar{a} \quad \bar{b}a(\bar{c} + 1) = \bar{b}a$

$$= (cb + ca + b\bar{a} + \bar{b}a) \cdot (\bar{c} + b + \bar{a}) \cdot (\bar{c} + \bar{b} + \bar{a}) =$$

$$= (cb + \underbrace{cb\bar{a} + cb\bar{a}}_{cb} + \underbrace{\bar{c}b\bar{a} + b\bar{a}}_{b\bar{a}(\bar{c}+1)=b\bar{a}} + \bar{c}b\bar{a}) \cdot (\bar{c} + \bar{b} + \bar{a}) =$$

$$= (cb + b\bar{a} + \bar{c}b\bar{a}) \cdot (\bar{c} + \bar{b} + \bar{a}) =$$

$$= cb\bar{a} + \bar{c}b\bar{a} + b\bar{a} + \bar{c}b\bar{a} =$$

$$= \underline{b\bar{a} + \bar{c}b\bar{a}}$$

$$f = d\bar{c}b\bar{a} + \bar{d}\bar{c}b\bar{a} + d\bar{c}b\bar{a} + \bar{d}\bar{c}b\bar{a} + d\bar{c}b\bar{a} + \bar{d}\bar{c}b\bar{a}$$

	d	c	b	a	
0	0	0	0	0	
1	0	0	0	1	1
2	0	0	1	0	
3	0	0	1	1	
4	0	1	0	0	1
5	0	1	0	1	
6	0	1	1	0	1
7	0	1	1	1	
8	1	0	0	0	
9	1	0	0	1	
10	1	0	1	0	
11	1	0	1	1	1
12	1	1	0	0	1
13	1	1	0	1	
14	1	1	1	0	1
15	1	1	1	1	

algebraisch

dc

minimalisace

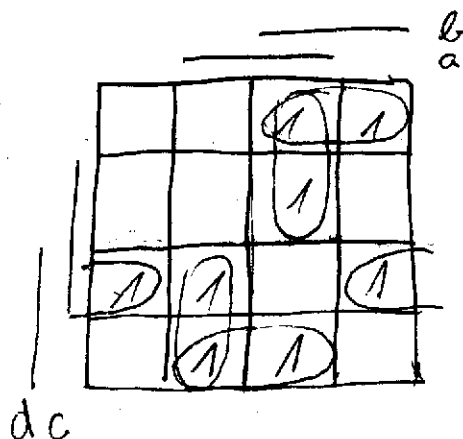
$$f = c\bar{a} + \bar{d}\bar{c}b\bar{a} + d\bar{c}b\bar{a}$$

$$\bar{c}\bar{a}(\bar{d}+d) + c\bar{b}\bar{a}(d+\bar{d}) = \bar{c}\bar{a} + c\bar{b}\bar{a} = \bar{c}\bar{a}(\bar{b}+b) = \bar{c}\bar{a}$$

$$f = \Pi(0, 2, 3, 5, 7, 8, 9, 10, 13, 15)$$

pre 4 promenných

$$f = \sum (2, 3, 7, 9, 11, 12, 13, 14)$$



$$f = \bar{d}\bar{c}b + \bar{d}ba + (d\bar{b}a) + d\bar{c}a + dca$$

$\times \quad + \quad +$

	d	c	b	a	
0	0	0	0	0	0
1	0	0	0	1	0
2	0	0	1	0	1
3	0	0	1	1	1
4	0	1	0	0	0
5	0	1	0	1	0
6	0	1	1	0	0
7	0	1	1	1	1

	d	c	b	a	
8	1	0	0	0	0
9	1	0	0	1	1
10	1	0	1	0	0
11	1	0	1	1	1
12	1	1	0	0	1
13	1	1	0	1	1
14	1	1	1	0	1
15	1	1	1	1	0

Uran

4 kordynery ABCD

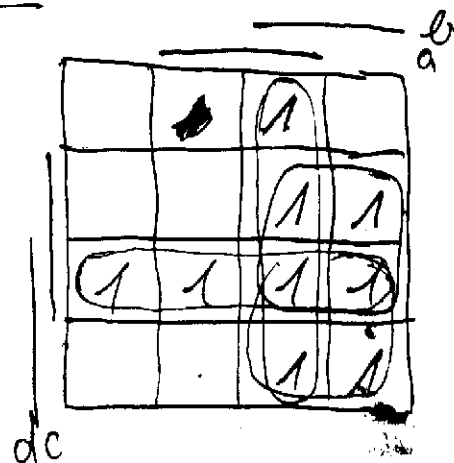
A - 1kg, B - 4kg, C - 3kg, D - 2kg

Kridické mn. 5 kg.

Výstup: 1 - složený nepřekříž

	D	C	B	A			D	C	B	A	
0	0	0	0	0	0	8	1	0	0	0	0
1	0	0	0	1	0	9	1	0	0	1	0
2	0	0	1	0	0	10	1	0	1	0	1
3	0	0	1	1	1	11	1	0	1	1	1
4	0	1	0	0	0	12	1	1	0	0	1
5	0	1	0	1	0	13	1	1	0	1	1
6	0	1	1	0	1	14	1	1	1	0	1
7	0	1	1	1	1	15	1	1	1	1	1

$$f = da + ba + cb + db$$



$$f(d, c, b, a) = \sum (1, 2, 4, 5, 7, 8, 10, 11, 13, 14)$$

			<u>b</u>
		<u>a</u>	
	1		1
1	1	1	
	1		1
1		1	1
dc			

$$f = b\bar{c}d + \bar{a}bd + \bar{a}b\bar{c} + \bar{a}\bar{c}d + \\ + a\bar{b}\bar{d} + a\bar{b}c + ac\bar{d} + \bar{b}c\bar{d}$$

$$f(d, c, b, a) = \sum (0, 1, 4, 5, 8, 9, 12, 13)$$

algebraically!

$$f = \bar{a}\bar{b}\bar{c}\bar{d} + \bar{d}\bar{c}\bar{b}\bar{a} + \bar{d}\bar{c}\bar{b}a + \bar{d}\bar{c}b\bar{a} + \bar{d}\bar{c}ba + d\bar{c}\bar{b}\bar{a} + d\bar{c}b\bar{a} + d\bar{c}ba$$

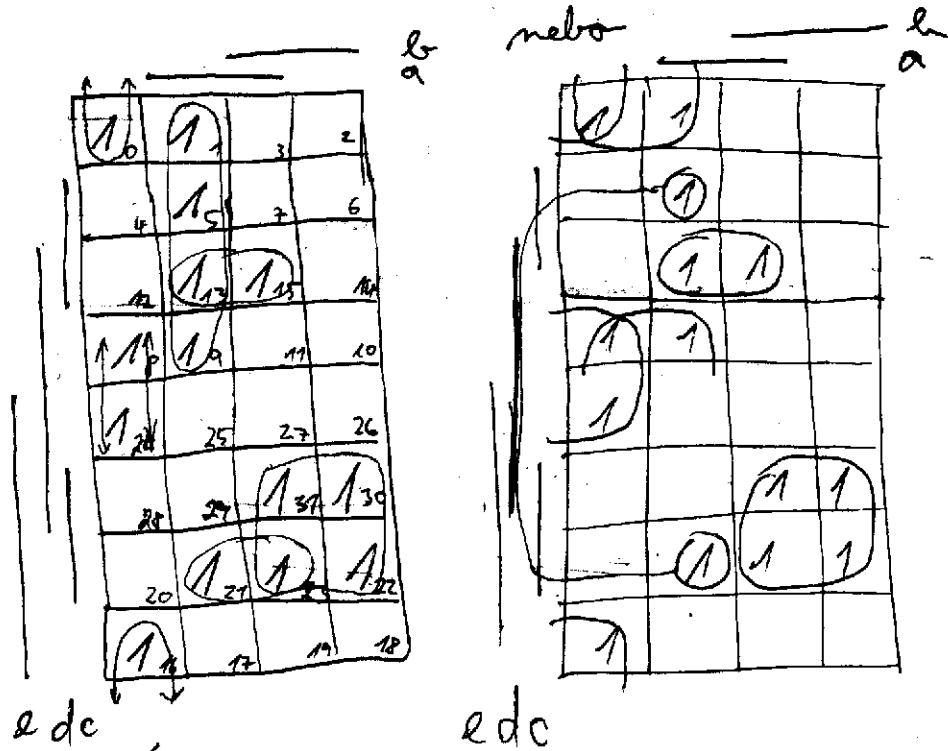
$$f = \bar{d}\bar{c}\bar{b}(\bar{a}+a) + \bar{d}\bar{c}\bar{b}(\bar{a}+a) + d\bar{c}\bar{b}(\bar{a}+a) + d\bar{c}\bar{b}(\bar{a}+a) =$$

$$= \bar{d}\bar{c}\bar{b} + \bar{d}\bar{c}\bar{b} + d\bar{c}\bar{b} + d\bar{c}\bar{b} =$$

$$= \bar{d}\bar{b}(\bar{c}+c) + d\bar{b}(\bar{c}+c) = \bar{d}\bar{b} + d\bar{b} = \underline{\underline{\bar{b}}}$$

