NAVRHOVÁNÍ LOGICKÝCH OBVODŮ

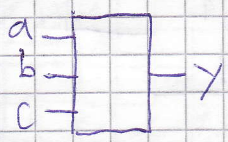
- logické obvody – kombinační – výstup závisí na vstupu
  - sekvenční – výstup závisí na vstupu a stavu

Navrhování kombinačních obvodů

a) popis kombinačního obvodu tabulkou

a	b	c	y
0	0	0	1
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	1

VSTUPY (a, b, c) — VÝSTUP (y)



b) popis kombinačního obvodu výrazem

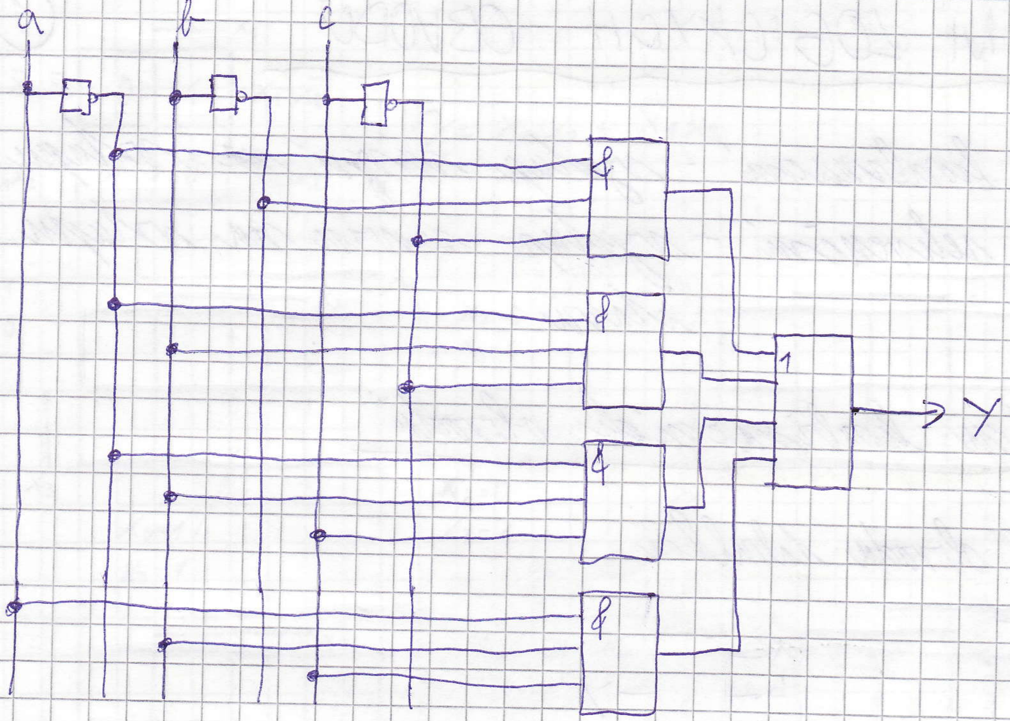
- kombinační obvod je reprezentován logickou fcí

$$y = F(X) \;;\quad X = X_1, X_2, \dots X_n$$

- každou logickou fci lze zapsat ve tvaru „součet součinů"

$$y = b_1 x_1 x_2 \cdots x_n + b_2 \bar{x}_1 x_2 \cdots x_n + \cdots b_k \bar{x}_1 \bar{x}_2 \cdots \bar{x}_n$$

$$y = \bar{a}\cdot\bar{b}\cdot\bar{c} + \bar{a}\cdot b\cdot\bar{c} + \bar{a}\cdot b\cdot c + a\cdot b\cdot c$$



$$y = \bar{a}\cdot\bar{b}\cdot\bar{c} + \bar{a}\cdot b\cdot\bar{c} + \bar{a}\cdot b\cdot c + a\cdot b\cdot c$$

NĚKTERÁ PRAVIDLA BOOLEAVY ALGEBRY

$a\cdot b = b\cdot a$ $\qquad$ $a+b = b+a$

$a\cdot(b+c) = a\cdot b + a\cdot c$ $\qquad$ $a+(b\cdot c) = (a+b)\cdot(a+c)$

$(a\cdot b)\cdot c = a\cdot(b\cdot c)$ $\qquad$ $(a+b)+c = a+(b+c)$

$\bar{\bar{a}} = a$

$a\cdot 0 = 0$ $\qquad$ $a+0 = a$ $\qquad$ $a+\bar{a} = 1$

$a\cdot 1 = a$ $\qquad$ $a+1 = 1$ $\qquad$ $a\cdot\bar{a} = 0$

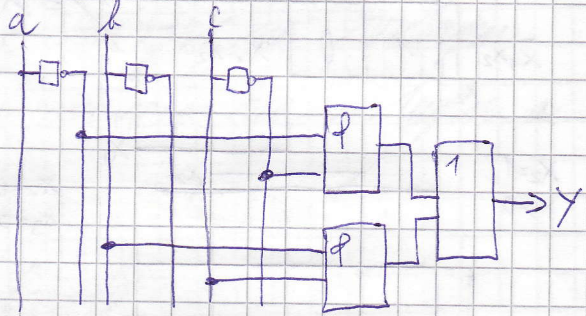
DEMORGANOVO PRAVIDLO

$\overline{a\cdot b} = \bar{a}+\bar{b}$ $\qquad$ $\overline{a+b} = \bar{a}\cdot\bar{b}$

$$y = \bar{a}\cdot\bar{b}\cdot\bar{c} + \bar{a}\cdot b\cdot\bar{c} + \bar{a}\cdot b\cdot c + a\cdot b\cdot c$$

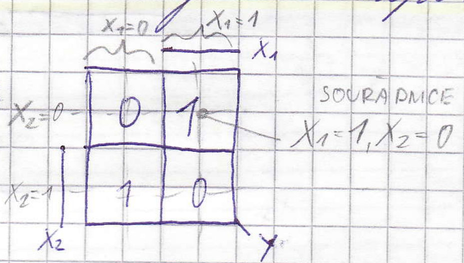
$$y = \bar{a}\cdot\bar{c}\cdot\underbrace{(\bar{b}+b)}_{1} + b\cdot c\cdot\underbrace{(\bar{a}+a)}_{1}$$

$$y = \bar{a}\cdot\bar{c} + b\cdot c$$



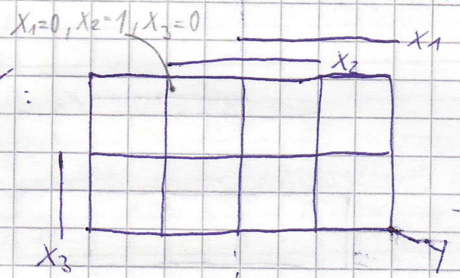
c) zápis klop. obvodu Karnaughovo mapou

pro 2 proměnné:

