1. MASOVNE !

B = 10

B-1

999
254
[745] B-1
+ 1
[746] B

B-1

254
+ 746
1000

011
100
+ 1
101

100
+101
001
broj + bkomp

44444
-43241
01203
1204

Oktalni i heksadekadski sistem

$10\,010_{(2)} = 52_{(8)}$

$\Rightarrow 7_{(8)} = 111\ 111$

$1110/1111_{(2)} = EF_{(16)}$

BCD
0000-0
0001-1
0010-2
0011-3
0100-4
0101-5
0110-6
0111-7
1000-8
1001-9
1010
1011

XS-3
0000
0001
0010
0011-0
0100-1
0101-2
0110-3
0111-4
1000-5
1001-6
1010-7
1011-8
1100-9
1101
1110
1111

Aikenov kod (2421)
0000-0
0001-1
0010-2
0011-3
0100-4
0101
0110
0111
1000
1001
1010
1011-5
1100-6
1101-7
1110-8
1111-9

kod
7214 - 10 1110 → kodirano u 7214
1000
→
3519 1011
→
13
14

Zbrajanje i oduzimanje kodovima

BCD

0110|0001 (BCD)
+0001|0001 (BCD)

6 9 (10)
1 1 (10)
8 0 (10)

1000 0000 (BCD)

XS-3

0111|1010 (XS3)
+1001|0110

4 7
6 3
11 0

0100|0100|0011

AIKEN

0100|1100|0010 (Aik)
+0001|0000

4 6 2
10

472(10
0100 1101 0010

1011 0001 0110 0100 (BIN)

5 7 1 9 (10) (BCD)

5 1 8 4 (10)

0 5 3 5 → 0000 0101 0011 0101 (BCD)

Grayov kod

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

00
01
10
11

d3 d2 d1 d0
0110

HAMMING

PODATKOVNI ZAŠT

4 3

1 1 0 0 1 1 0
1 2 3 4 5 6 7
0 0 0 0 0 0 0
0 0 0 1 1 1 1
0 1 1 0 0 1 1
1 0 1 0 1 0 1
= = = = = = =

parni pariteta
XOR bitova
mora biti 0.

$R = \frac{r}{m}$

m = ukupno bi
r = zaštitna
K = Kodna riječ
m = r + K.

1110 POSLANO

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

0011 → 3
0100 → 3
1110 → 2

min. distanca

GREŠKE KOJE MOŽEMO DETEKTIRATI

$d-1$, distanca koda

Greške koje možemo ispraviti

$$\left\lfloor \frac{d-1}{2} \right\rfloor$$

PRIMLJENO

1 1 1 0 1 1 1
← ←
0 0 1 0 1 1 1
0 0 0 1 1 1
0 1 1 0 0 1 1
1 0 1 0 1 0 1

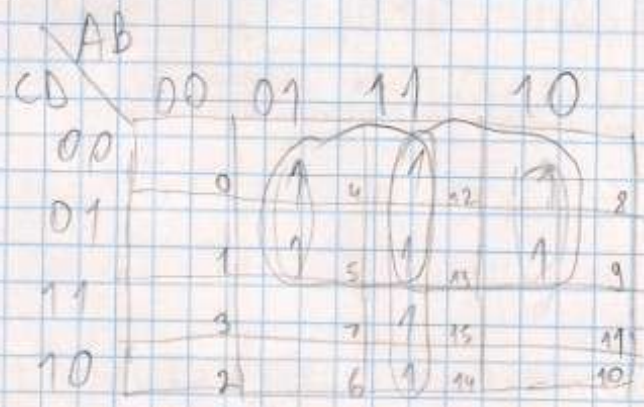
000
011
011 – 3. mjesto – simbolom

$f(A,B,C,D) = ABC + ABC\bar{D} + A\bar{C} + B\bar{C}$

A B C D	f
0 0 0 0	0
0 0 0 1	0
0 0 1 0	0
0 0 1 1	0
0 1 0 0	1
0 1 0 1	1
0 1 1 0	0
0 1 1 1	0
1 0 0 0	1
1 0 0 1	1
1 0 1 0	0
1 0 1 1	0
1 1 0 0	1
1 1 0 1	1
1 1 1 0	1
1 1 1 1	1