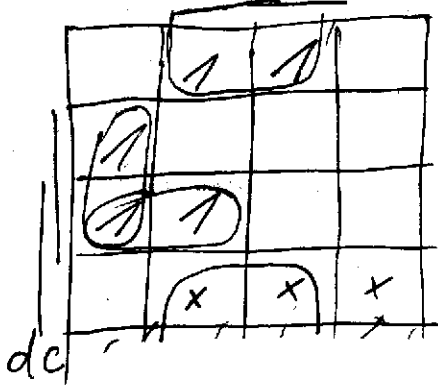
			<u>b</u>
		<u>a</u>	
	1	1	
	1	1	
	1	1	
	1	1	
dc			

$$f(e, d, c, b, a) = \sum (0, 1, 5, 8, 9, 13, 15, 16, 21, 22, 23, 24, 30, 31)$$



$$f = \bar{c}\bar{b}\bar{a} + \bar{e}\bar{b}\bar{a} + ecb + \bar{e}dca + edca$$

$$f(d, c, b, a) = \sum (1, 3, 4, 12, 13) + \sum_x (9, 10, 11)$$



$$f = \bar{c}a + c\bar{b}\bar{a} + dcb$$

NAND

$\bar{c}$	a	c	$\bar{b}$	$\bar{a}$	d	c	$\bar{b}$

+ schema

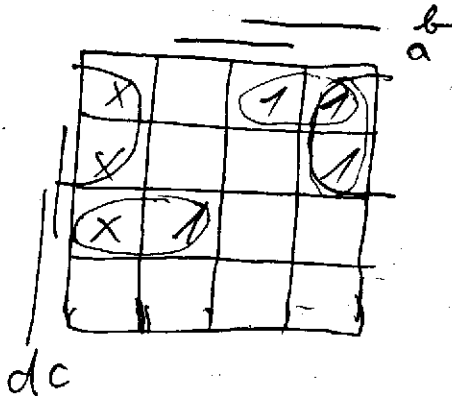
a to samy $\approx$ AND + OR

• to samy $\approx$ 2 vstup NAND

$$\bar{c}a + d\bar{c}\bar{b} + c\bar{b}\bar{a}$$

$$\overline{\overline{\bar{c}}|a} \quad \overline{\overline{d|\bar{c}|\bar{b}}} \quad \overline{\overline{c|\bar{b}|\bar{a}}}$$

$$f = \Sigma(2, 3, 6, 13) + \Sigma_x(9, 4, 12)$$



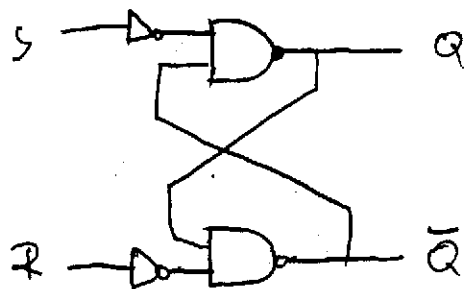
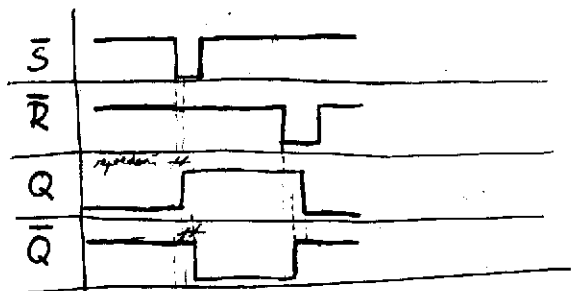
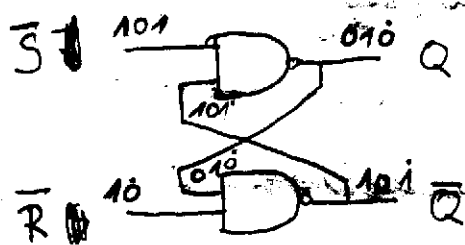
$$f = \bar{d}\bar{c}\bar{b} + \bar{d}\bar{a} + d\bar{c}\bar{b}$$

2 vstup NAND

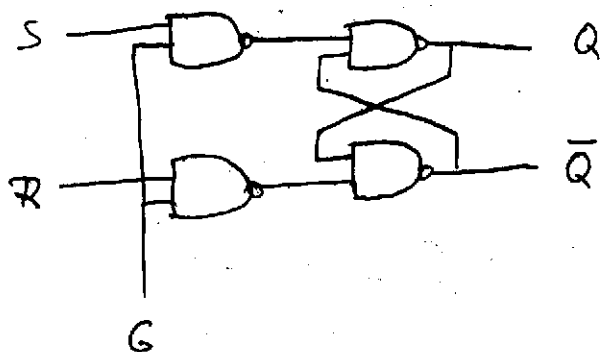
$$\bar{a}d + \bar{b}\bar{c}\bar{d} + \bar{b}cd$$

$$\overline{\overline{\bar{a}}|d} \quad \overline{\overline{b|\bar{c}|\bar{d}}} \quad \overline{\overline{b|c|d}}$$

klopový obvod RS



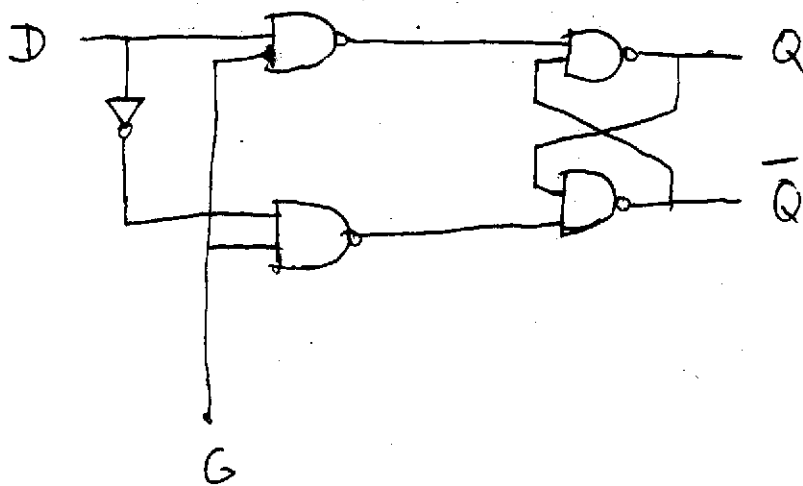
hrádlový RS



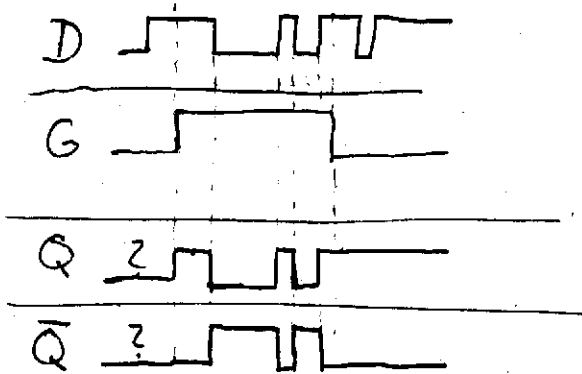
zakázaný stav

$$R, S = 1 \text{ při}$$

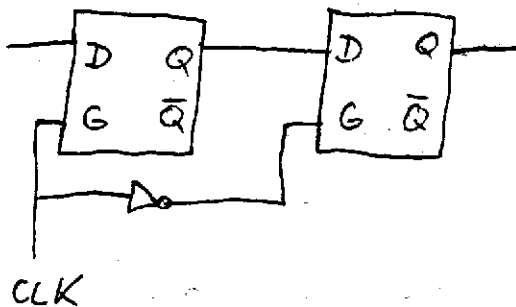
D (D latch)



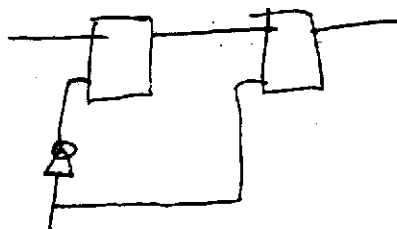
hladinový klopný
obvod - řízení
hladinou G