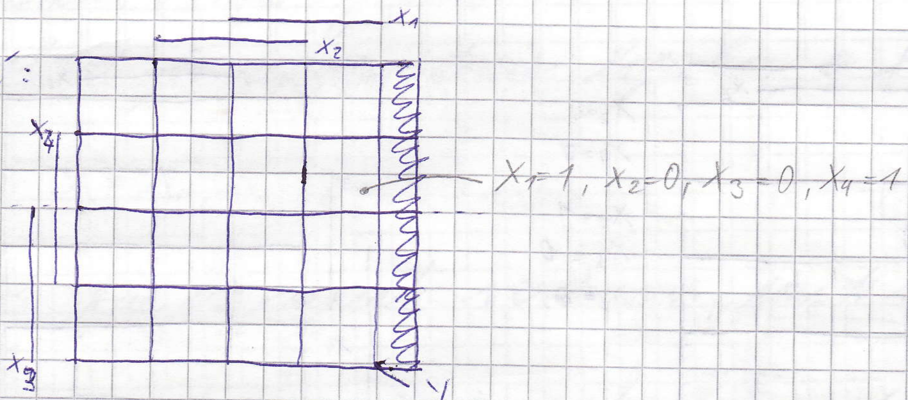


X_1	X_2	Y
0	0	0
0	1	1
1	0	1
1	1	0

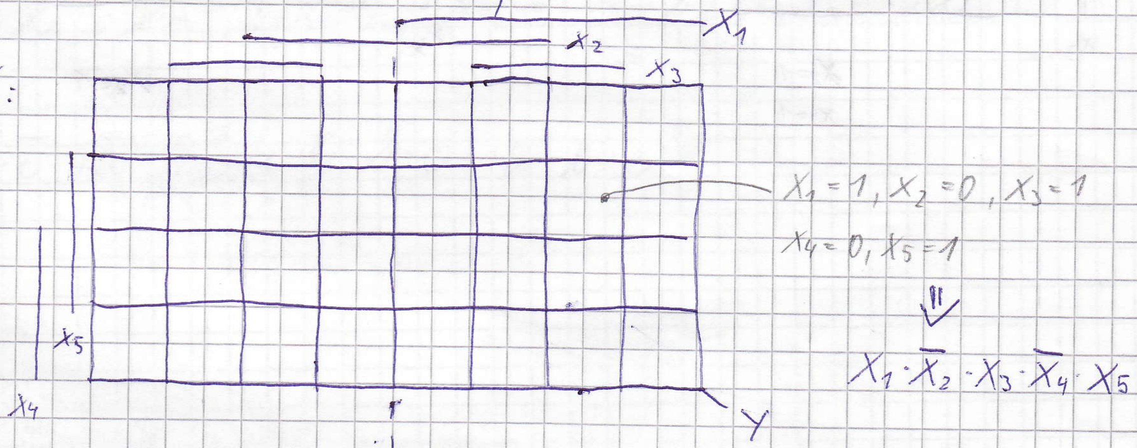
pro 3 proměnné:

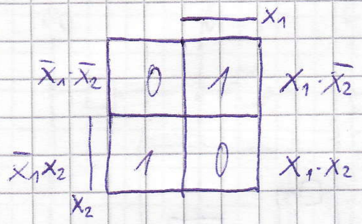


pro 4 proměnné:

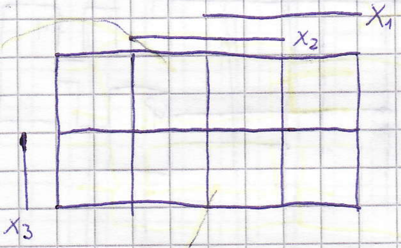


pro 5 proměnné:





$$y = x_1 \cdot \bar{x}_2 + \bar{x}_1 x_2$$

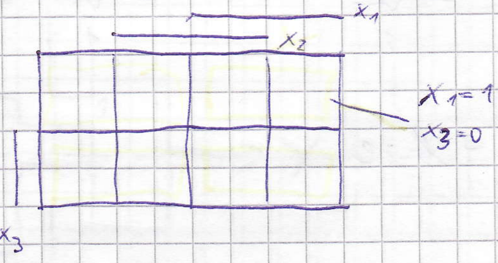


$x_2 = 1$
$x_3 = 0$

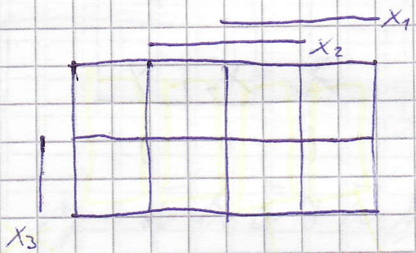
$x_2 = 0$
$x_3 = 0$

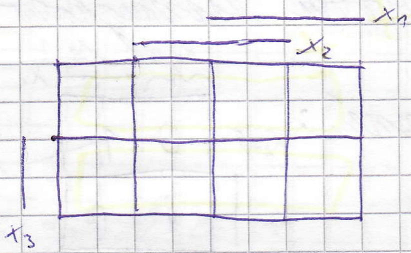
$x_2 = 0$
$x_3 = 1$

$x_2 = 1$
$x_3 = 1$



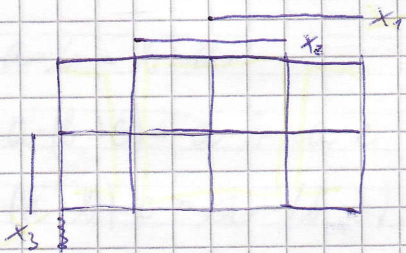
$x_1 = 1$
$x_3 = 0$

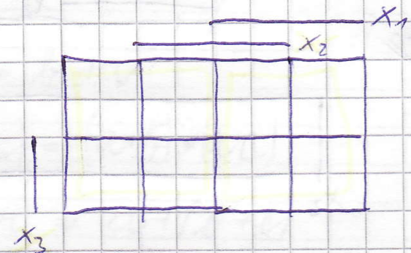


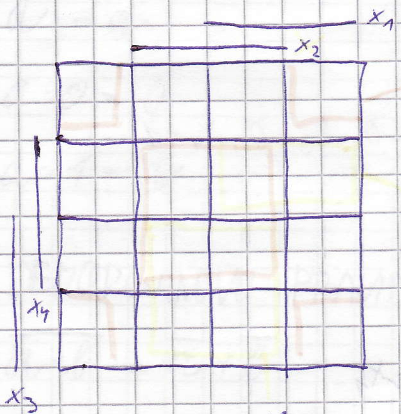


$x_1 = 1$
$x_2 = 1$

$x_1 = 1$
$x_2 = 0$



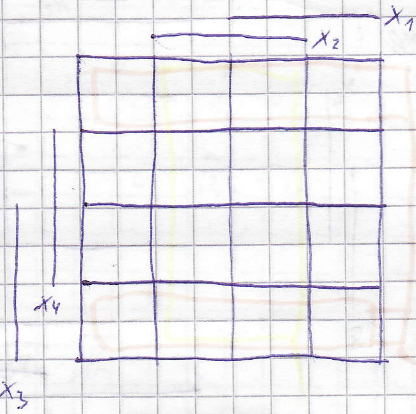




$x_2 = 0$
$x_4 = 0$

$x_1 = 1$
$x_3 = 0$
$x_4 = 1$

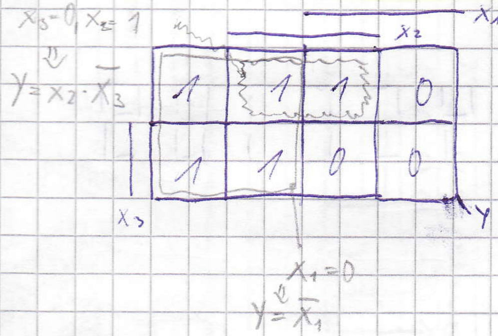
$x_2 = 1$
$x_3 = 1$



$x_4 = 0$

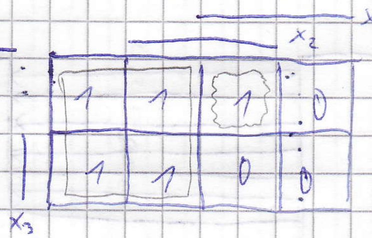
$x_2 = 1$

Minimalizace v Karnaughovo mapě:



$Y = \overline{X_1} + X_2 \cdot \overline{X_3}$

POZNÁMKA

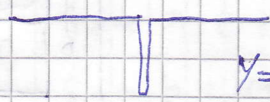


$Y = \overline{X_1} + X_1 \cdot X_2 \cdot \overline{X_3}$

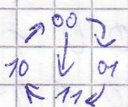
VŽDY JE MAXIMÁLNÍ 1 SOUČIN = 1

$Y = \underbrace{\overline{X_1}}_{1} + \underbrace{X_2 \cdot \overline{X_3}}_{1}$

