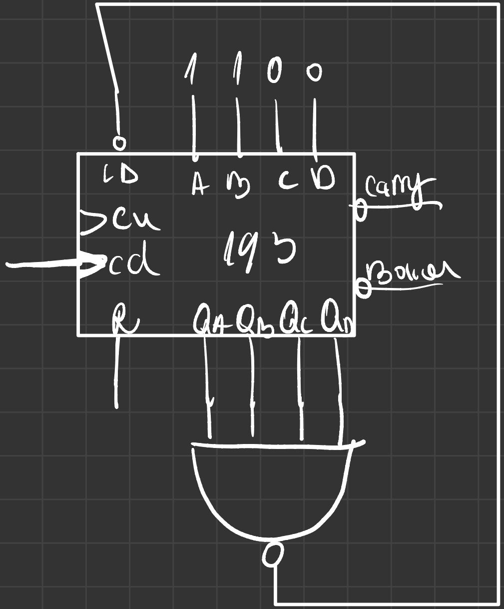
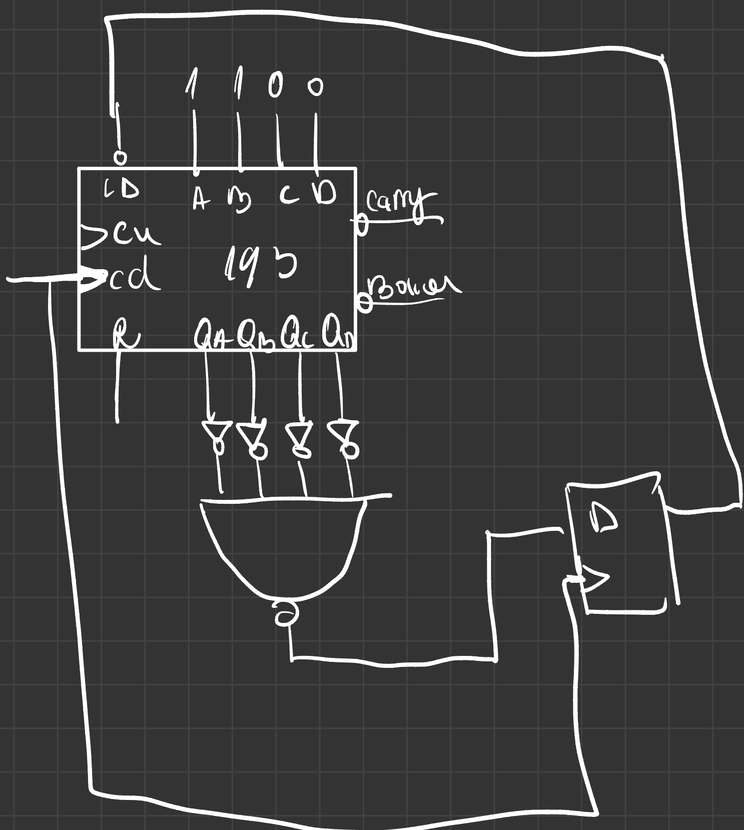
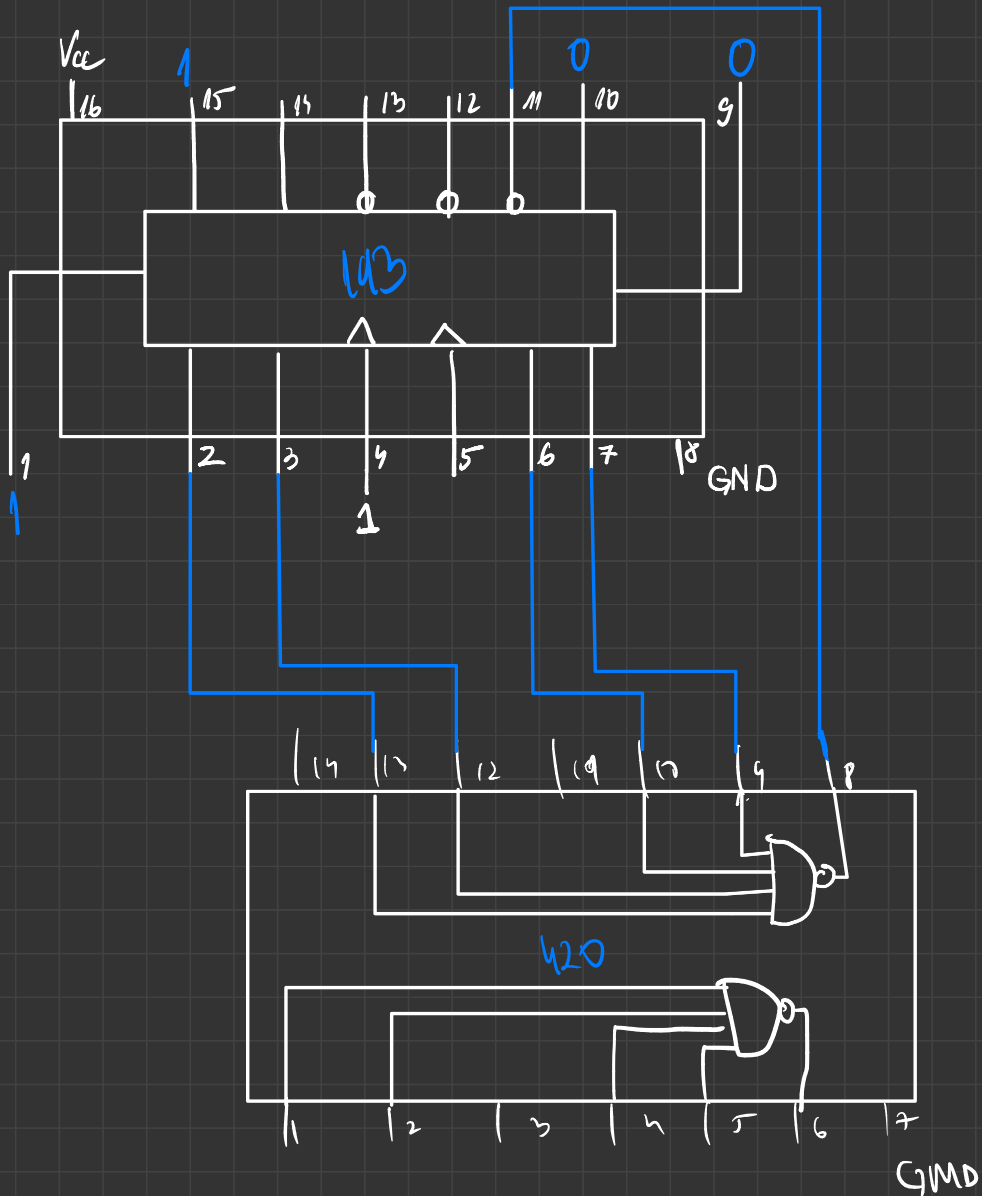
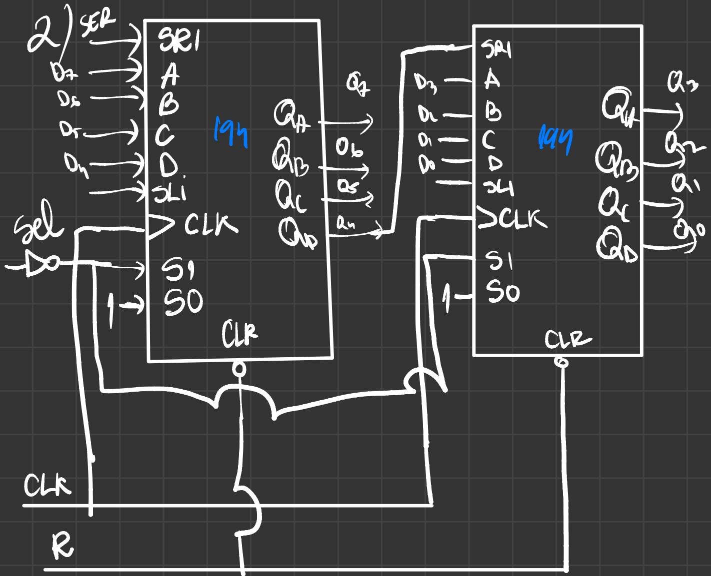