Master - Slave, Flip-Flop

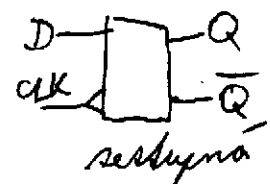
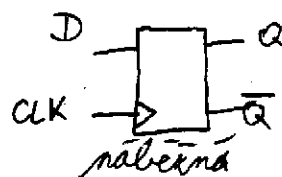


v okamžiku sáverné
hrany se vstúp přepíše
na výstúp

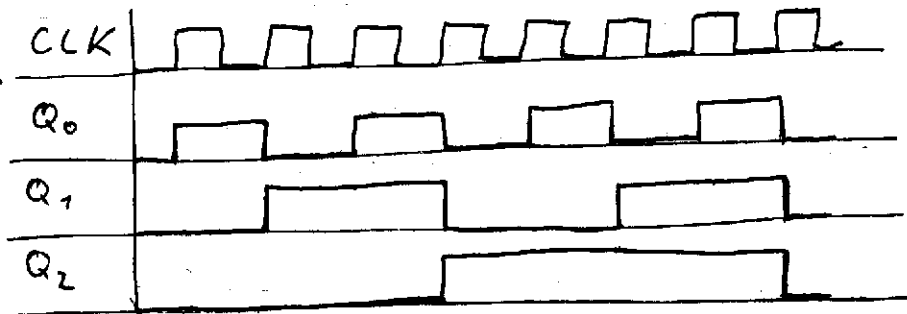
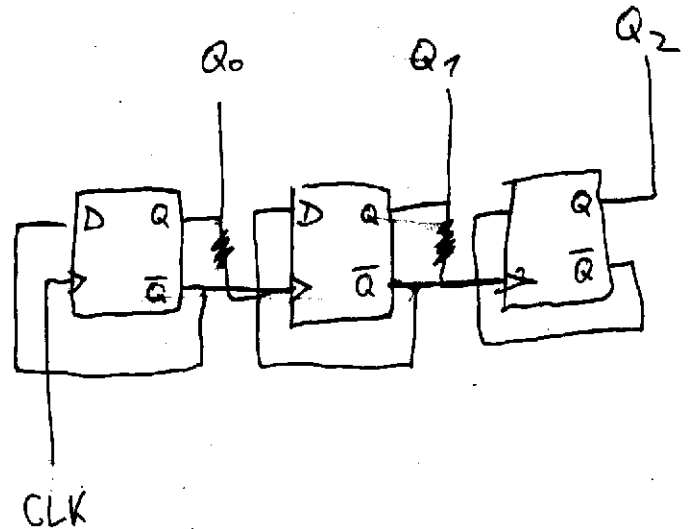


při náběrné hrane

D-FF

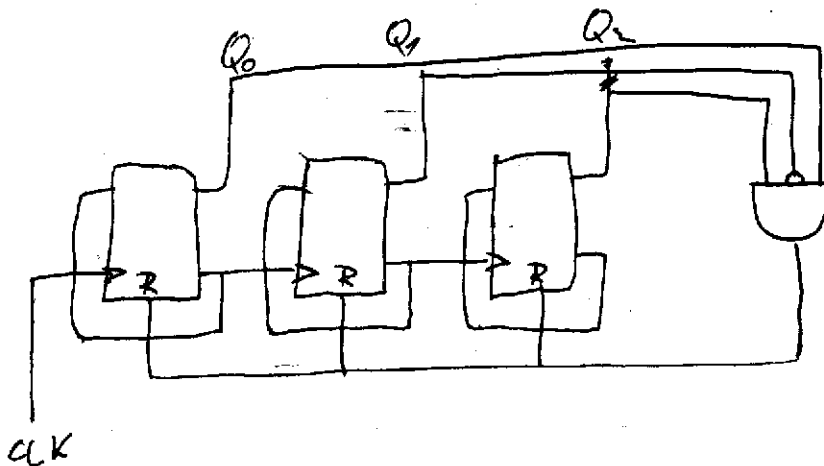


3-bitový čítač



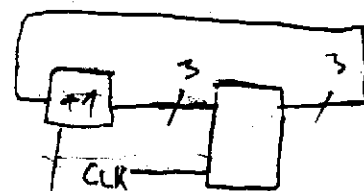
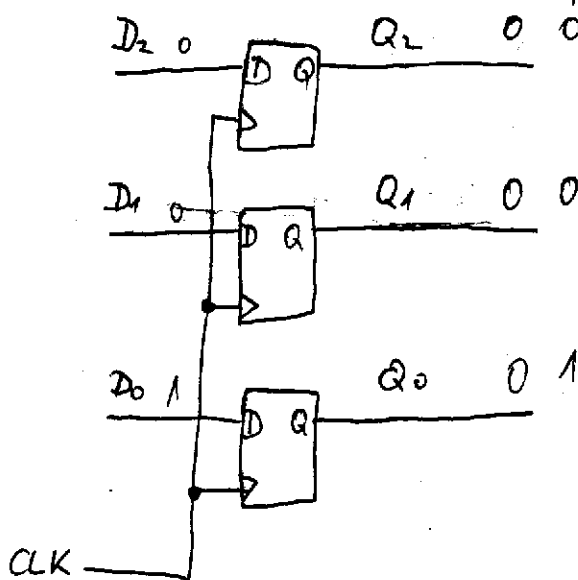
ne fungovalo by to, ale je to pomalý
 zmena proclánsi postupně - rozložení D flip-flopů.
 je to asynchronní obvod.

3bit c. modulo 5



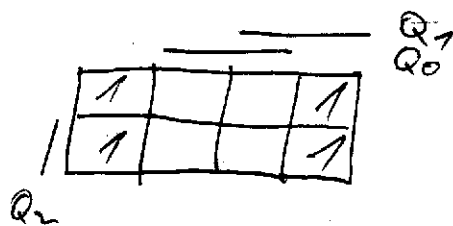
jak se objeví 101,
 tak se to rychle
 resetne
 pětná volovina :)

3-bitový čítač
správne Dka jako paměť po náb. hraně

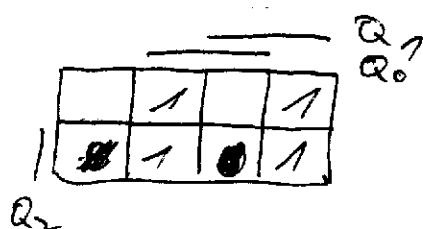


komb. logika - přídava

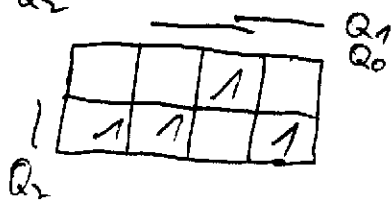
	Q_2	Q_1	Q_0	D_2	D_1	D_0
0	0	0	0	0	0	1
1	0	0	1	0	1	0
2	0	1	0	0	1	1
3	0	1	1	1	0	0
4	1	0	0	1	0	1
5	1	0	1	1	1	0
6	1	1	0	1	1	1
7	1	1	1	0	0	0