$\sum m(4,8,9,12,13,14,15) =$

0100
$\bar{A} \cdot B \cdot \bar{C} \cdot \bar{D}$



- UZIMATI ŠTO VEĆE KOMADE

$f(A,B,C,D) = AB + A\bar{C} + B\bar{C}$

$f(A,B,C,D) = A\bar{B}\bar{C} + AB + \bar{A}B$

A	B	C	C_{im}	f
0	0	0	0	0
0	0	0	1	1
0	0	1	0	1
0	0	1	1	0
0	1	0	0	1
0	1	0	1	0
0	1	1	0	0
0	1	1	1	1
1	0	0	0	1
1	0	0	1	0
1	0	1	0	0
1	0	1	1	1
1	1	0	0	0
1	1	0	1	1
1	1	1	0	1
1	1	1	1	0

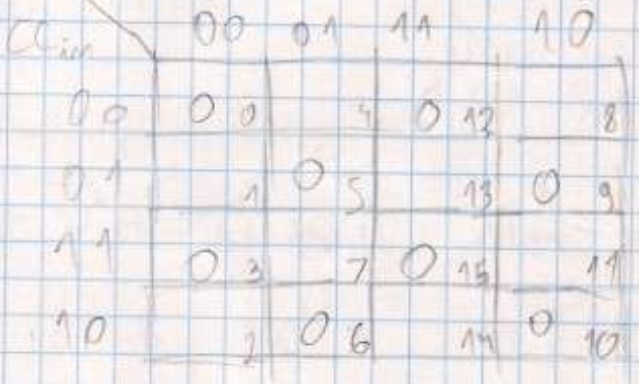
$\Sigma_m(1,2,4,7,8,11,13,14)$

$\Pi M(0,3,5,6,9,10,12,15)$

$(A+B+C+C_{im})$

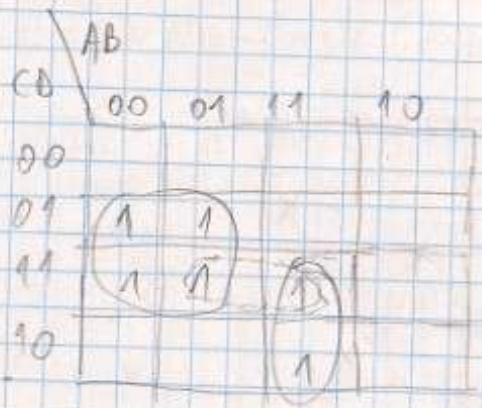
$\bar{A}\bar{B}\bar{C}\bar{C}_{im}$

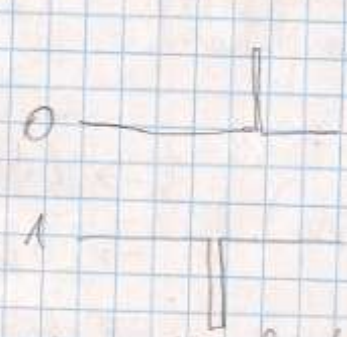
EPIC WIN!



$(A+B+C+C_{im})(A+B+\bar{C}+\bar{C}_{im})$

$(A+\bar{B}+C+\bar{C}_{im})(A+\bar{B}+\bar{C}+C_{im})$



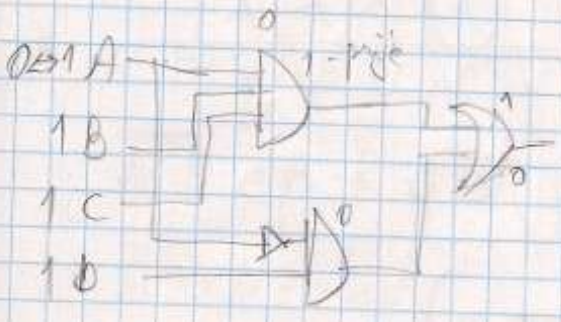


Logički 0-hazard

Logički 1-hazard

Hazard možeš lako ne susrećeš zaključenja - možemo hazard dodavanjem zaključenja.