1 1 0 0
LD
A B C D
carry
>cu
>cd
193
Borrow
R
QA QB QC QD


1 1 0 0
LD
A B C D
carry
>cu
>cd
193
Borrow
R
QA QB QC QD
D

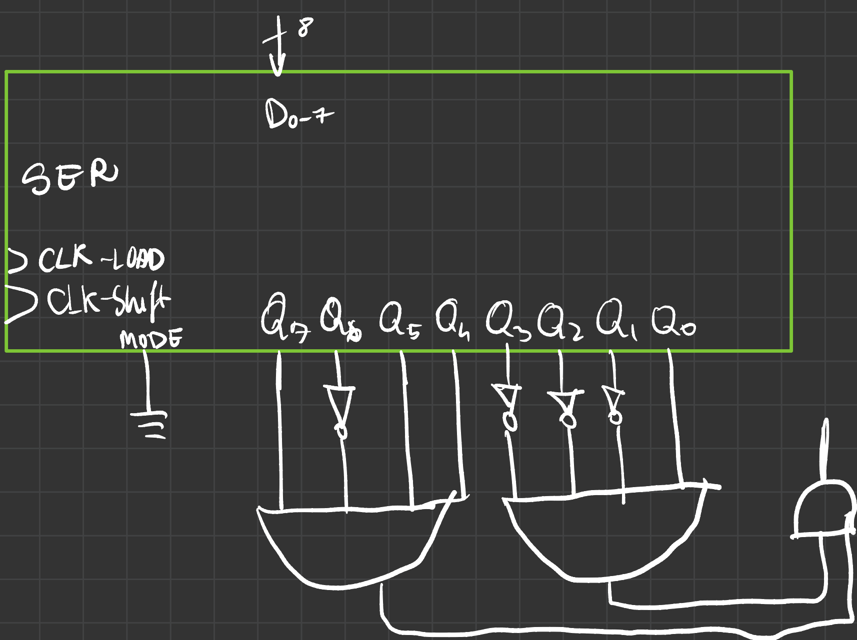

Vcc
16
1
15
14
13
12
11
0
10
0
9
193
1
1
2
3
4
5
6
7
8
GND
1
14
13
12
11
10
9
8
420
1
2
3
4
5
6
7
GND

2)



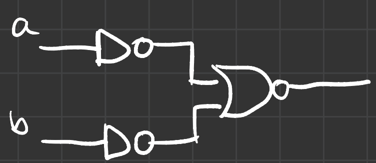
S_1	S_0	sel
0	0	memorize
0	1	right
1	0	left
1	1	Load

Q_7	Q_6	Q_5	Q_4	Q_3	Q_2	Q_1	Q_0
1	0	1	1	0	0	0	1

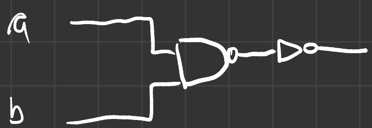


3) AND

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



2 NOT 1 NOR

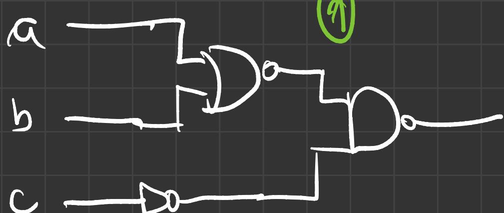


1 NAND 1 NOT

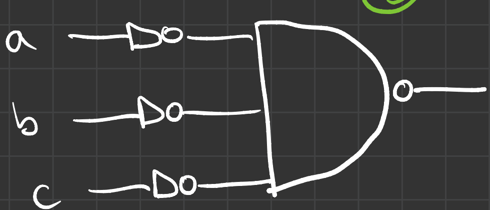
$$f = a + b + c = \overline{\overline{a + b + c}} = \overline{\overline{a + b} \cdot \bar{c}}$$

$$= \overline{\bar{a} \cdot \bar{b} \cdot \bar{c}}$$

$$= \overline{a \cdot \overline{b + c}}$$



NOT + NAND → NOR

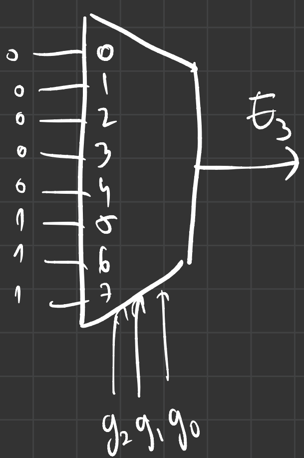


NOT + NAND

Bilet 22

1) 3 bit Gray to Excess-3 code 8:1 Mux

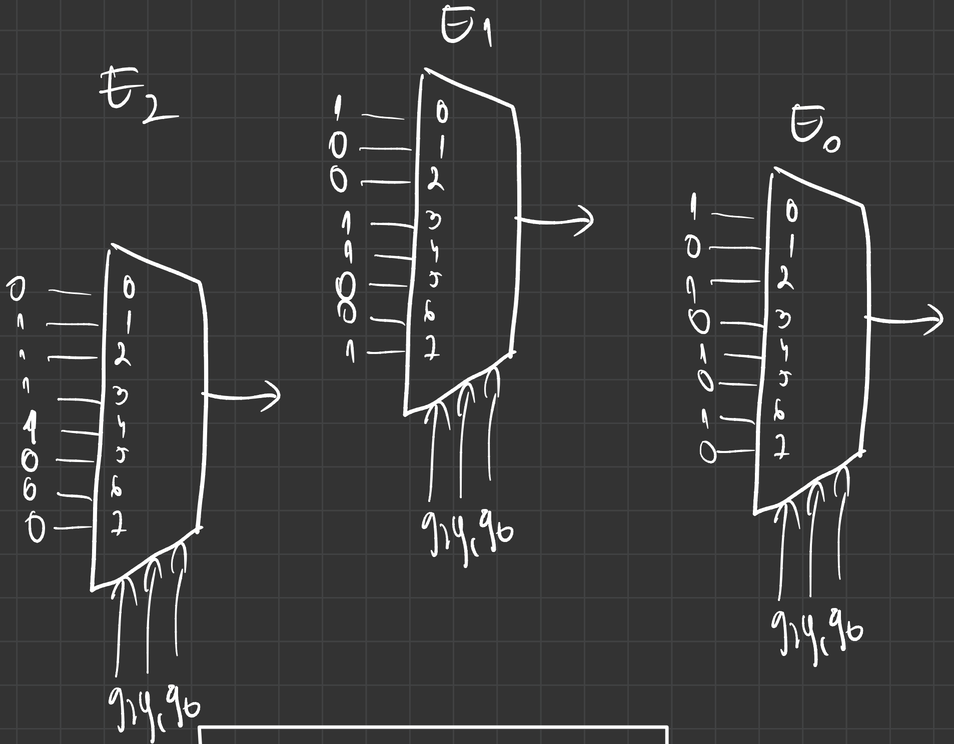
	Gray			Excess 3			
	g_2	g_1	g_0	E_3	E_2	E_1	E_0
0	0	0	0	0	0	1	1
1	0	0	1	0	1	0	0
2	0	1	1	0	1	0	1
3	0	1	0	0	1	1	0
4	1	1	0	0	1	1	1
5	1	1	1	1	0	0	0
6	1	0	1	1	0	0	1
7	1	0	0	1	0	1	0