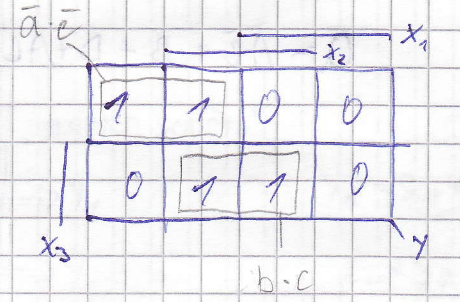
PRO $X_1=0, X_2=1, X_3=0$ ⇒ JSOU SOUČINY = 1



$Y = \overline{X_1}\,\overline{X_2} + X_1 X_2$

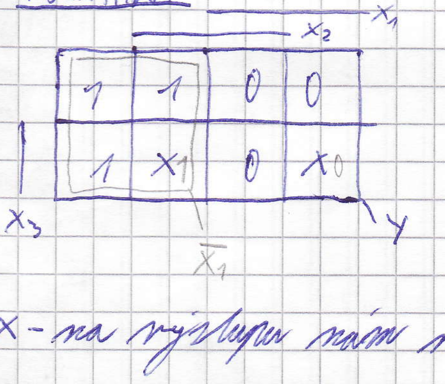


a	b	c	y
0	0	0	1
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	1



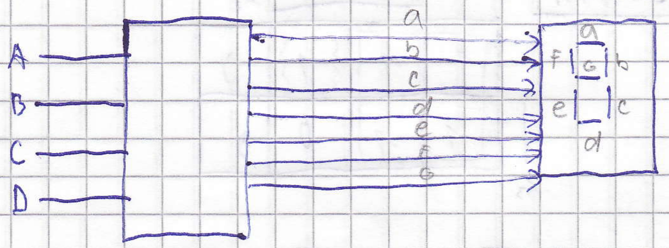
$Y = \bar{a} \cdot \bar{c} + b \cdot c$

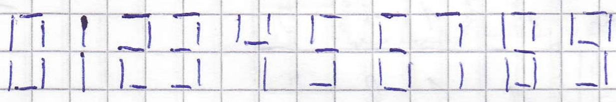
POZNÁMKA



X – na výstupu nám nezáleží

Př: PŘEVOD BCD → 7 SEGMENTŮ

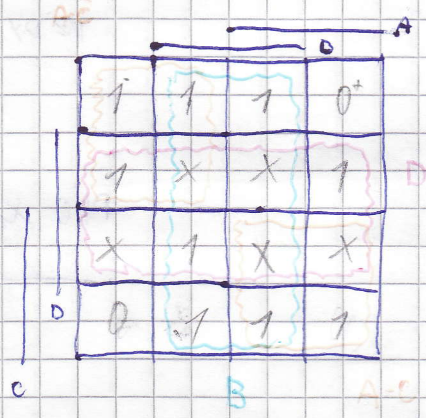




D	C	B	A		
0	0	0	0	....	0
0	0	0	1	....	1
0	0	1	0	....	2
			⋮		⋮
1	0	0	1	....	9
1	0	1	0	....	X
					⋮
1	1	1	1	....	X

a	
1	0
0	1
1	2
1	3
0	4
1	5
1	6
1	7
1	8
1	9
X	
⋮	
X	

DCBA	
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1001	9



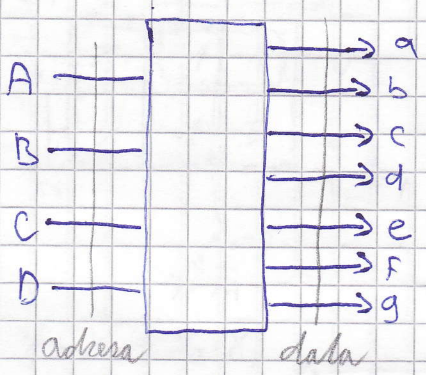
$a = \bar{A}\cdot\bar{C} + B + D + AC$

MINOUT 0

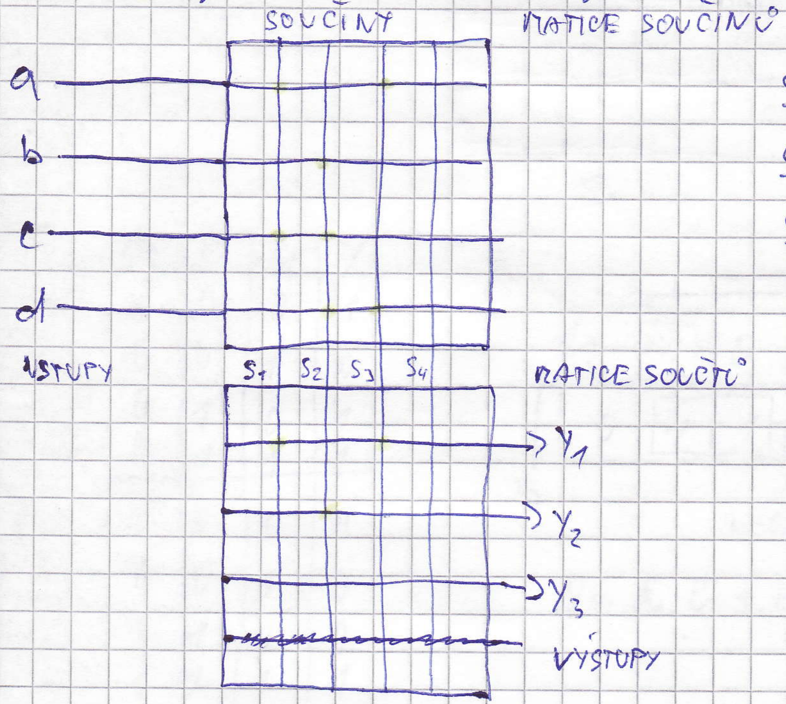
DVOJCE → VYPADNE 1

ČTYŘICE → 2

OSMICE → 3



Programovatelná logika:



$S_1 = a \cdot c$

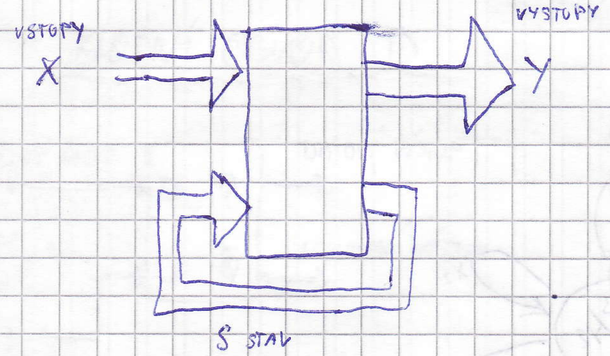
$S_2 = b \cdot c \cdot d$

$S_3 = a \cdot d$

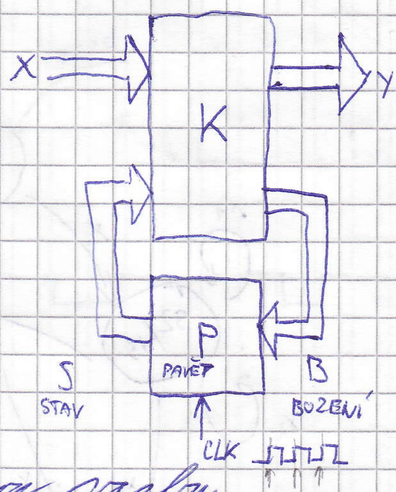
$Y_1 = S_1 + S_3 = a \cdot c + a \cdot d$