$$D_0 = \bar{Q}_0$$

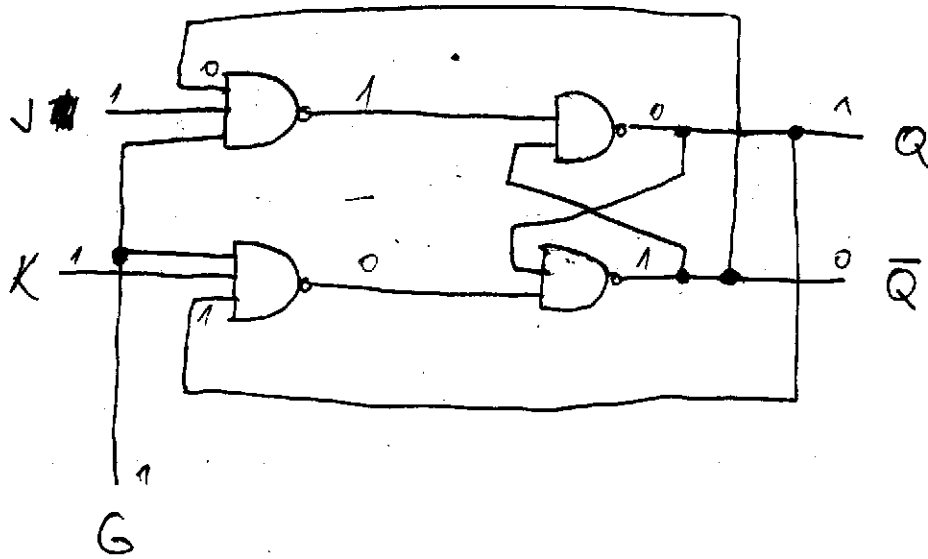


$$D_1 = Q_1 \bar{Q}_0 + \bar{Q}_1 Q_0 \quad (\text{xor})$$

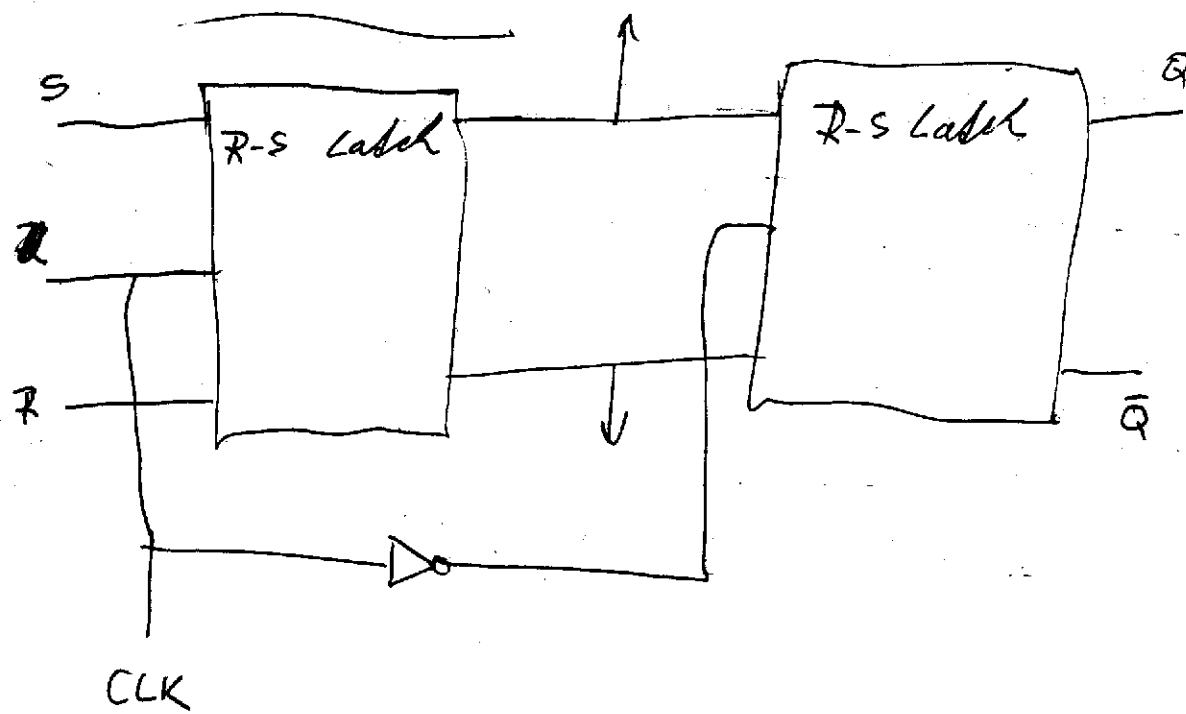


$$D_2 = Q_2$$

J-K Latch



RS Master-Slave

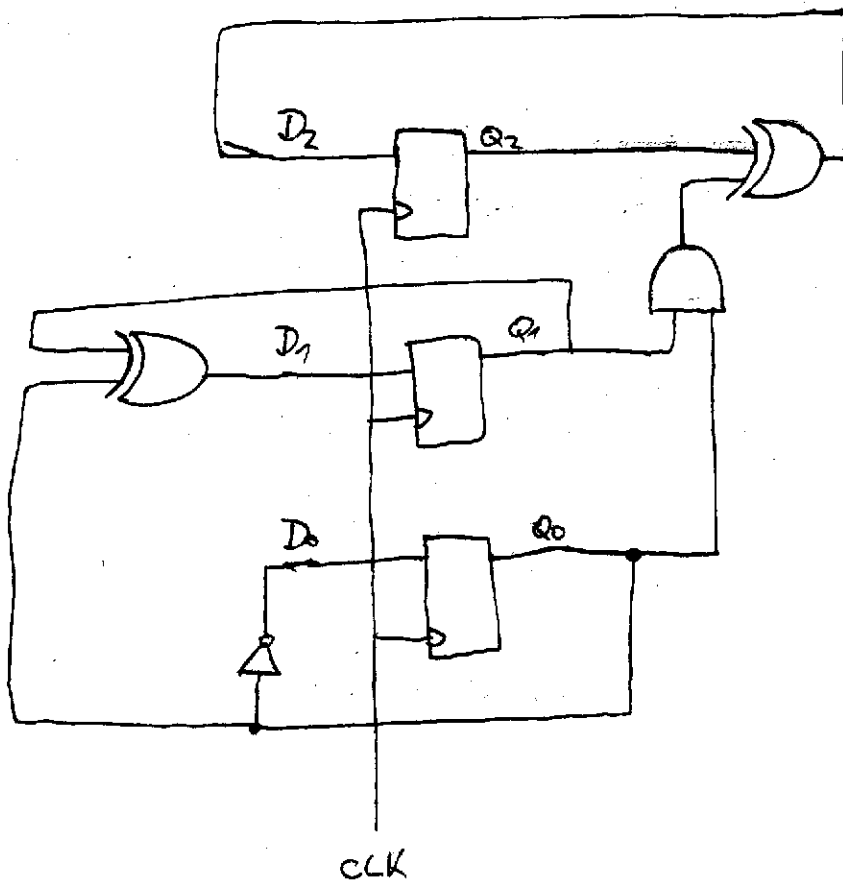


JK

L

~~D~~

čítač od 0 do 7



	Q_2	Q_1	Q_0	D_2	D_1	D_0
0	0	0	0	0	0	1
1	0	0	1	0	1	0
2	0	1	0	0	1	1
3	0	1	1	1	0	0
4	1	0	0	1	0	1
5	1	0	1	1	1	0
6	1	1	0	1	1	1
7	1	1	1	0	0	0

$D_0:$

	$\overline{Q_0}$						
	1				1		
Q_2	1				1		

$$D_0 = \overline{Q_0}$$

$D_1:$

	$\overline{Q_0}$	Q_0					
		1			1		
Q_2		1			1		

$$D_1 = Q_0 \overline{Q_1} + Q_1 \overline{Q_0} = Q_1 \oplus Q_0$$

$D_2:$

	$\overline{Q_0}$	Q_0	$\overline{Q_1}$	Q_1			
			1				
Q_2			1				

$$D_2 = \overline{Q_0} Q_2 + Q_0 Q_1 \overline{Q_2} + \overline{Q_1} Q_2$$

$$= Q_2 (\overline{Q_0} + \overline{Q_1}) + Q_0 Q_1 \overline{Q_2} =$$

$$= \overline{Q_0} Q_1 Q_2 + Q_0 Q_1 \overline{Q_2} =$$

$$= (Q_0 Q_1) \oplus Q_2$$

čítací modulo 5

	Q_2	Q_1	Q_0	D_2	D_1	D_0
0	0	0	0	0	0	1
1	0	0	1	0	1	0
2	0	1	0	0	1	1
3	0	1	1	1	0	0
4	1	0	0	0	0	0
5	1	0	1	x0	x1	x0
6	1	1	0	x0	x1	x0
7	1	1	1	x1	x0	x0

při zablouštění se dostane do definovaných

$D_0:$

	$\overline{Q_2}$	$\overline{Q_1}$	$\overline{Q_0}$	Q_0
Q_2	1	x	x	1
	x	x	x	x

$$D_0 = \overline{Q_2} \overline{Q_0} = \overline{(Q_2 + Q_0)}$$

$D_1:$

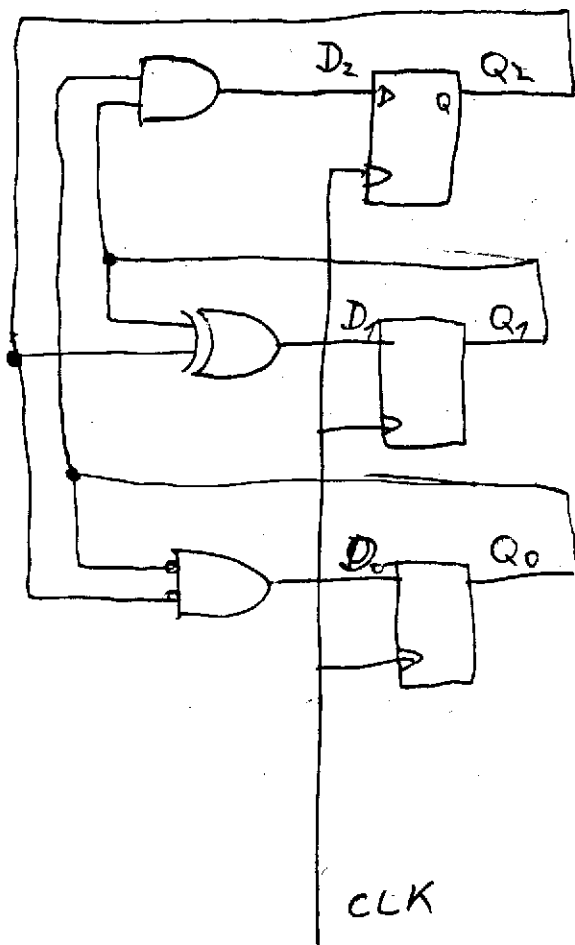
	$\overline{Q_2}$	$\overline{Q_1}$	$\overline{Q_0}$	Q_0
Q_2	x	x	x	1
	x	x	x	x