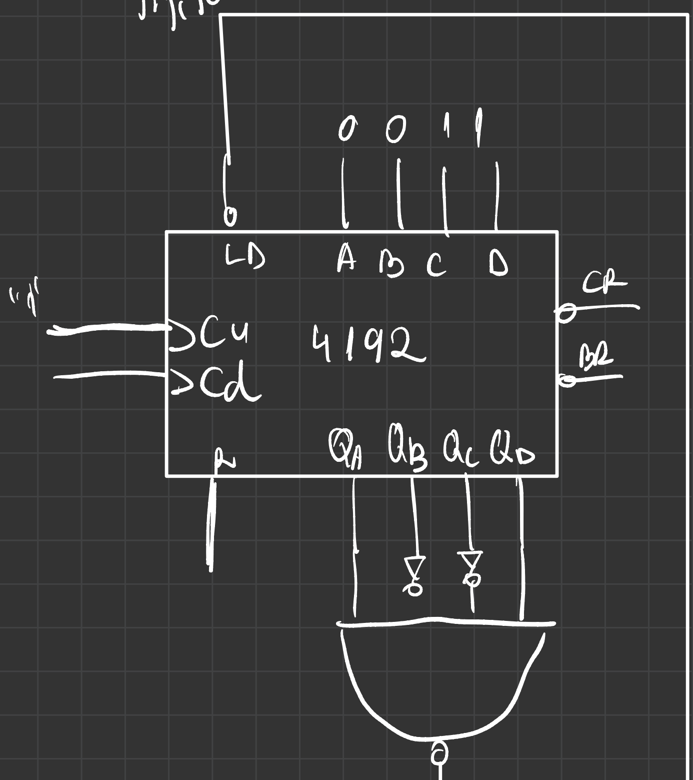
E_3

g_2g_1 \ g_0	0	1
00	0	0
01	0	0
11	1	1
10	0	1

$f: g_2g_1 + g_0g_2$

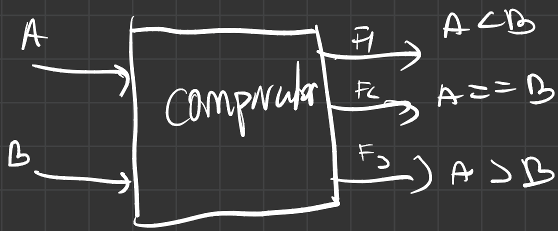

E2
E1
E0
0
1
2
3
4
5
6
7
q2,q1,q0

2.


0 0 1 1
LD
A B C D
CR
BR
"1"
Cu
Cd
4192
R
QA QB QC QD

Numără (0,9)

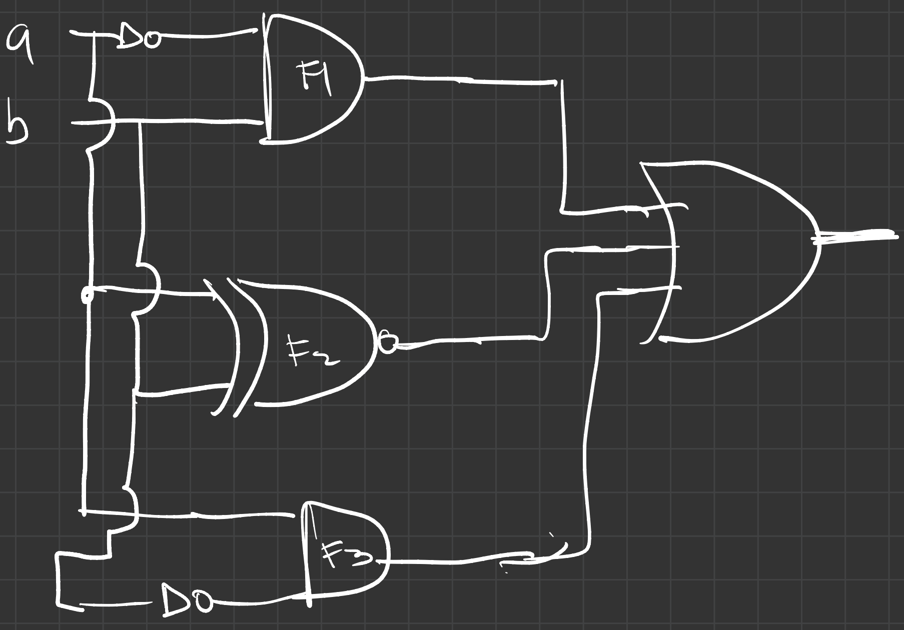
3)