Pri promjeni A događa se hazard zbog kašnjenja invertora



Quine - McCluskey

$f(A,B,C,D) = \sum m(1,3,5,6,9,11,12,13,14,15)$

0001 (1)
0011 (3)
0101 (5)
0110 (6)
1001 (9)
1011 (11)
1100 (12)
1101 (13)
1110 (14)
1111 (15)

0001 (1) ✓
0011 (3) ✓
0101 (5) ✓
0110 (6) ✓
1001 (9) ✓
1011 (11) ✓
1100 (12) ✓
1101 (13) ✓
1110 (14) ✓
1111 (15) ✓

00X1 (1,3) ✓
0X01 (1,5) ✓
X001 (1,9) ✓
X011 (3,11) ✓
X101 (5,13) ✓
X110 (6,14)
10X1 (9,11) ✓
1X01 (9,13) ✓
11X0 (12,13) ✓
11X0 (12,14) ✓
1X11 (11,15) ✓
11X1 (13,15) ✓
111X (14,15) ✓

X0X1 (1,3,9,11)
XX01 (1,5,9,13)
X0X1 (1,9,3,11)
XX01 (1,9,5,13)
1XX1 (9,11,13,15)
1XX1 (9,13,11,15)
11XX (12,13,14,15)
11XX (12,14,13,15)

II

- primarni implikanti:

	1	3	5	6	9	11	12	13	14	15
→ $BC\bar{D}$				⊗						X
→ $\bar{B}D$			X	⊗		X				X
→ $\bar{C}D$		X	X	⊗		X				X
AD				X	X	X				X
→ AB							⊗	X	X	X
			√	√	√	√	√	√	√	√

$f = BC\bar{D} + \bar{B}D + \bar{C}D + AB$

$f(A,B,C,D) = \sum m(1,4,5,8,11) + \sum d(7,10,12)$

D - kontrola

	D
0001 (1)	0
0100 (4)	0
1000 (8)	0
0101 (5)	0
1010 (10)	1
1100 (12)	1
1011 (11)	0
0111 (7)	1

	D
0X01 (1,5)	0
010X (4,5)	0
X100 (4,12)	0
10X0 (8,10)	0
1X00 (8,12)	0
01X1 (5,7)	0
101X (10,11)	0

II.

	1	4	5	8	11	
$\bar{A}\bar{C}D$	⊗		X			P_0
$\bar{A}B\bar{C}$		X	X			P_1
$B\bar{C}\bar{D}$		X				P_2
$AB\bar{D}$				X		P_3
$A\bar{C}\bar{D}$				X		P_4
$A\bar{B}D$			X			P_5
$A\bar{B}C$					⊗	P_6
	√	⊗	√	⊗	√	

Pyne-McCluskey

$P = (P_0 + P_2)(P_3 + P_4)$

$= (P_0P_3) + (P_0P_4) + (P_2P_3) + (P_2$

ili ili ili

$f_1 = \bar{A}\bar{C}D + A\bar{B}C + \bar{A}\bar{B}C$

$f_2 = \text{—}''\text{—} + A\bar{C}\bar{D}$

$f_3 = \text{—}''\text{—} +$

$f_4 = \text{—}''\text{—} +$

$\overline{A+B} = NOR(NOR(A,B))$ $\quad \overline{A \cdot B} = NOR(A,B)$

$\overline{A+A} = \overline{A}$ $\quad NOR(A).$

$x = B \cdot \overline{C}$

$B \cdot \overline{C} + A = NOR(NOR(x, A)) \quad = NOR(NOR(B, C))$

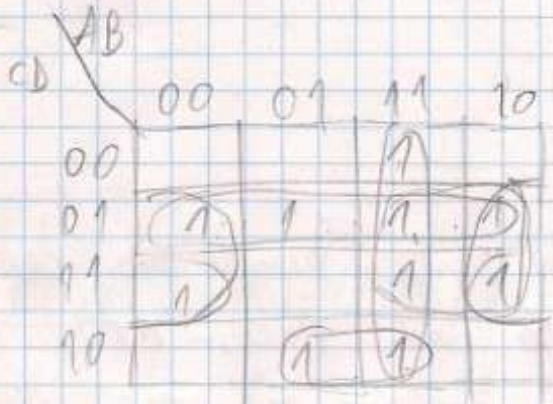
$x \quad = NOR(NOR(NOR(NOR(B), C), A))$

$\overline{A \cdot B} = \overline{A} + \overline{B}$ $\quad NAND(A,B)$

$\overline{A \cdot B} = A \cdot B$ $\quad NAND(NAND(A,B))$

$\overline{A} = NAND(A)$

$f(A,B,C,D) = \Sigma(1,3,5,6,9,11,12,13,14,15)$



$A\bar{B} + \bar{C}D + \bar{B}D + BC\bar{D}$

Bitmi primari

A, D – primarni

PMOS
NMOS
PUN
PDN

A
B
C
f

PUN - pull up
PDN - pull down
mreža

1. serijski spoj · (i)
- paralelni spoj + (ili)