$Y_2 = S_2 = b \cdot c \cdot d$

NAVRHOVÁNÍ SEKVENČNÍCH OBVODŮ



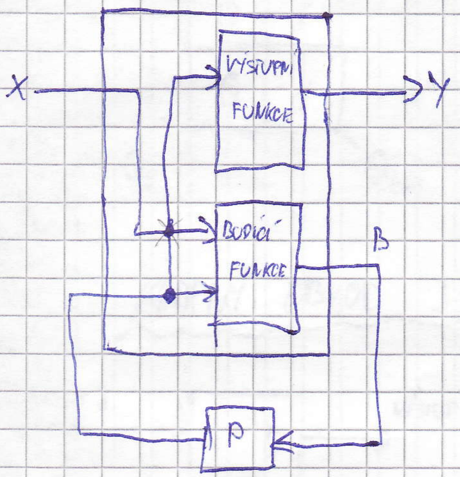
SEKVENČNÍ SYNCHRONNÍ OBVOD



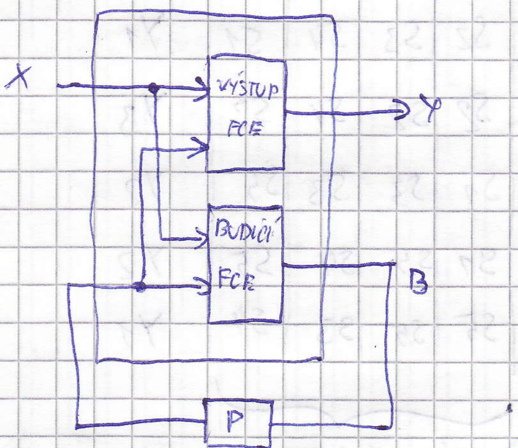
- sekvenční obvod, protože má zpětnou vazbu

SEKVENČNÍ OBVODY: Mealyho ... výstup závisí na stavu
Moorův ... výstup závisí na stavu a vstupu

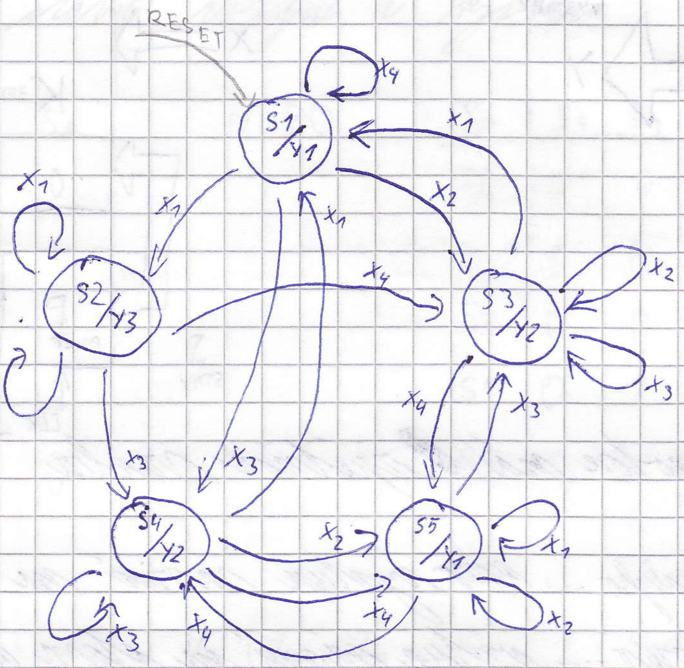
MEALYHO KOMBINAČNÍ ČÁST



MOORŮV



Popis sekvenčního obvodu stavovým diagramem



STAV	X1	X2	X3	X4	Y
S1	S2	S3	S4	S1	Y1
S2	S2	S2	S4	S3	Y3
S3	S1	S3	S3	S5	Y2
S4	S1	S5	S4	S5	Y2
S5	S5	S5	S3	S4	Y1

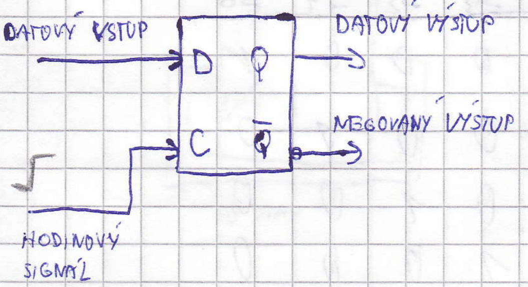
VSTUPY: X1–X4; VÝSTUP: Y

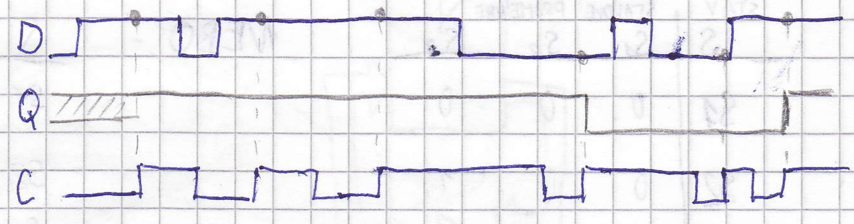
SOUČASNÝ STAV S_t

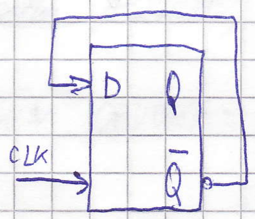
NÁSLEDUJÍCÍ STAV S_{t+1}

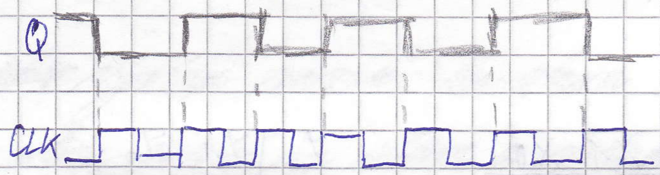
Paměťové obvody

KLOPNÝ OBVOD D









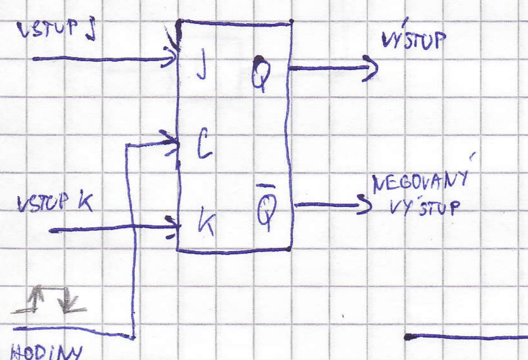
Formální model klop. obv. D

D VSTUP

0	1
0	1

Q_t Q_{t+1}

KLOPNÝ OBVOD J-K



Při hraně ⎍ na C se zapamatují hodnoty J a K. Při hraně ⎍ se změní výstup podle J a K.