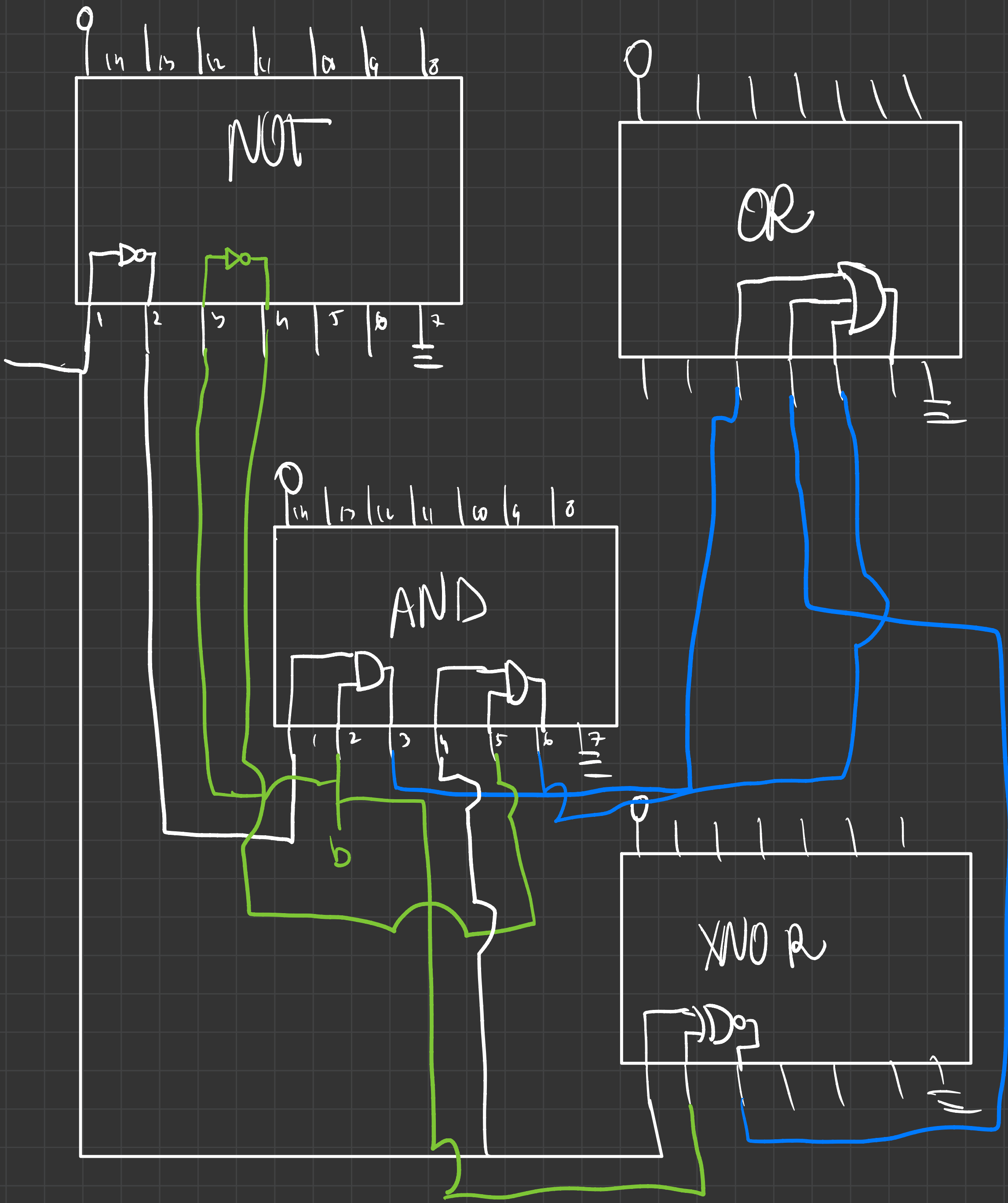


$F_1 = \bar{a} \cdot b$

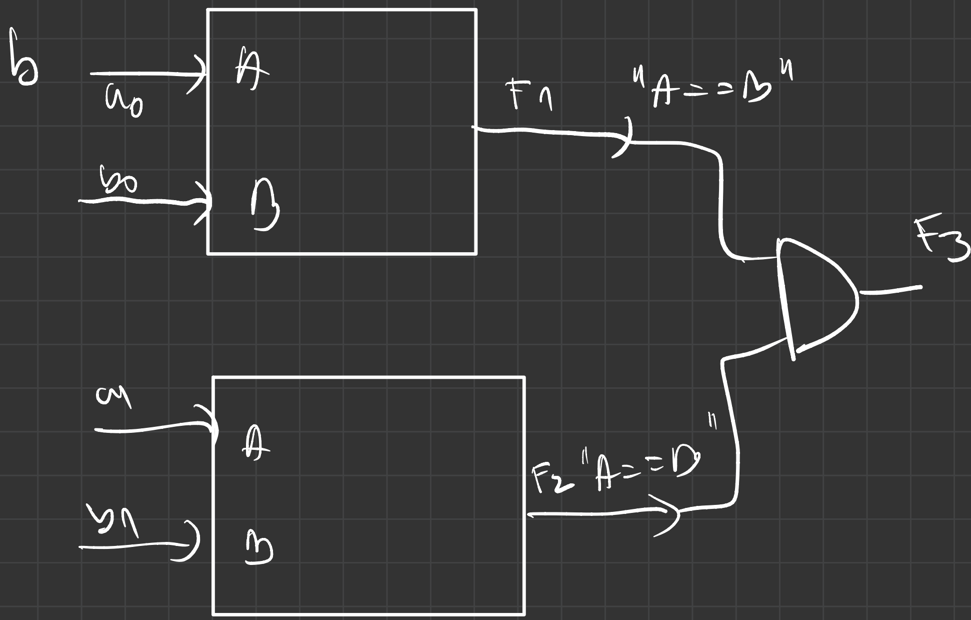
$F_2 = \overline{a \oplus b}$

$F_3 = a \cdot \bar{b}$

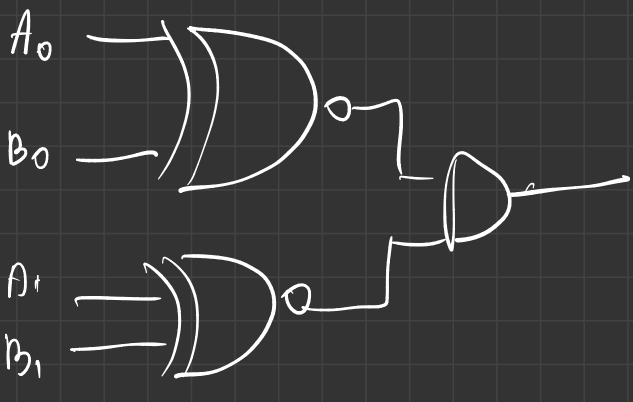




NOT
OR
AND
XNOR



$$(\overline{A_0 \oplus B_0}) \cdot (\overline{A_1 \oplus B_1})$$



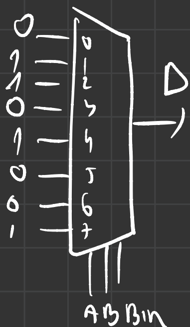
Bilet 18

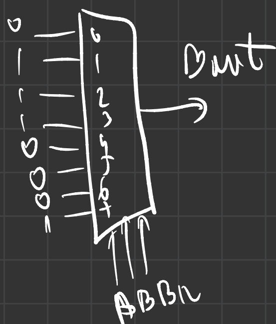
1

A	B	Bin	D	Bout
0	0	0	0	0
0	0	1	1	1
0	1	0	1	1
0	1	1	0	1
1	0	0	1	0
1	0	1	0	0
1	1	0	0	0
1	1	1	1	1

$D = \sum(1, 2, 4, 7)$

BBin \ A	0	1
00	0	1
01	1	0
11	0	1
10	1	0





D

A \ BBin	00	01	11	10
0	0	1	0	1
1	1	0	1	0

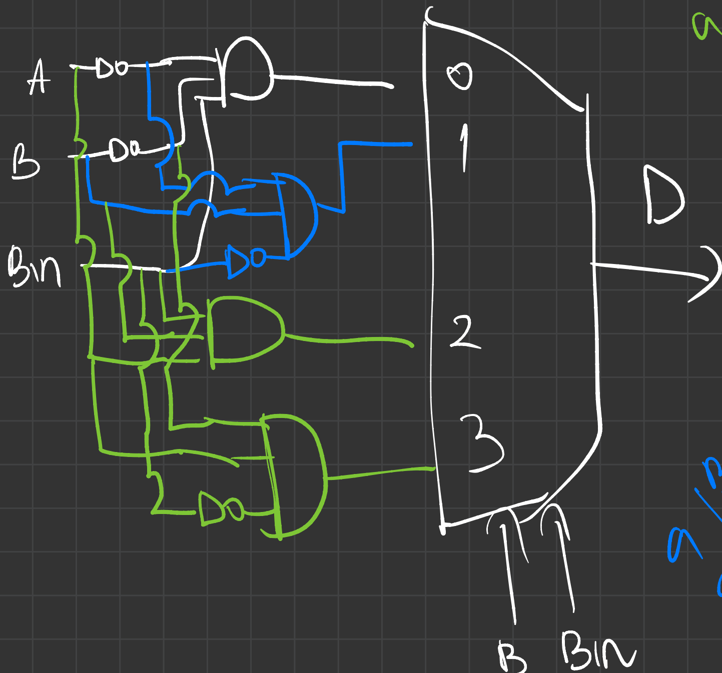
D

AB \ Bin	0	1
00	0	1
01	1	0
11	0	1
10	1	0

$$f = \overset{0}{\bar A \bar B B_n} + \overset{1}{\bar A B \overline{B_{in}}} + \overset{2}{A B B_{in}} + \overset{3}{\bar A B \overline{B_{in}}}$$

0 = A   2 = $\bar A$

1 A   3 = A



a \ BBin	00	01	11	10
0	0	1	0	1
1	1	0	1	0

D

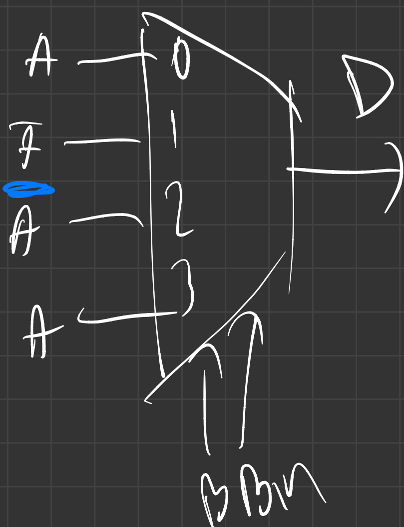
$0 = A$ $1 = \bar{A}$ $2 = \bar{A}$ $3 = A$