$$D_1 = Q_1 \overline{Q_0} + \overline{Q_1} Q_0 = Q_1 \oplus Q_0$$

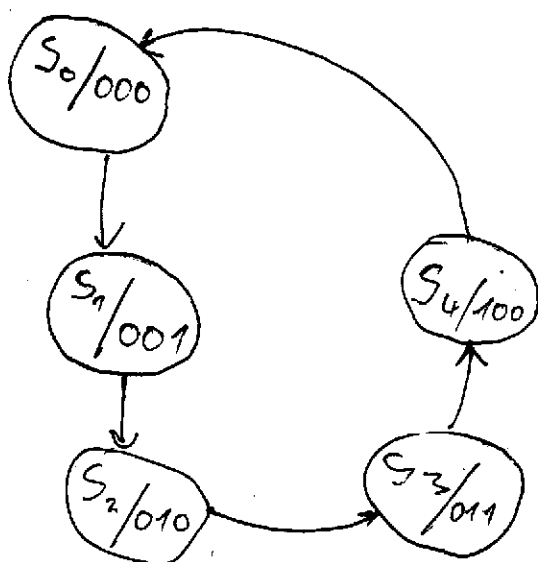
$D_2:$

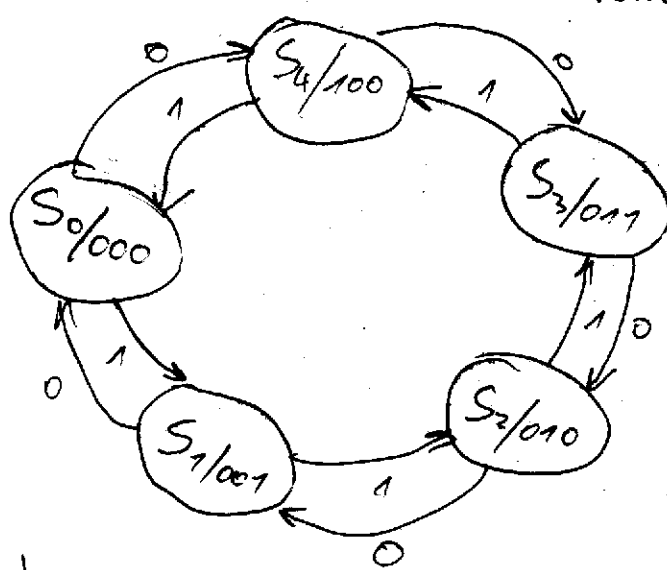
	$\overline{Q_2}$	$\overline{Q_1}$	$\overline{Q_0}$	Q_0
Q_2	x	x	x	1
	x	x	x	x

$$D_2 = Q_1 Q_0$$



k tomu graf přechodů

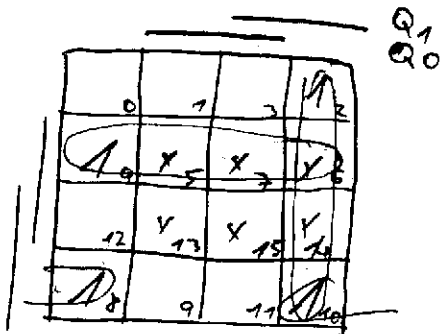




state \ reply	0	1
S ₀	S ₄	S ₁
S ₁	S ₀	S ₂
S ₂	S ₁	S ₃
S ₃	S ₂	S ₄
S ₄	S ₃	S ₀

	Q ₂ Q ₁ Q ₀ \ U	0	1
S ₀	000	100	001
S ₁	001	000	010
S ₂	010	001	011
S ₃	011	010	100
S ₄	100	011	000

D₀:



D₀ =

UQ₂

D_1 :

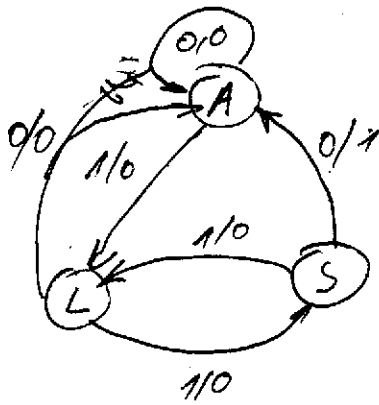
		1	
1	x	x	x
	x	x	x
	1		1

SSO vstup, výst

rozpočet sudý počet 1 na vstup

sčítaním s 0 na vst. od po domhle α

na výst 1



x \ y	0	1	0	1
A	A	L	0	0
L	A	S	0	0
S	A	L	1	0

x \ y	0	1	0	1
A	00	01	0	0
L	01	00	0	0
S	10	00	01	1

D_0 :