J, K

0	0	1	1
1	0	0	1

Q_t Q_{t+1}

Postup při návrhu sekvenčního obvodu

1. Zakódování stavů, vstupů a výstupů

STAV S	STAVOVÉ PROMĚNNÉ S_1	S_2	S_3
S1	0	0	0
S2	0	0	1
S3	0	1	0
S4	0	1	1
S5	1	0	0

NEBO

S	S_4	S_3	S_2	S_1	S_0
S1	0	0	0	0	1
S2	0	0	0	1	0
S3	0	0	1	0	0
S4	0	1	0	0	0
S5	1	0	0	0	0

X	X_1	X_0
x_1	0	0
x_2	0	1
x_3	1	0
x_4	1	1

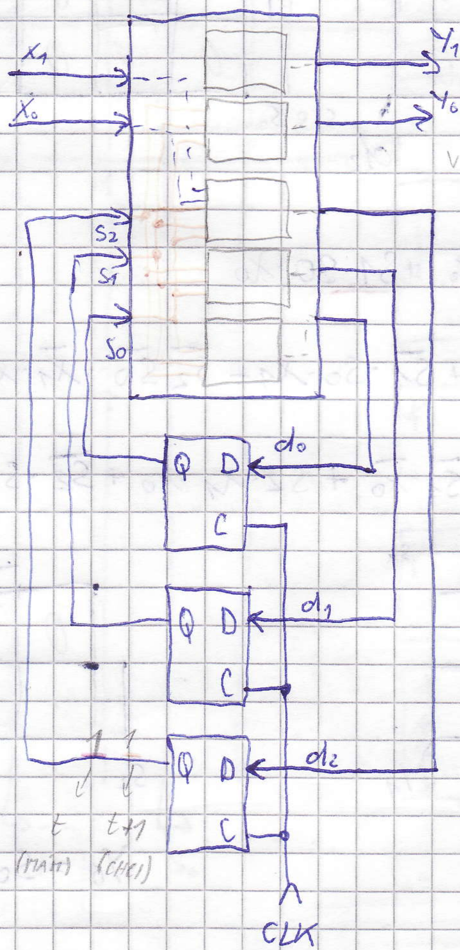
Y	Y_1	Y_0
Y_1	0	0
Y_2	1	0
Y_3	1	1

S	X_1	X_2	X_3	X_4	Y
S1	S2	S3	S4	S1	Y1
S2	S2	S2	S4	S3	Y3
S3	S1	S3	S3	S5	Y2
S4	S1	S5	S4	S5	Y2
S5	S5	S5	S3	S4	Y1

	$S_1 S_1 S_0$	X_1 ($x_1 x_0$ = 0 0)	X_2 ($x_1 x_0$ = 0 1)	X_3 ($x_1 x_0$ = 1 0)	X_4 ($x_1 x_0$ = 1 1)	Y_1 Y_0
S_1	000	001	010	011	000	00
S_2	001	001	001	011	010	11
S_3	010	000	010	010	100	10
S_4	011	000	100	011	100	10
S_5	100	100	100	010	011	00

S_{2t} S_t S_{2t+1} S_{t+1} — S_2 S_1 S_0

S	S_2	S_1	S_0
S1	0	0	0
S2	0	0	1
S3	0	1	0
S4	0	1	1
S5	1	0	0



VSTUP VEDE TAKY DO VSECH DOLE

BUDÍCÍ FCE d_2

$S_2 S_1 S_0$	$x_1 x_0$ 0 0	$x_1 x_0$ 0 1	$x_1 x_0$ 1 0	$x_1 x_0$ 1 1
000	0	0	0	0
001	0	0	0	0
010	0	0	0	1
011	0	1	0	1
100	1	1	0	0

Q_t \ D	0	1
0	0	1
1	0	1

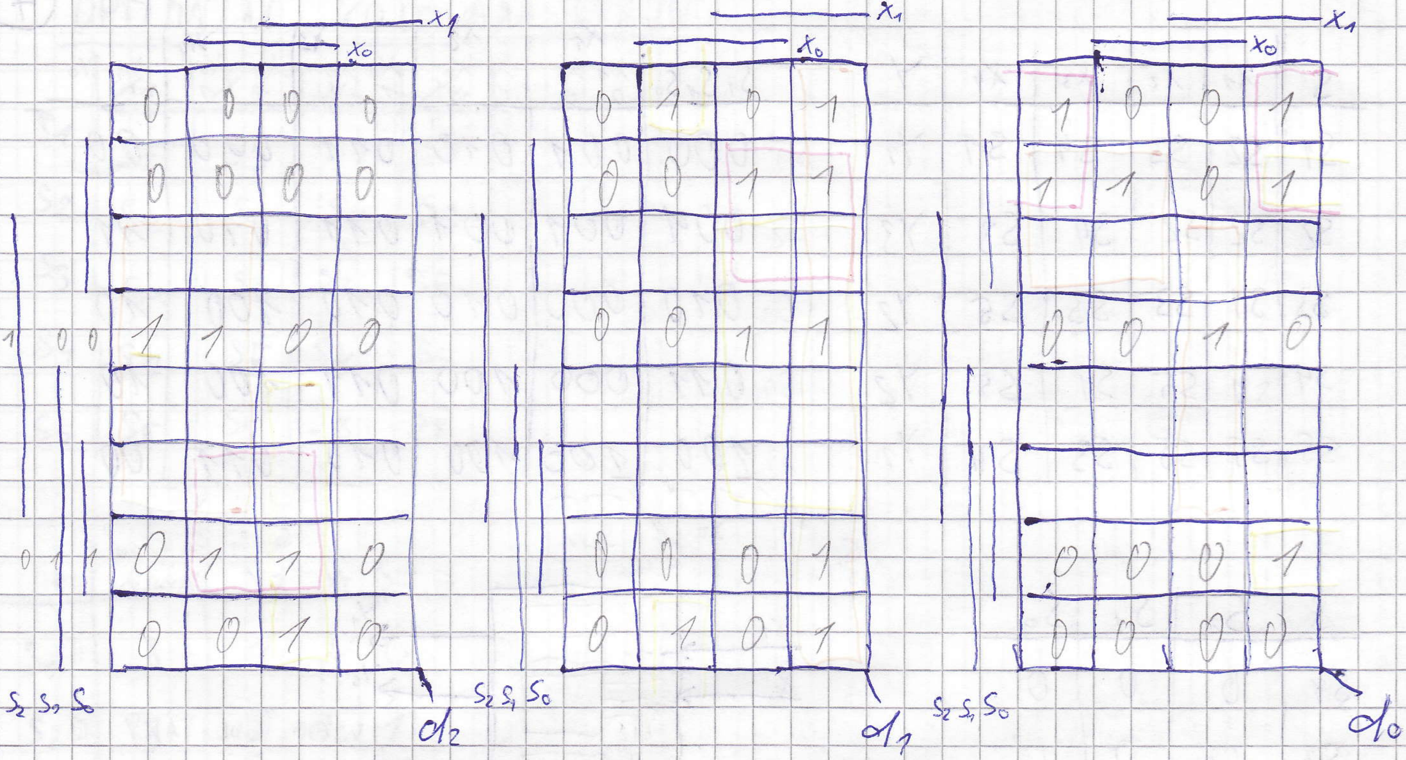
Q_{t+1}

BUDÍCÍ FCE d_1

$S_2 S_1 S_0$	$x_1 x_0$ 0 0	$x_1 x_0$ 0 1	$x_1 x_0$ 1 0	$x_1 x_0$ 1 1
000	0	1	1	0
001	0	0	1	1
010	0	1	1	0
011	0	0	1	0
100	0	0	1	1

BUDÍCÍ FCE d_0

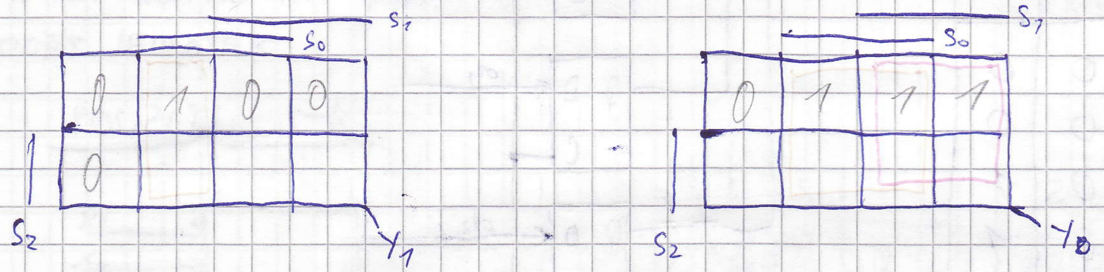
$S_2 S_1 S_0$	$x_1 x_0$ 0 0	$x_1 x_0$ 0 1	$x_1 x_0$ 1 0	$x_1 x_0$ 1 1
000	1	0	1	0
001	1	1	1	0
010	0	0	0	0
011	0	0	1	0
100	0	0	0	1



$d_2 = S_2 \cdot \overline{x_1} + S_1 \cdot x_1 \cdot x_0 + S_1 \cdot S_0 \cdot x_0$