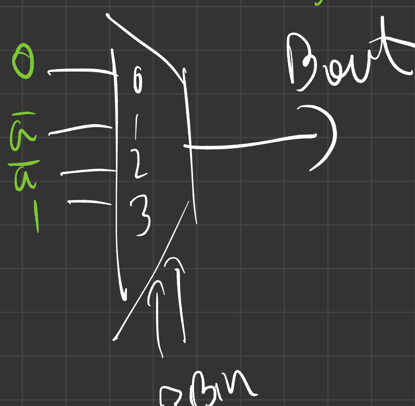
$0 - \bar{A}$
$1 - A$
$2 - \bar{A}$
$3 - \bar{A}$

a \ BBin	00 (0)	01 (1)	11 (3)	10 (2)
0	0	1	1	0
1	0	0	1	0

f: $0 - 0$
$1 - \bar{a}$
$2 - \bar{a}$
$3 - 1$

4:1





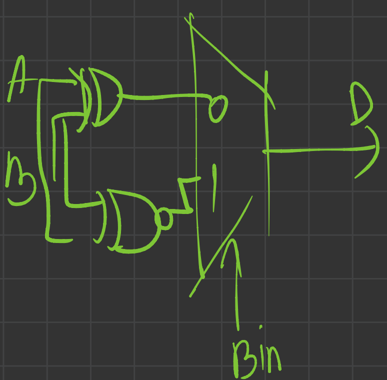
D

AB \ Bin	0	1
00	0	1
01	1	0
11	0	1
10	1	0

f:

$0 - \bar{A}B + A\bar{B} = A \oplus B$

$1 - \bar{A}\bar{B} + AB = \overline{A \oplus B}$

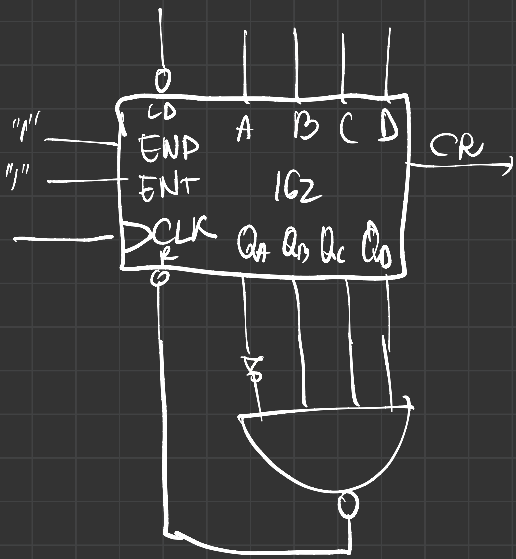


AB \ Bin	0	1
00	0 $_0$	1 $_1$
01	1 $_2$	1 $_3$
11	0 $_6$	1 $_7$
10	0 $_4$	0 $_5$

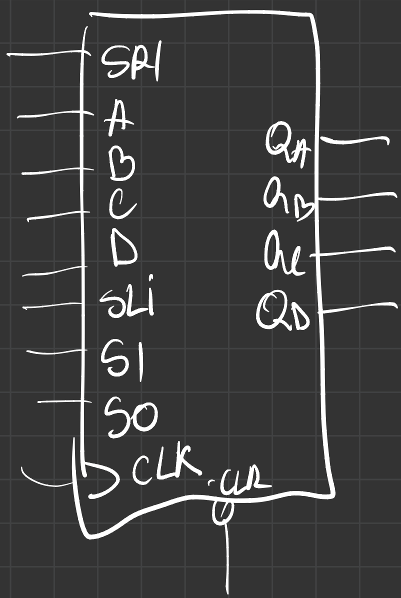
$0 - \bar{a} b$

$1 - A + B$

2) 4162 modulo 8 (0,7)



3)