2. PUN - čitamo komplemente varijabli
PDN - čitamo komplement funkcije

$$(\bar{A} + B \cdot \bar{C})(\bar{D} + \bar{E}) = f'$$

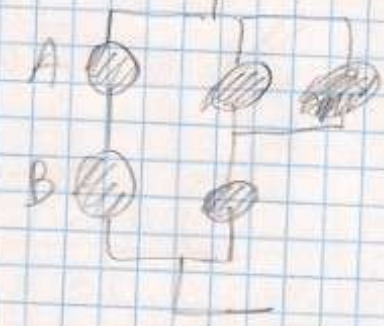
preko PUN i PDN dobijemo isto

$$\overline{A \cdot (B + C) + DE} = f'$$

$$f = A$$

$$f = \bar{A} \cdot \bar{B} + (\bar{C} + \bar{D}) \cdot \bar{E}$$

- ako je bez komplemenata dovodimo jer radimo PMOS - NMOS spoj i crtamo po gore



1. Dinamička disipacija

$$P = f \cdot C \cdot U^2$$

I	II
U_1	$0{,}9U_1$
P_1	$1{,}08P_1$
f_1	f_2

$P_1 = f_1 \cdot C \cdot U_1^2$ $\quad C = \frac{P_1}{f_1 U_1^2}$

$1{,}08P_1 = f_2 \cdot C \cdot 0{,}9U_1$

$\frac{P_1}{f_1 U_1^2} = \frac{1{,}08 P_1}{f_2 \cdot (0{,}9U_1)^2}$

$P_1 f_2 \cdot (0{,}9U_1)^2 = 1{,}08 P_1 \cdot f_1 U_1^2$

$f_2 = \frac{1{,}08}{0{,}9^2} f_1$

$f_2 = 1{,}33 f_1$

$\Delta f = 0{,}33 = 33\%$

FAKTOR GRANANJA

$\frac{\text{Izlaz}}{\text{Ulaz}}$ f. gr. P_1 i $\frac{I_{OH}}{I_{IH}} = \frac{I_{OL}}{I_{IL}} =$ → uzmemo manji

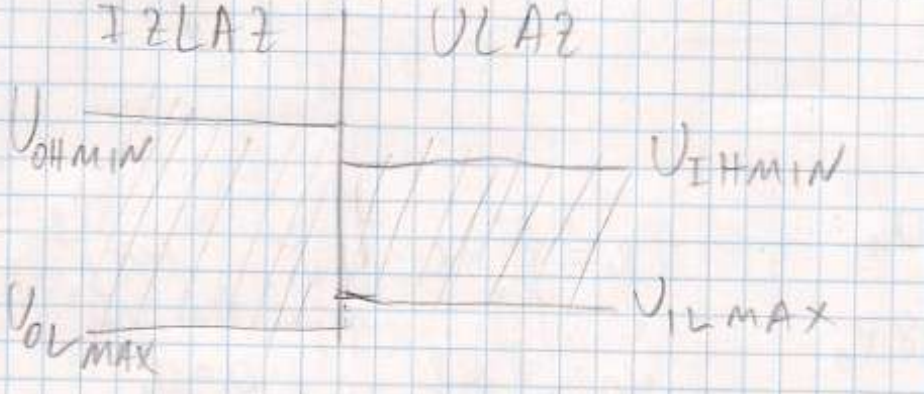
visoka s visokom
niska s niskom

f. gr. P_2

f. gr. izlaz 2 na ulaz 1 P_{2-1}

$\frac{I_{OH}(2)}{I_{IH}(1)}$ $\quad \frac{I_{OL}(2)}{I_{IL}(1)}$

GRANICA | STOSMJERNE SMETNJE



granica smetnje visoka razina $U_{GSV} = U_{OH} - U_{IH}$

niska razina $U_{GSN} = U_{IL} - U_{OL}$

Širina zabranjenog područja na ulazu/izlazu

$U_{IH} - U_{IL}$

na izlazu $U_{OH} - U_{OL}$

Za maksimum U granice smetnji moraju biti jednake