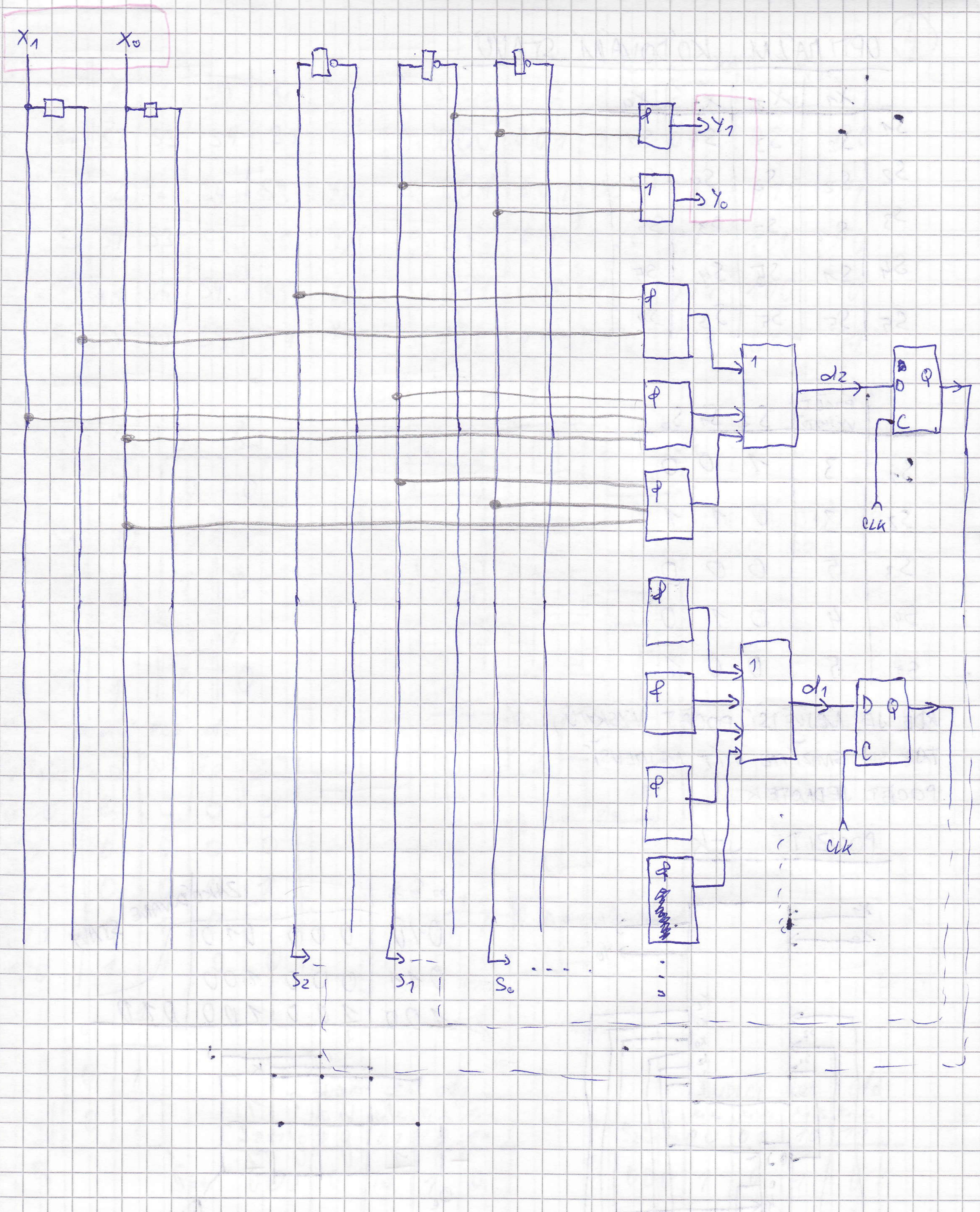
$d_1 = S_2 \cdot x_1 + x_1 \cdot \overline{x_0} + \overline{S_1} \cdot S_0 \cdot x_1 + \overline{S_2} \cdot \overline{S_0} \cdot \overline{x_1} \cdot x_0$

$d_0 = \overline{S_1} \cdot S_0 \cdot \overline{x_1} + \overline{S_2} \cdot \overline{S_1} \cdot \overline{x_0} + S_2 \cdot x_1 \cdot x_0 + \overline{S_2} \cdot S_0 \cdot x_1 \cdot \overline{x_0}$



$Y_1 = \overline{S_1} \cdot S_0$

$Y_0 = S_0 + S_1$



X1
X0
Y1
Y0
d2
D
Q
C
CLK
d1
D
Q
C
CLK
S2
S1
S0

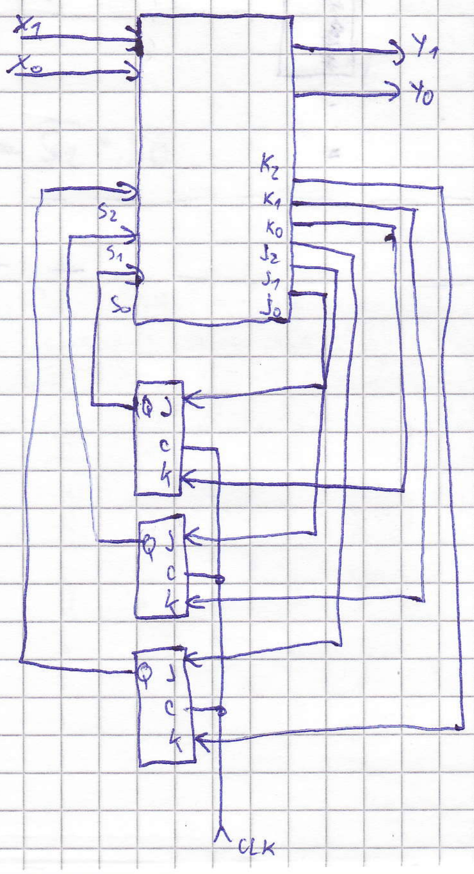
OPTIMÁLNÍ KÓDOVÁNÍ STAVŮ

	x_1	x_2	x_3	x_4
S_1	S_2	S_3	S_4	S_1
S_2	S_2	S_2	S_4	S_3
S_3	S_1	S_3	S_3	S_5
S_4	S_1	S_5	S_4	S_5
S_5	S_5	S_5	S_3	S_4

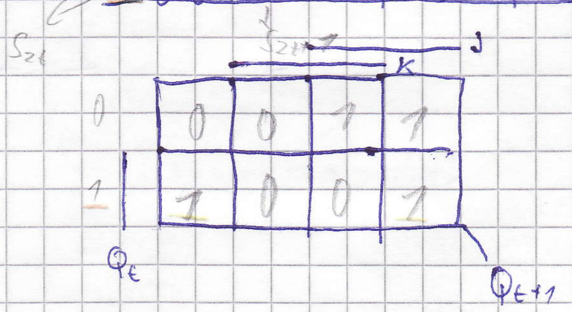
	POČET VÝSKYTŮ	S_2	S_1	S_0
S_1	3	1	0	0
S_2	3	0	1	1
S_3	5	0	0	0
S_4	4	0	1	0
S_5	5	0	0	1

KDE JE NEJVĚTŠÍ POČET VÝSKYTŮ, TAK SE SNAŽÍME MÍT NEJMENŠÍ POČET JEDNOTEK

POUŽITÍ J-K



$S_2 S_1 S_0$			ZAKÓDOVANÉ STAVY
010	000	010	
011	000	100	
100	100	100	010



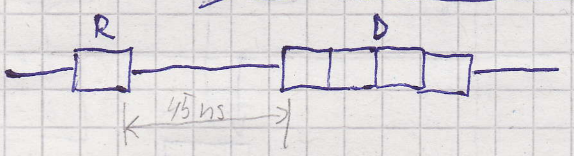
MIPS (PCSpin)