x \ y	0	1	0	1
0	0	0	x	0
1	1	0	x	1

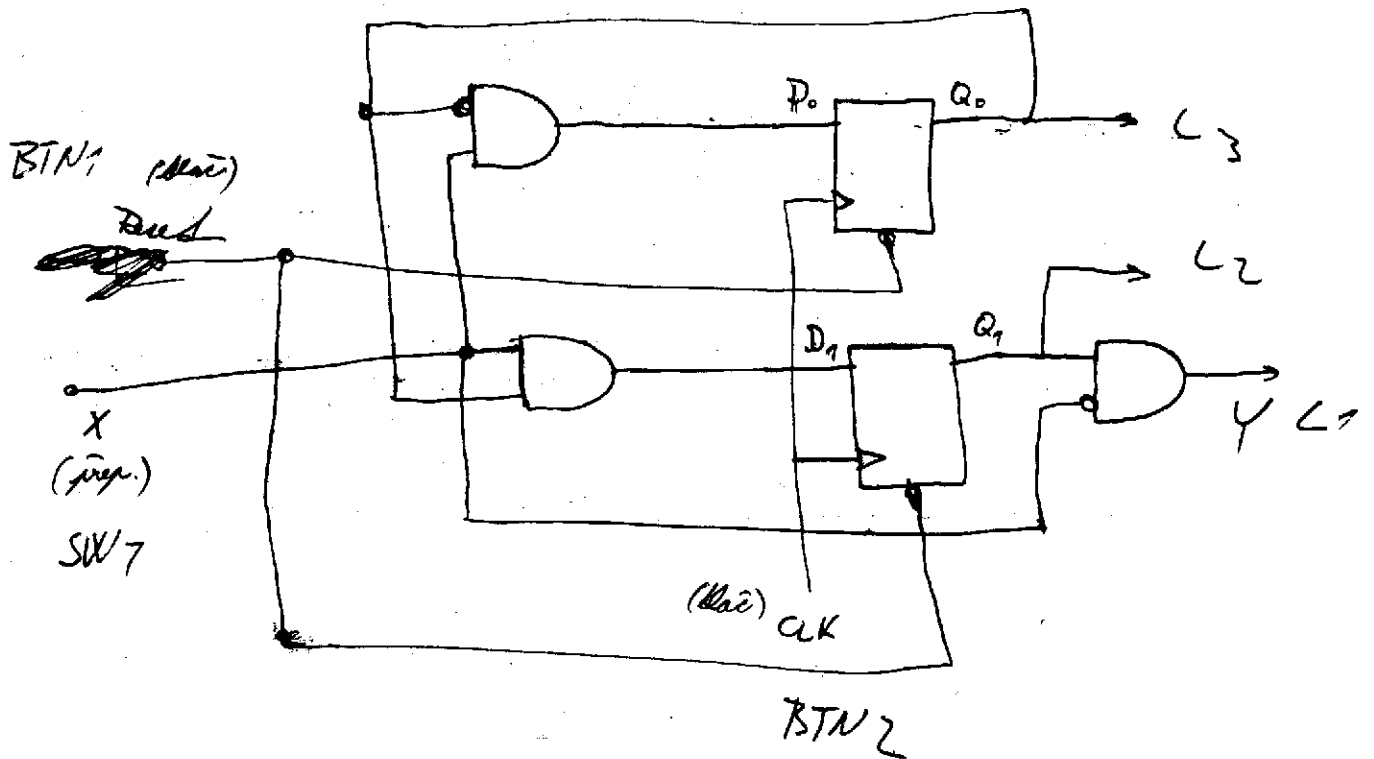
$$D_0 = x \bar{y}_0$$

x \ y	0	1	0	1
0	0	0	x	0
1	0	1	x	0

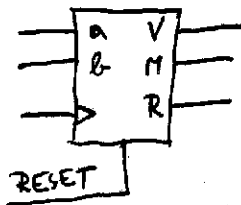
$$D_1 = x y_0$$

x \ y	0	1	0	1
0	0	0	x	1
1	0	0	x	0

$$Y = y_1 \bar{x}$$



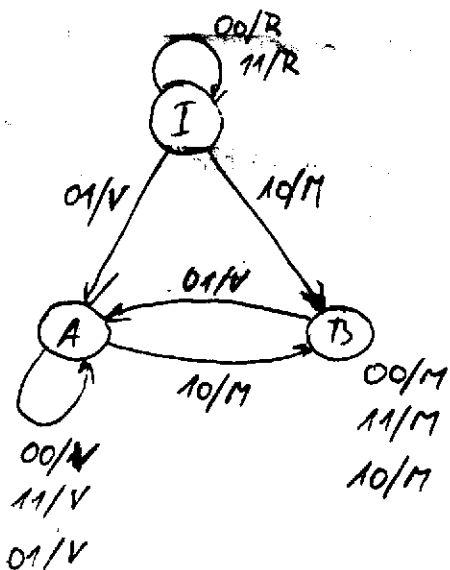
Komparáson



010100101 a

110000101 b

10 01



	00	01	10	11	00	01	10	11
I	I	~~A~~	~~B~~	I	R	V	M	R
A	A	A	B	A	V	V	M	V
B	B	A	B	B	M	V	M	M

$R=00, V=01, M=10$

b_a	00	01	10	11	00	01	10	11
q_0	00	01	10	00	00	01	10	00
01	01	01	10	01	01	01	10	01
10	10	01	10	10	10	01	10	10

D_0 :

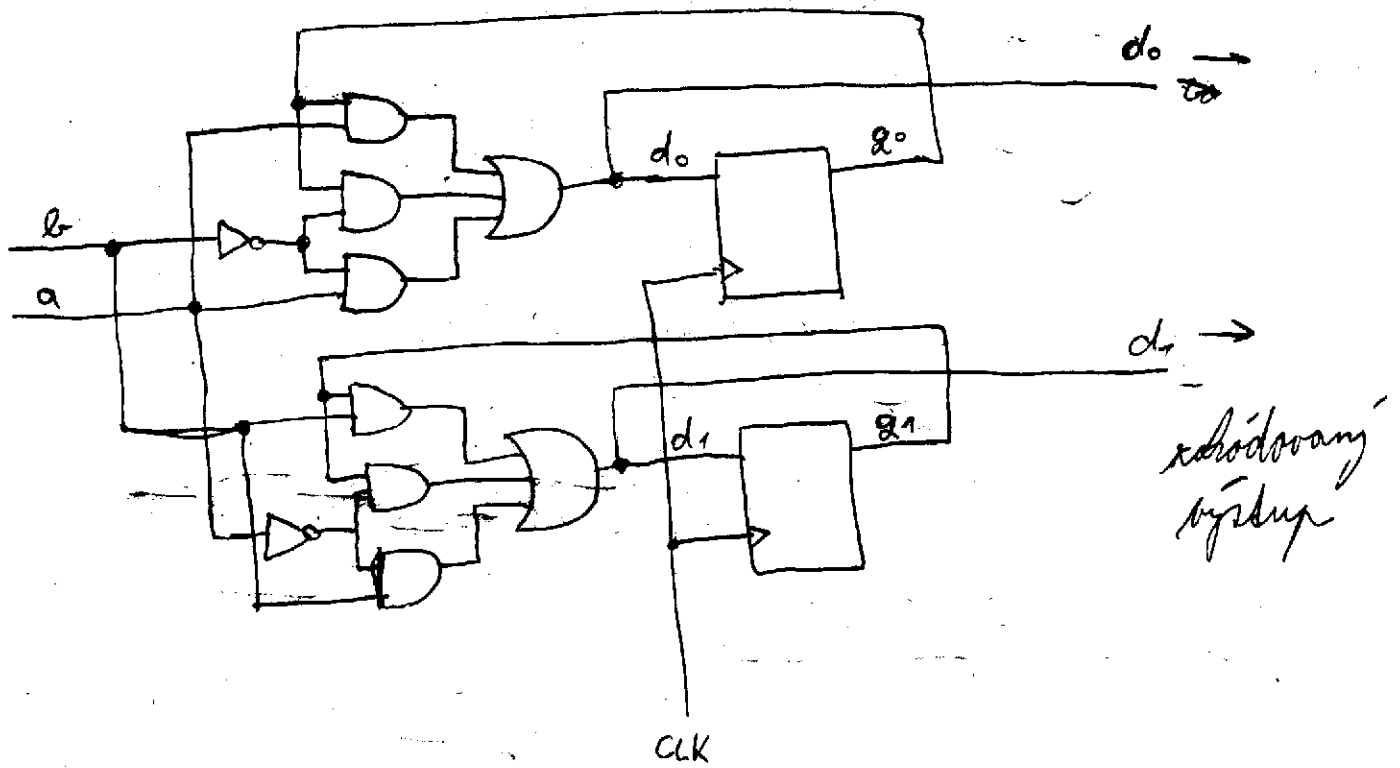
b_a	00	01	10	11
q_0	0	1	x	0
01	1	1	x	1
10	0	1	x	0
11	0	0	x	0

$$D_0 = \bar{b}a + \bar{b}q_0 + aq_0$$

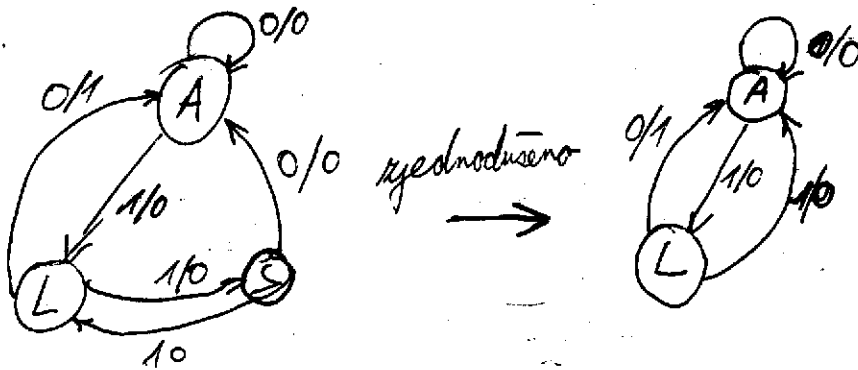
D_1 :