S_1	S_0	
0	0	memorie
0	1	right
1	0	Left
1	1	Load

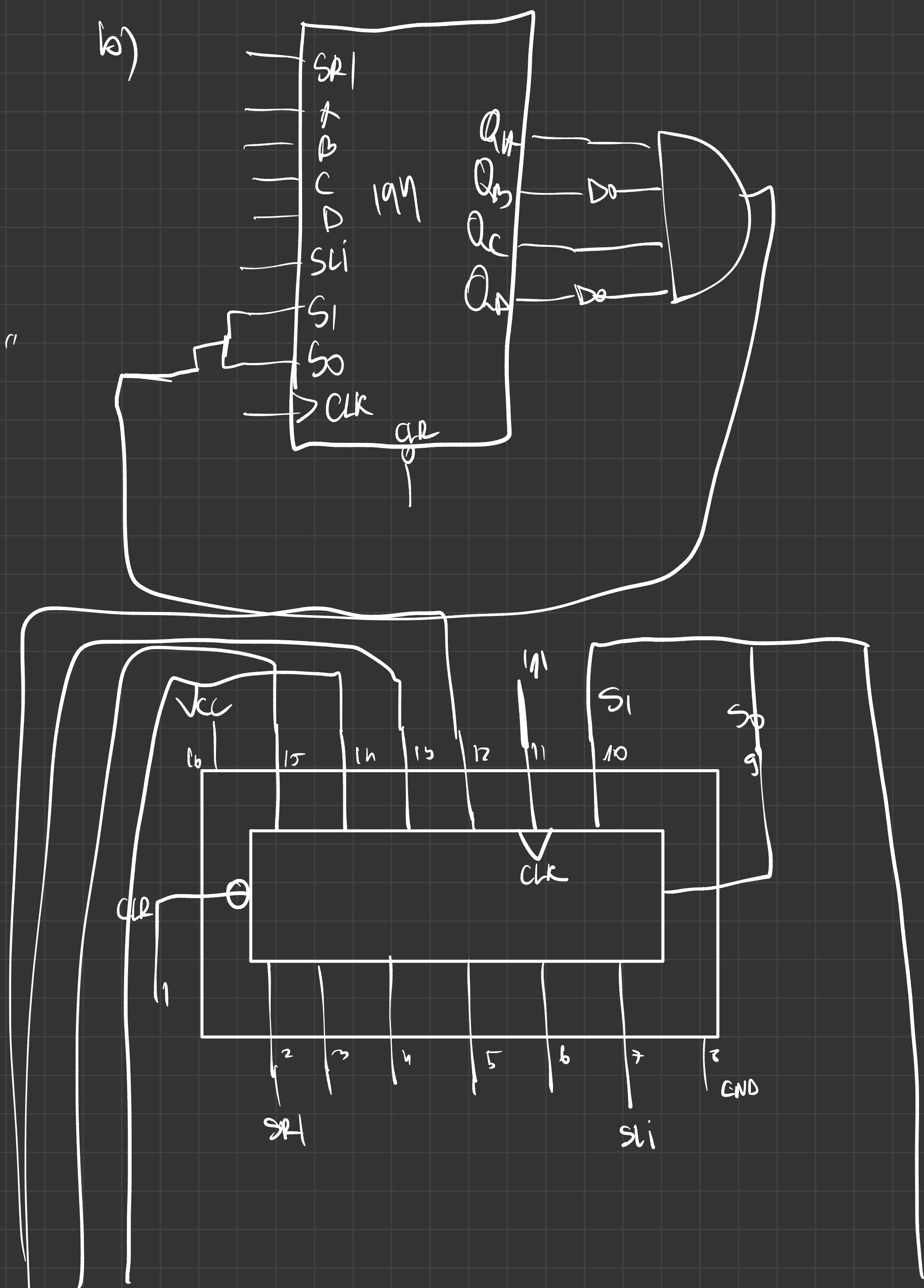
SRi - shift dreapta

SLi - shift left

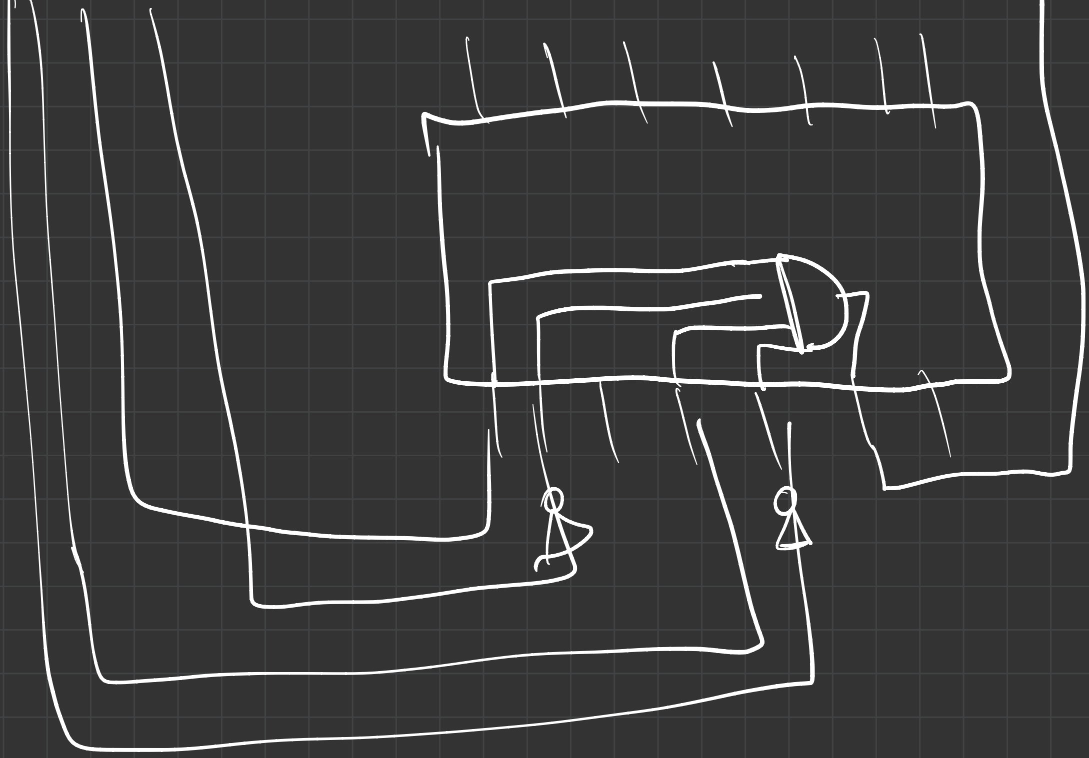
$Q_{A,B,C,D}$ - outputs

ABCD - inputs

b)



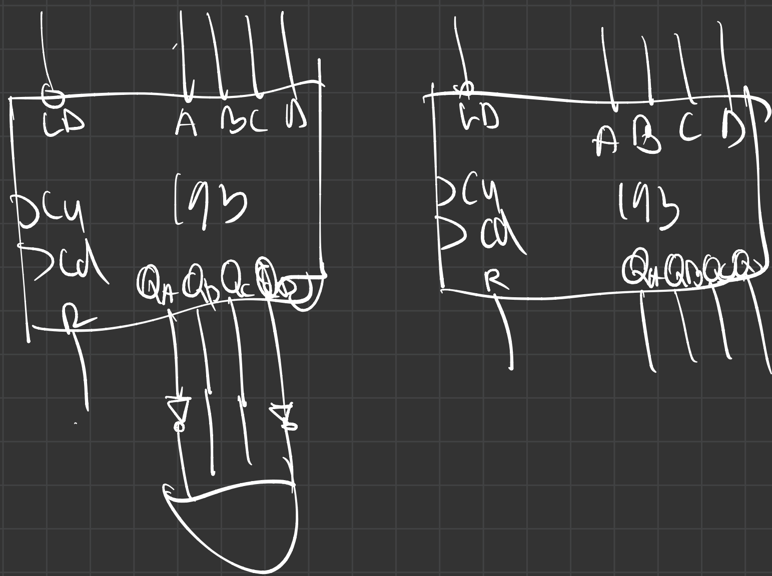
SR1
A
B
C
D
SLi
S1
S0
CLR
194
QA
QB
QC
QD
CLR
VCC
16
15
14
13
12
11
10
9
'1'
S1
S0
CLK
CLR
1
2
3
4
5
6
7
8
GND
SR
SLi

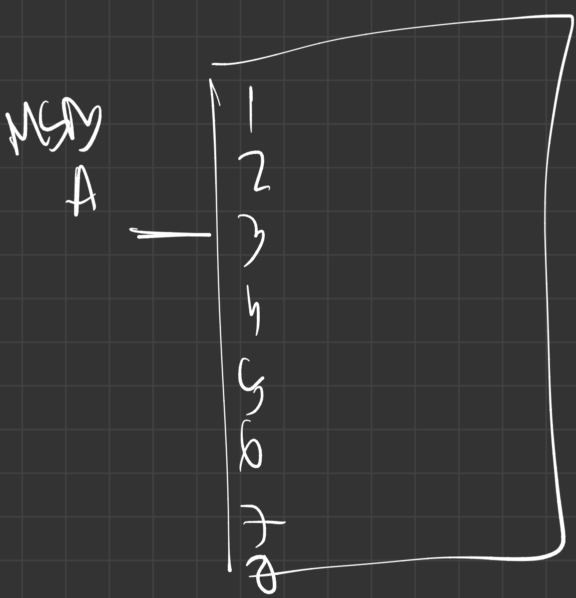


1 6B 191 103 02

0 11 000 11

193

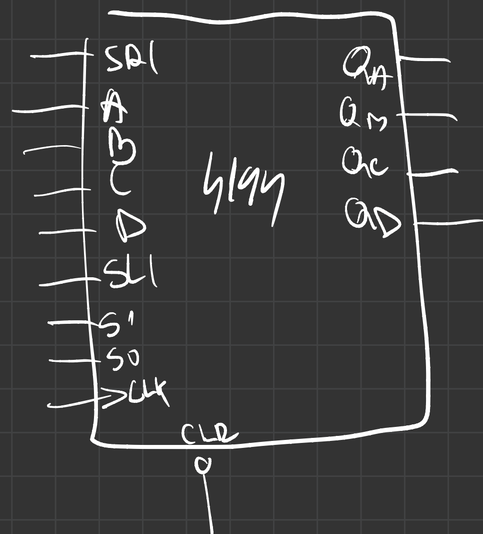




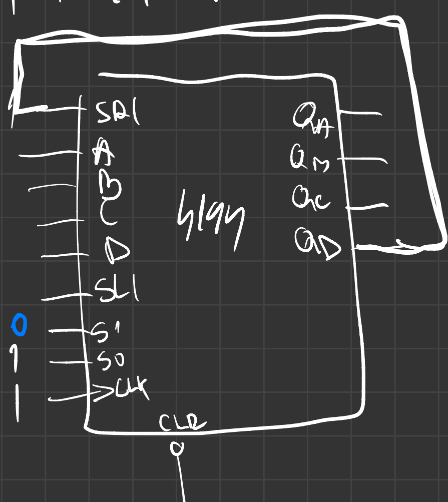
Bilet 5

1) asemanari + diferente 495 4194

a)