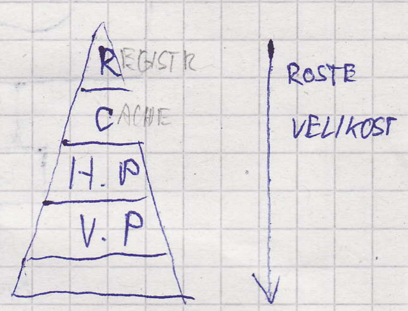
ADD $1, $2, $3 # $1 ← $2 + $3

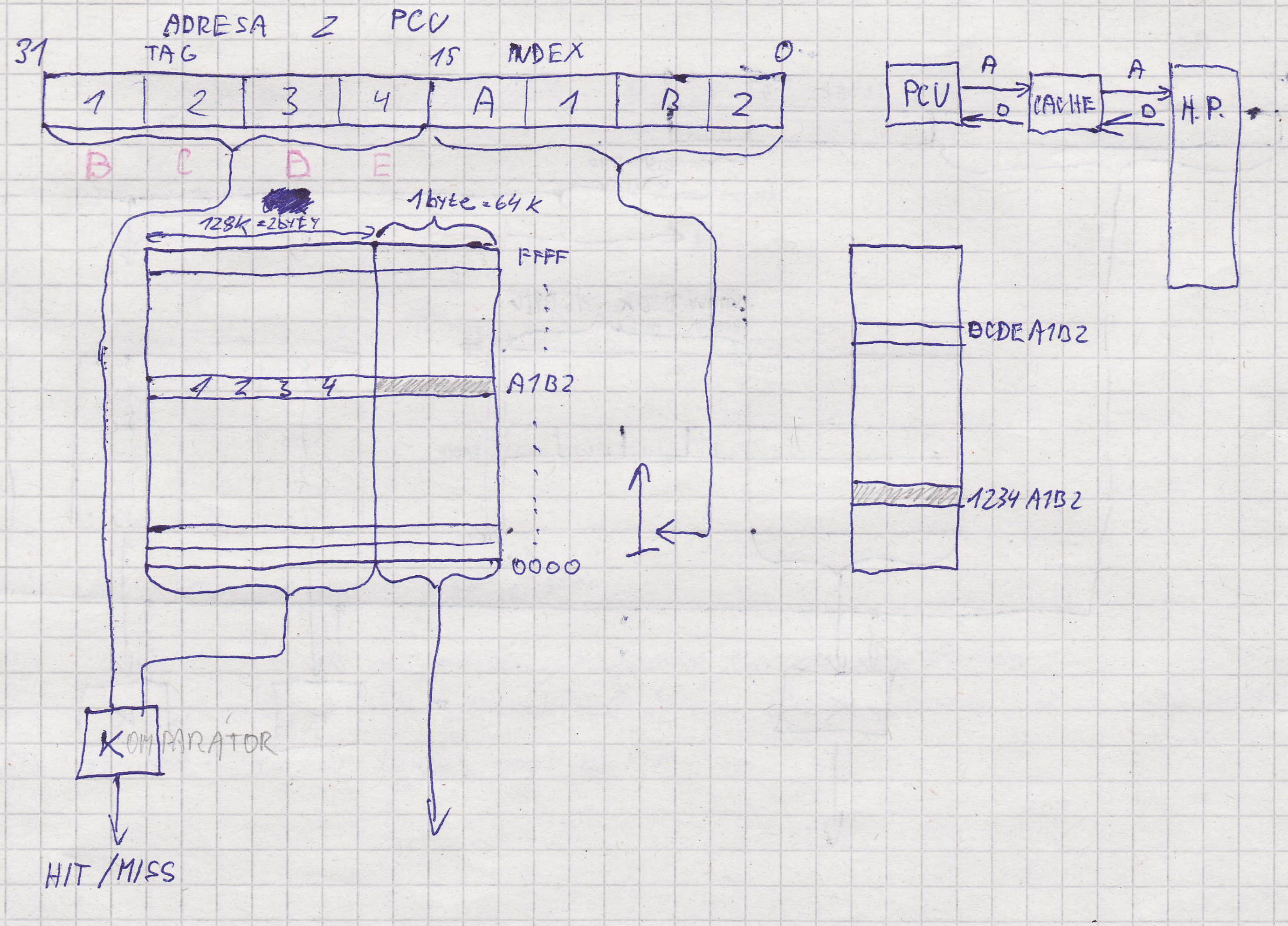
MOVE $2, $1 # $2 ← $1

LW $10, VAR_1 # uložení ze symbolické adresy do proměnné

Paměti CACHE

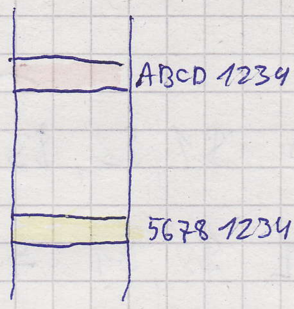


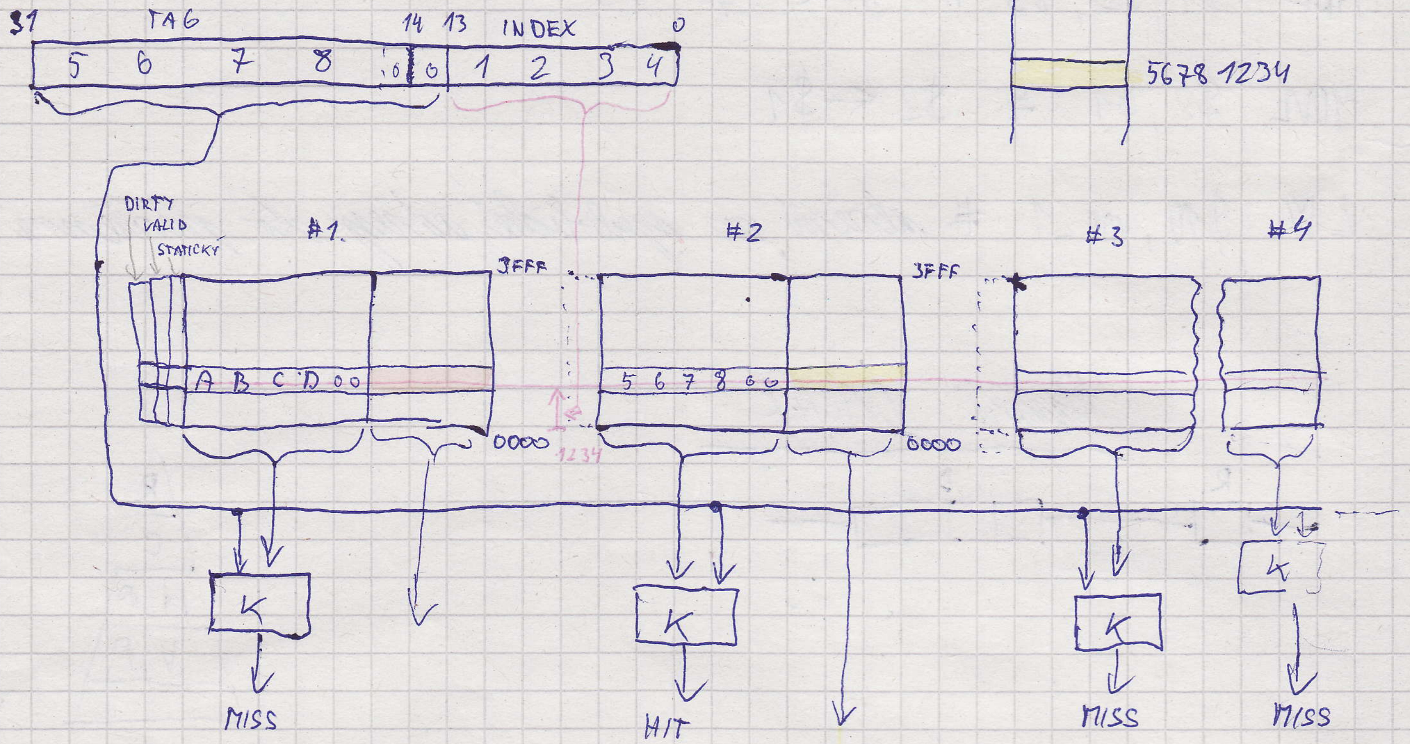


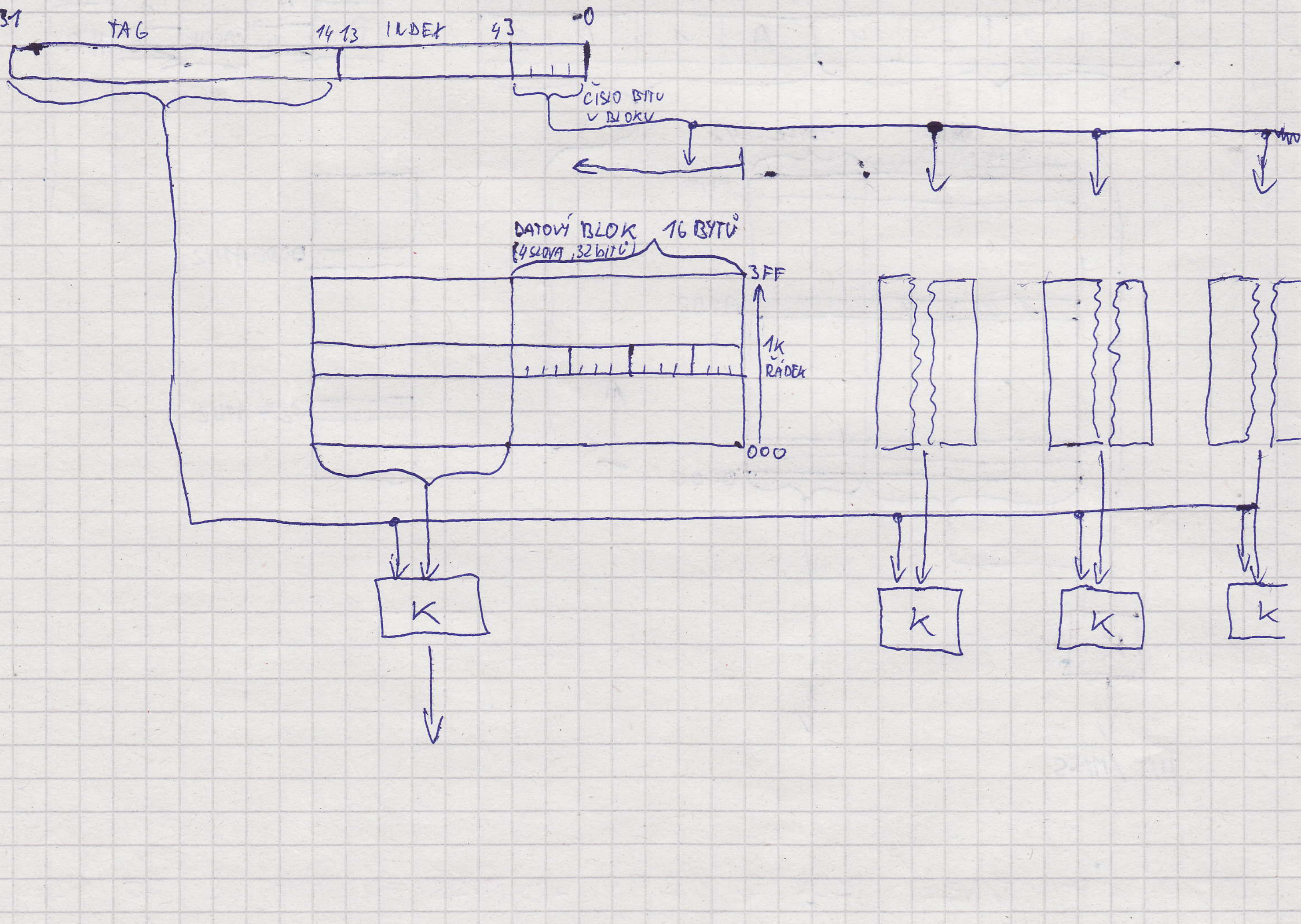


DOCHÁZÍ K POROVNÁNÍ BCDE S 1234 => MISS => SÁHÁ SE DO HLAV. P.