b_a	00	01	10	11
q_1	0	0	x	1
01	0	0	x	0
10	0	0	x	1
11	1	1	x	1

$$D_1 = b\bar{a} + bq_1 + \bar{a}q_1$$



Pr. Určit lichý počet jedniček



	0	1	0	1
A	A	L	0	0
L	A	A	1	0

~~X~~	0	1	0	1
0	0	1	0	0
1	0	0	1	0

J_a

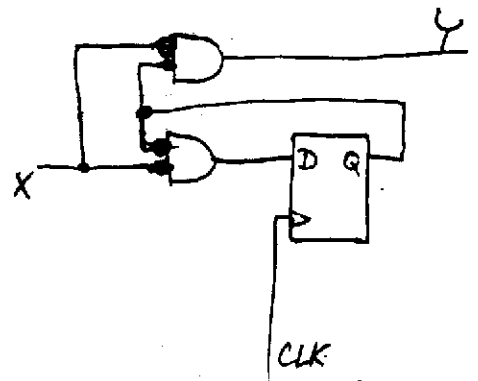
	0	1
q	0	1

$$D = \cancel{X} \times \bar{q}$$

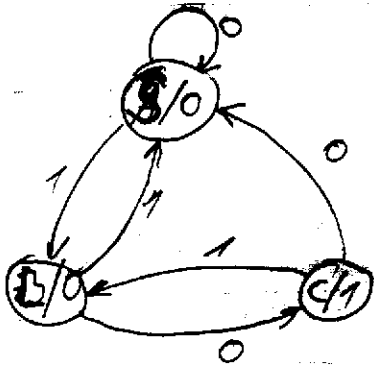
Y

	0	1
q	0	1

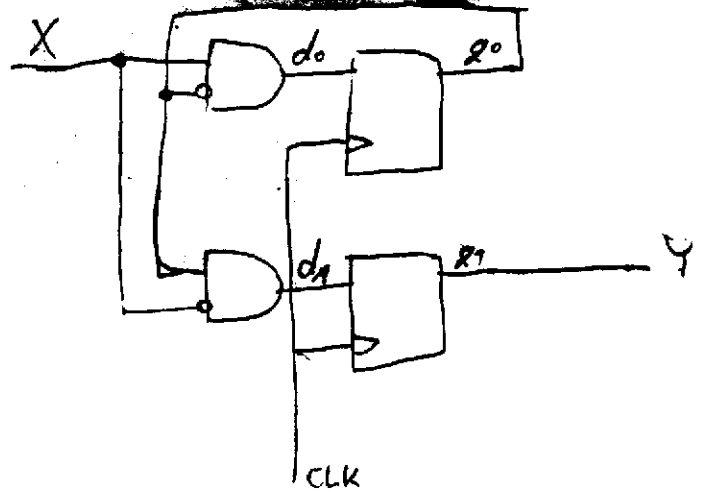
$$Y = \cancel{X} \bar{q}$$



John Moore



	0	1	Y
S	S	L	0
L	C	S	0
C	S	L	1



X \ q ₀ q ₁	00	01	Y
00	00	01	0
01	10	00	0
10	00	01	1

D_0

0	0	x	0
1	0	x	1

$D_0 = x \bar{q}_0$

D_1

0	1	x	0
0	0	x	0

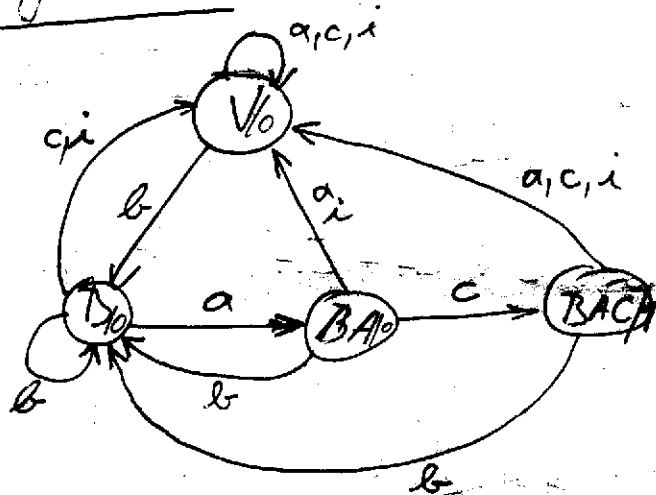
$D_1 = \bar{x} q_0$

Y

0	0
1	1

$Y = q_1$

Kódový náčrt



Moore

Cílač

→ 0 → 1 → 3 → 8 → 11 → 12 → 4 → 00

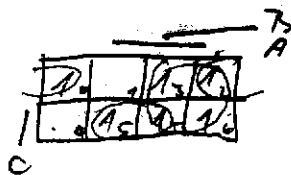
0000	0001
0001	0011
0011	1000
1000	1011
1011	1100
1100	0100
0100	0000

DODO

Kódomý rámec - dekodér

C	B	A	x_1	x_0
0	0	0	1	1
0	0	1	0	0
0	1	0	0	1
0	1	1	1	1
1	0	0	1	0
1	0	1	1	1
1	1	0	1	1
1	1	1	1	1

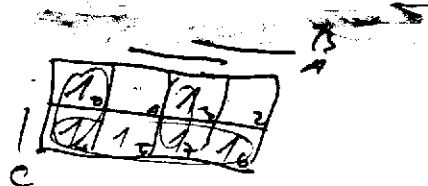
x_0



$$x_0 = B + CA + \bar{C}\bar{A}$$

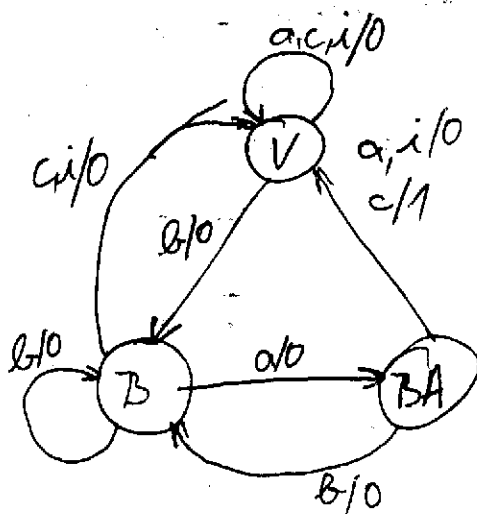
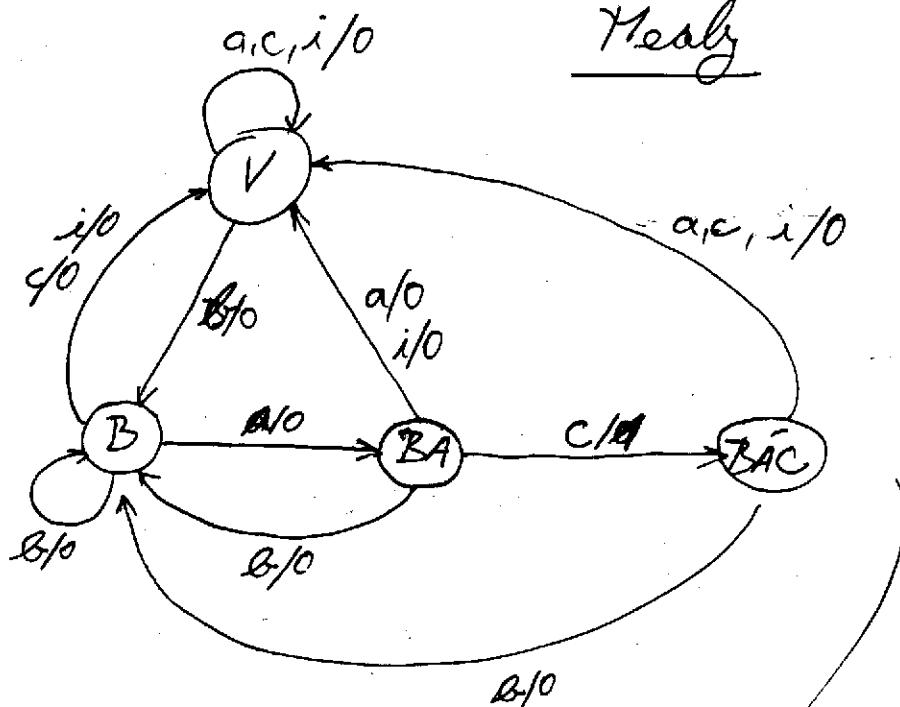
$$\frac{B + CA + \bar{C}\bar{A}}{\bar{B} \mid \bar{C} \mid \bar{A}}$$

x_1



$$x_1 = C + \bar{B}\bar{A} + BA$$

Mealy



	a	b	c	i	a	b	c	i
V	V	B	V	V	0	0	0	0
B	BA	B	V	V	0	0	0	0
BA	V	B	V	V	0	0	1	0

V	00
B	01
BA	10

g_1, g_0	x_1, x_0 00 01 10 11	00	01	10	11
00	00 01 00 00	0	0	0	0
01	10 01 00 00	0	0	0	0
10	00 01 00 00	0	0	1	0

d_1 :

0	1	x	0
0	0	x	0
0	0	x	0
0	0	x	0

x_1, x_0

$$d_1 = g_0 \bar{x}_0 \bar{x}_1$$

d_0 :

0	0	x	0
1	1	x	1
0	0	x	0
0	0	x	0

x_1, x_0

$$d_0 = \bar{x}_1 x_0$$

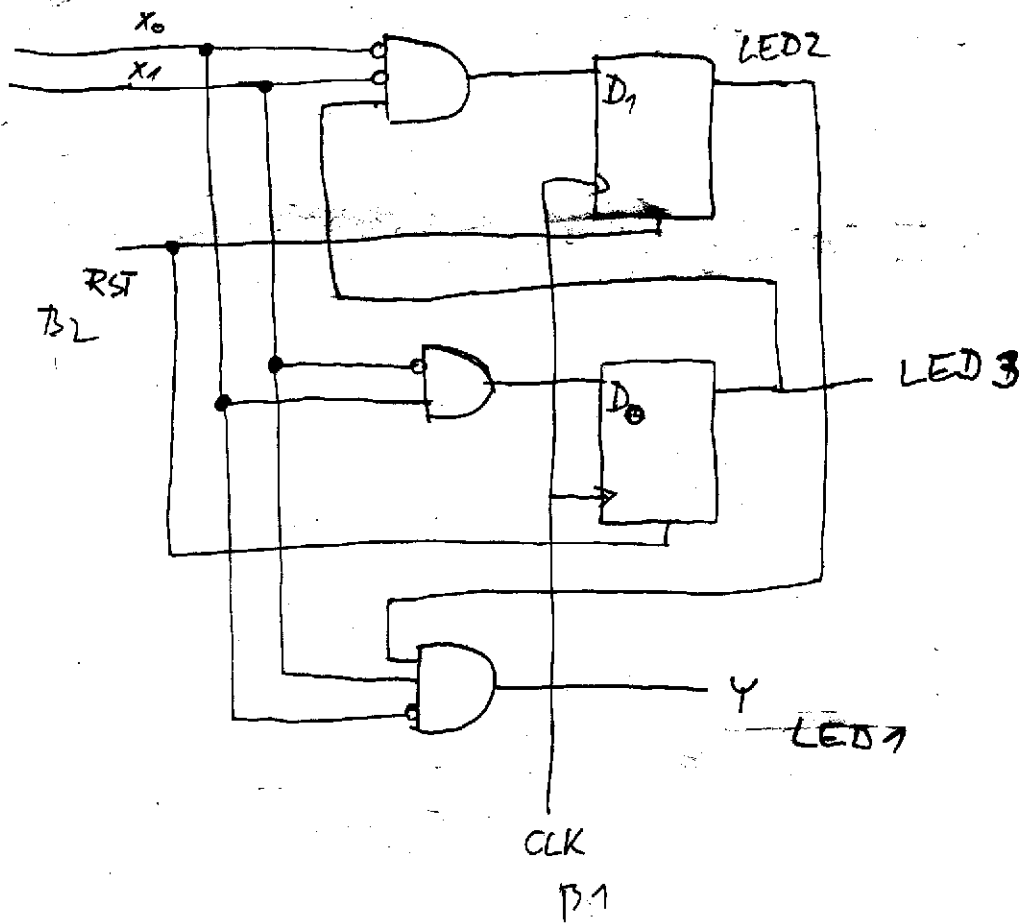
g :