b) 4194 as 495

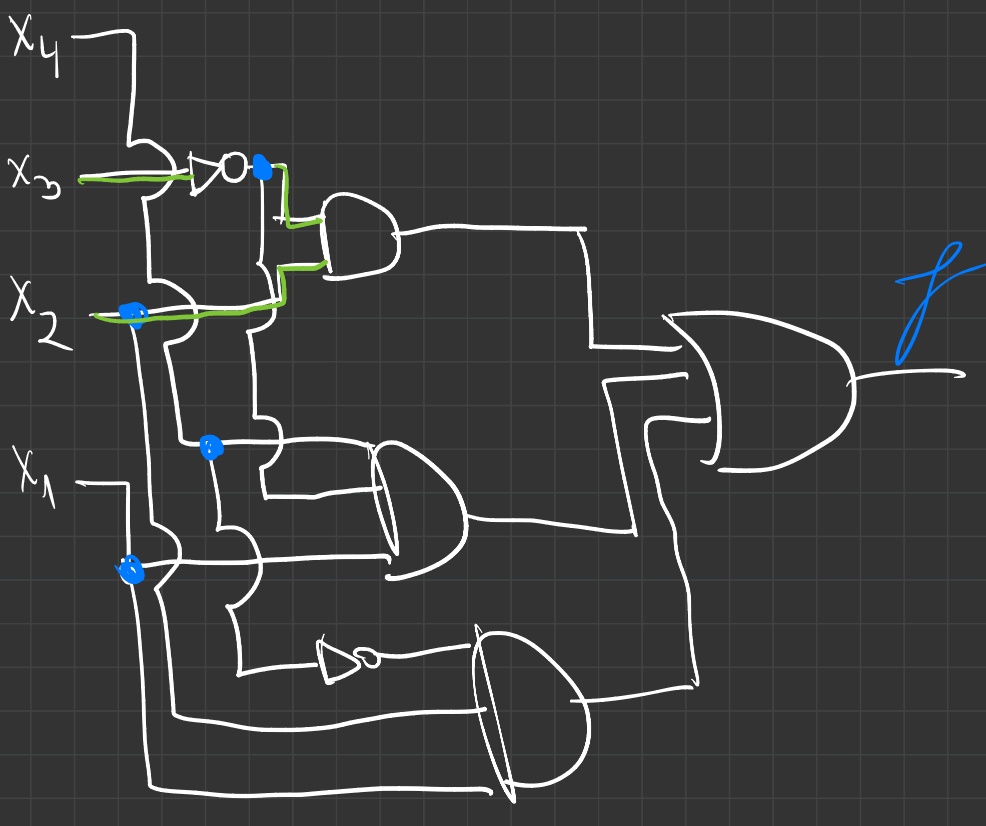


S_1 S_0	
0 0	memor
0 1	Right
1 0	Left
1 1	Load

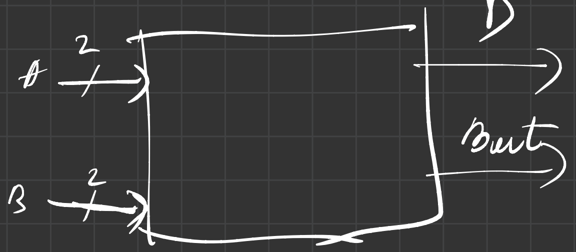
2) $f(x_1, x_2, x_3, x_n) = \sum(2, 3, 7, 9, 10, 11)$

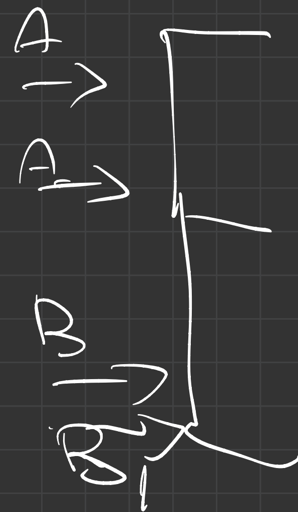
$x_4x_3 \backslash x_2x_1$	00	01	11	10
00	0	0	1	1
01	0	0	1	0
11	0	0	0	0
10	0	1	1	1