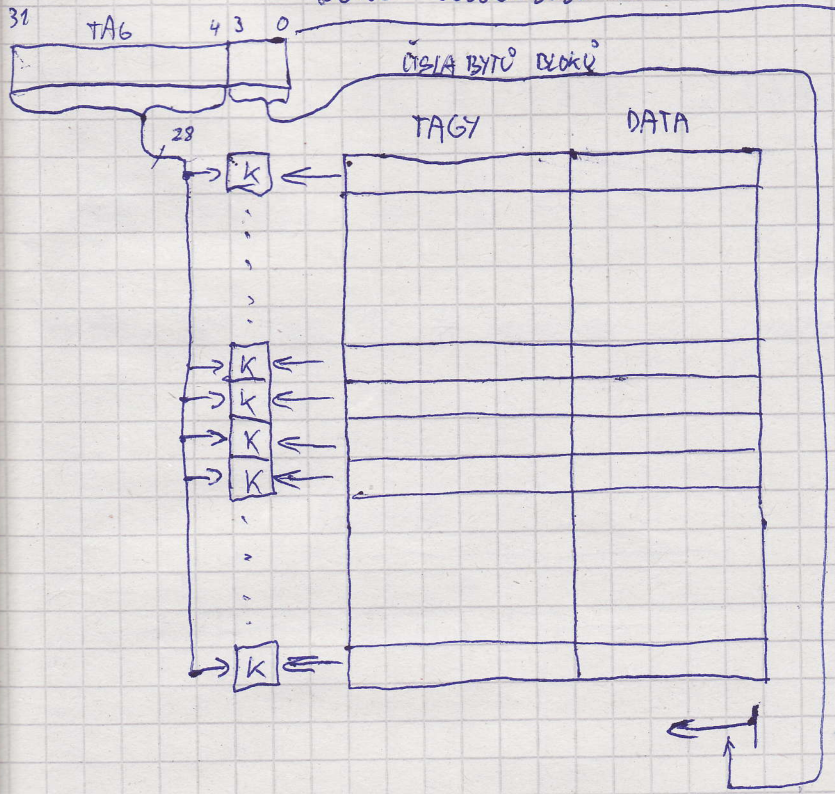
4 cestná CACHE



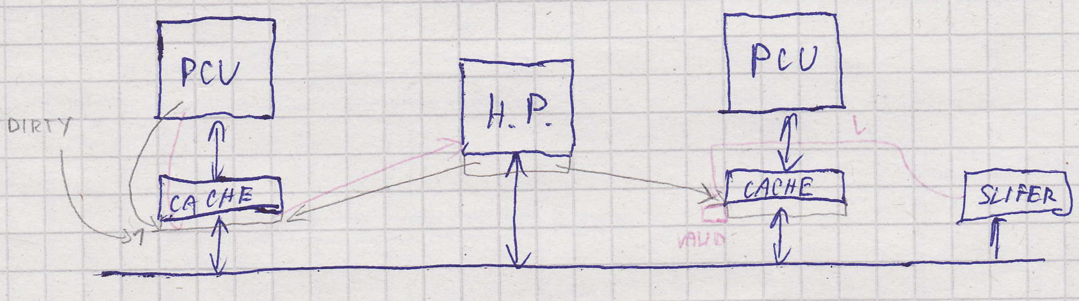




Plně asociativní CACHE



Poznámka k platnosti dat v CACHE



- WRITE BACK - zápis pouze do CACHE
  - do H.P. až v případě přepisu jinou položkou
  - zápis do H.P. pomocí bufferu (CACHE → BUFFER, HP → CACHE, BUFFER → HP)
- WRITE THROUGH - zápis vždy též do H.P.