0	0	x	0
0	0	x	0
0	0	x	0
0	0	x	1

x_1, x_0

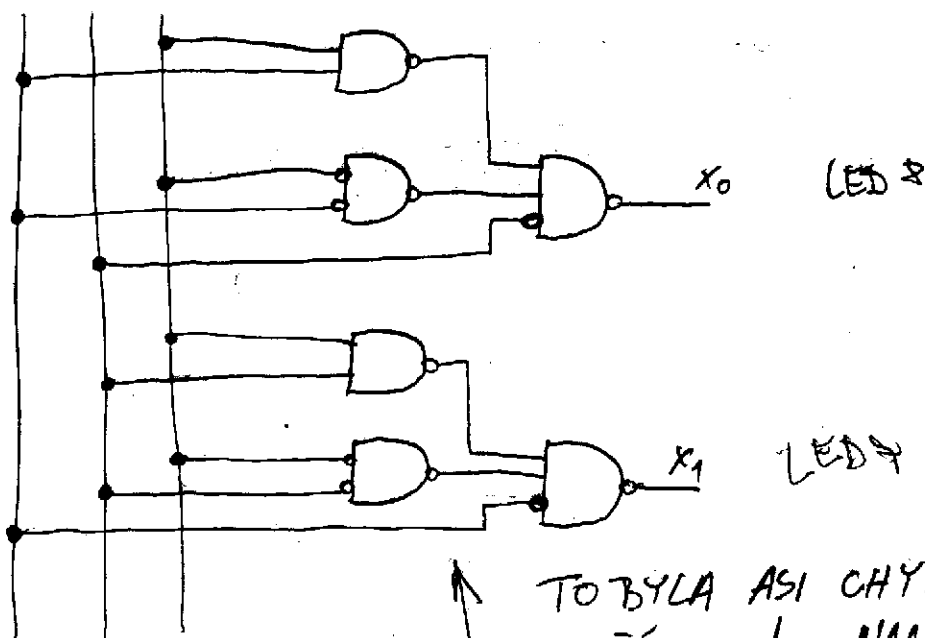
$$g = x_1 \bar{x}_0 g_1$$

Mealy



decoder

SW3 SW2 SW1
C B A



TO BYLA ASI CHYBA
aby přímo do NAND 3
mohly být ještě negované

Moore

	a	b	c	i	y
V	V	~~B~~	V	V	0
B	BA	~~B~~	V	V	0
BA	V	~~B~~	BAC	V	0
BAC	V	~~B~~	V	V	1

V	00
~~BA~~	01
BA	10
BAC	11

$q_1 q_0$	$x_1 x_0$	00	01	10	11	y
00	00	00	01	00	00	0
01	10	01	00	00	00	0
10	00	01	11	00	00	0
11	00	01	00	00	00	1

d_1 :

	$x_1 x_0$	00	01	10	11
$q_1 q_0$	00	0	1	0	0
	01	0	0	0	0
	10	0	0	0	0
	11	0	0	0	1

$$d_1 = \frac{x_1 \bar{x}_0 q_1 \bar{q}_0 + \bar{x}_1 \bar{x}_0 \bar{q}_1 q_0}{\text{F11} \quad \text{111}}$$

d_0 :

	$x_1 x_0$	00	01	10	11
$q_1 q_0$	00	0	0	0	0
	01	1	1	1	1
	10	0	0	0	0
	11	0	0	0	1

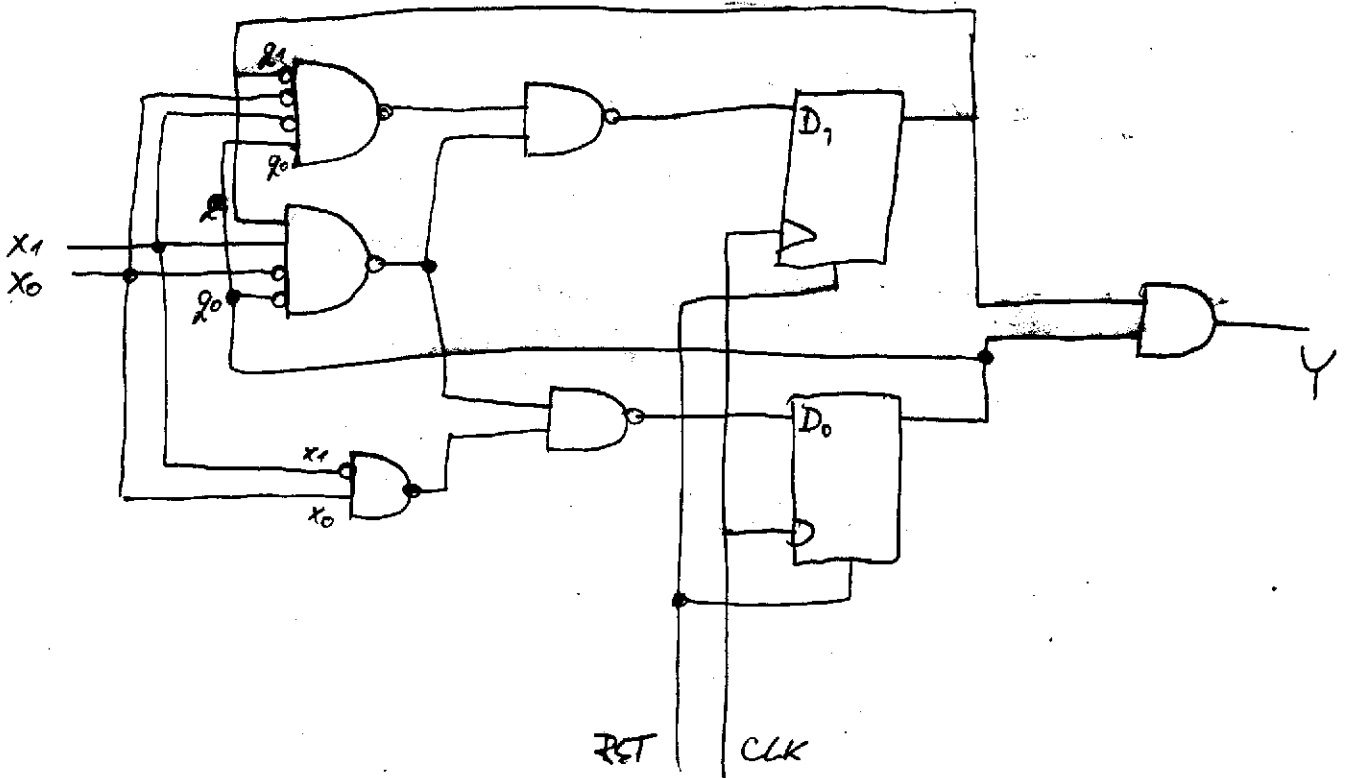
$$d_0 = \bar{x}_1 x_0 + x_1 \bar{x}_0 q_1 \bar{q}_0$$

y

	q_1	0	1
q_0	0	0	1
	1	0	0

$$y = q_1 q_0$$

Moore

Test

1. ~~MS~~ MS in Bodley + 3

→ 0, 3, 1, 4, 2

$\sqrt{-K}$ wird, NAND2,3

76



2. max. f solo $\uparrow$, spórtení klav 30 ms, hradla 15 ms
správné výsledek 40 ms před dotí CLK 4B

46

3. ~~the~~ ^{the} model R-S master-slave

4b

7. syn. čítací M6 v Greyboxe H.

0 0 0
0 0 1
0 1 1
0 1 0
1 1 0
1 1 1

D, NAND2, 3

2. t_{max}

3. J-K master slave nakresliť

C. 1. odstup, 1 výst

posloupnosť 3-bit $\bar{c}$, rozpozná liché
při rejoytím bitu na výst 1

#

J-K, NAND

2. max f

3. D syn. úroveň