$f: \bar{x}_3 x_2 + x_4 \bar{x}_3 x_1 + \bar{x}_4 x_2 x_1$

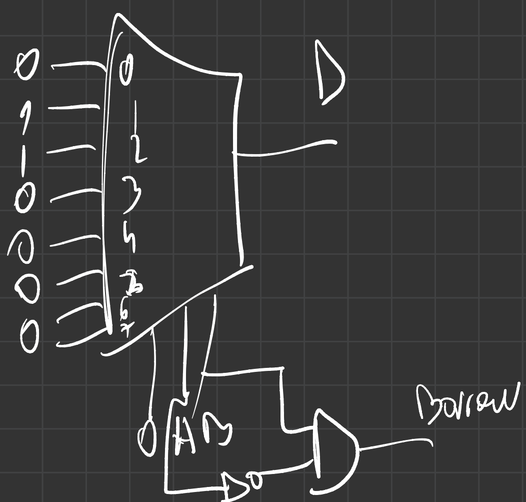


3) 2 bit half subtractor



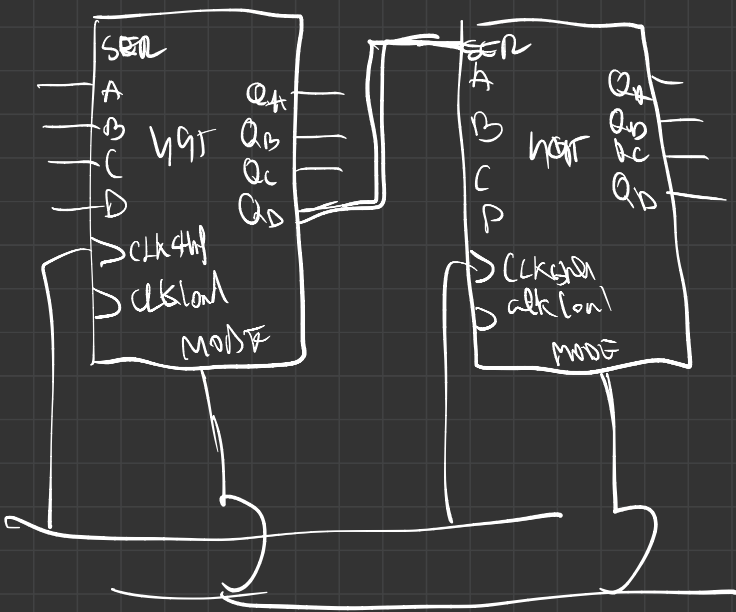


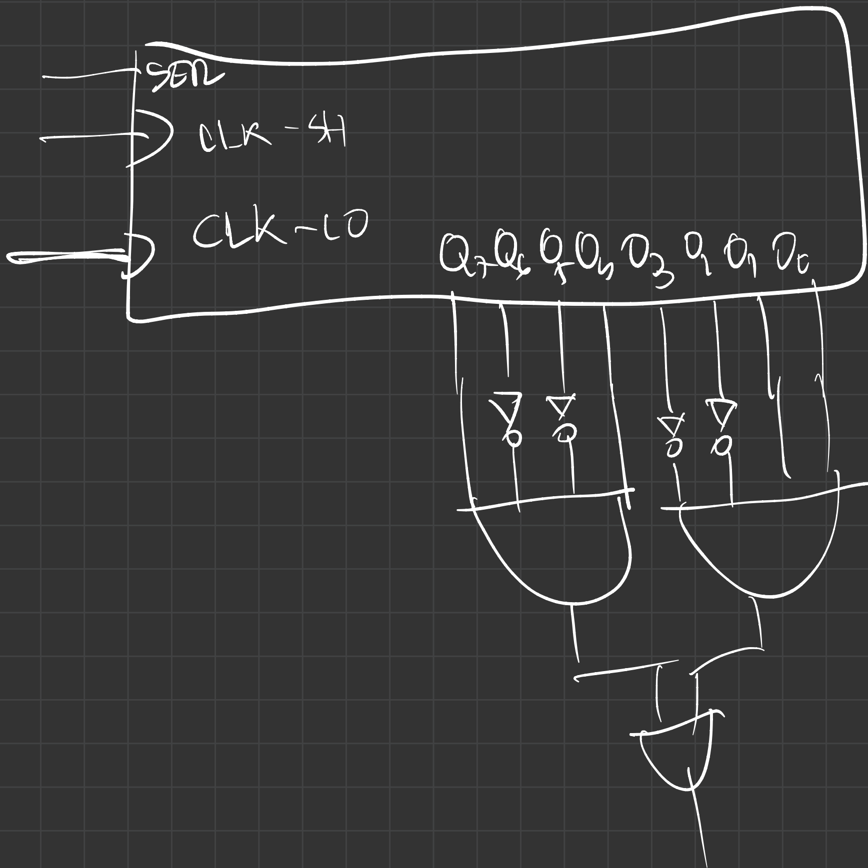
A	B	D	Bout
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0



Bilt 6

1) a) 4 bit shift register





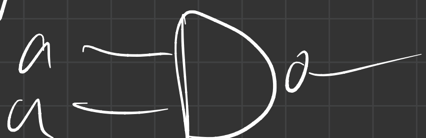
$a \oplus a$

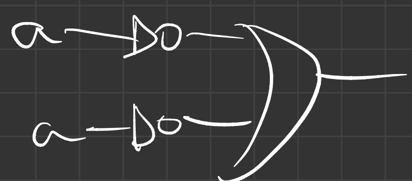
2. Not

$a\bar{a} + \bar{a} \cdot a$

$0 + 0 = 0$

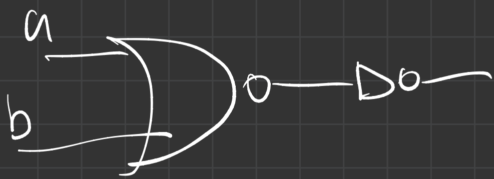
$f = \bar{a} = \overline{a \cdot a} \quad \bar{a} + \bar{a}$

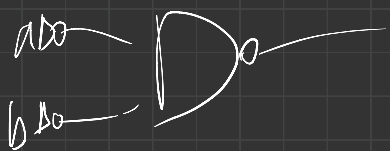




OR

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





6. $f(A,B,C,D) = A + \bar{C}\cdot D + B\cdot\bar{D} + \bar{D}\cdot\bar{B}$

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

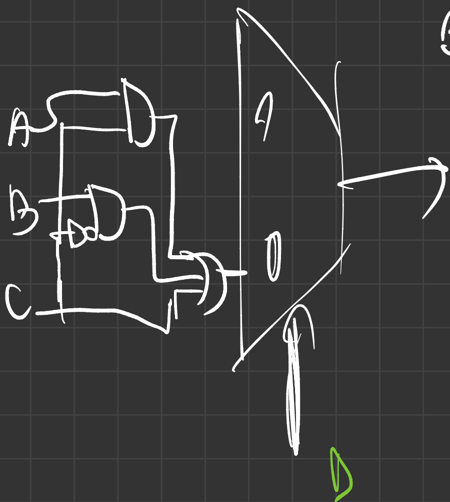
$$A + \bar{C}D + B \oplus D + \bar{B}C$$

01

$\overline{B}C$

0

$B\cdot\overline{D} =$



AB \ CD	00	01	11	10
00	0	1	1	1
01	1	1	0	1
11	1	1	1	1
10	1	1	1	1

1

0

1

D=0

AB \ C	0	1
00	0	1
01	1	1
11	1	1
10	1	1

D=0

$f: C + \overline{C}B + \overline{C}A$

D = 1

AB \ C	0	1
00	1	1
01	1	0
11	1	1
10	1	1

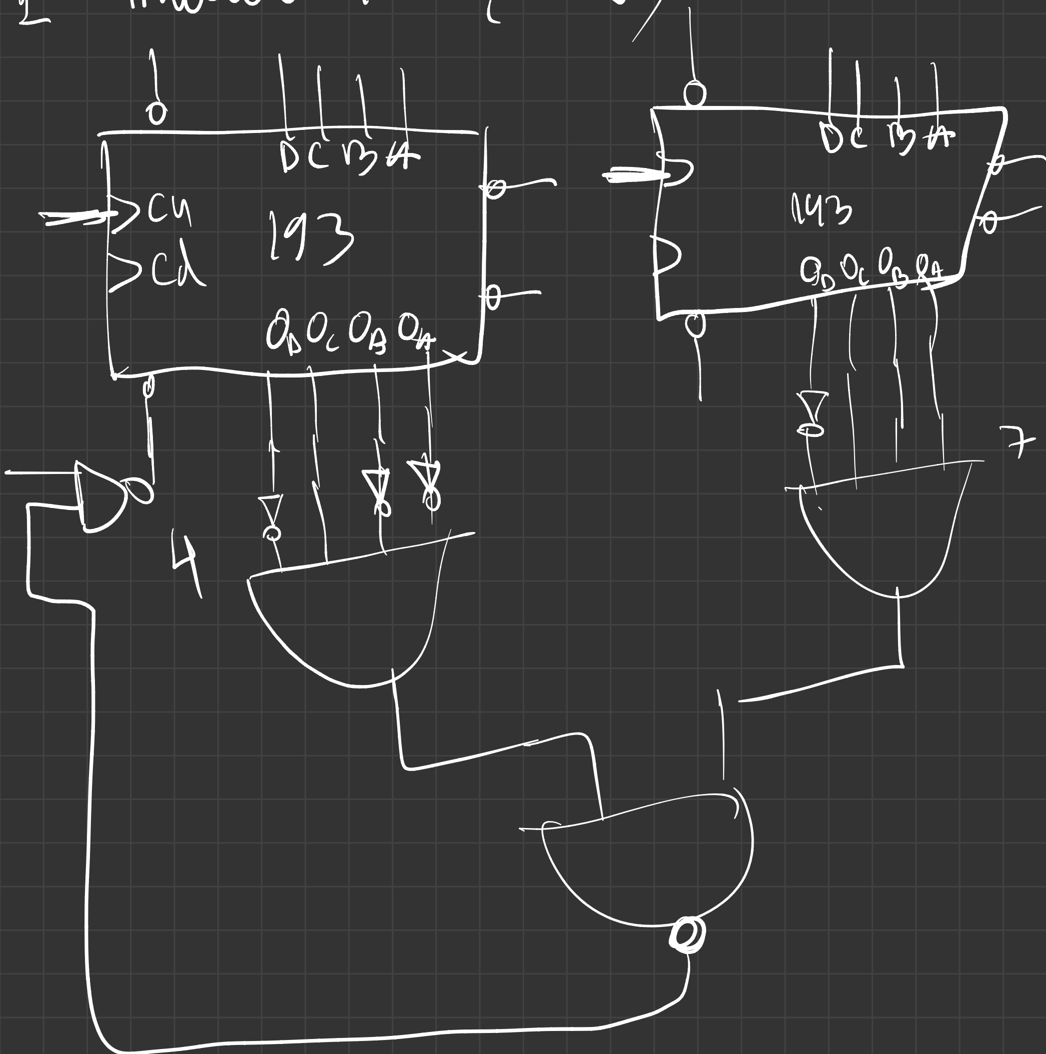
$f: C + \overline{B} + \overline{C}A$

B23

99 ÷ 16 = 6

96 + 3

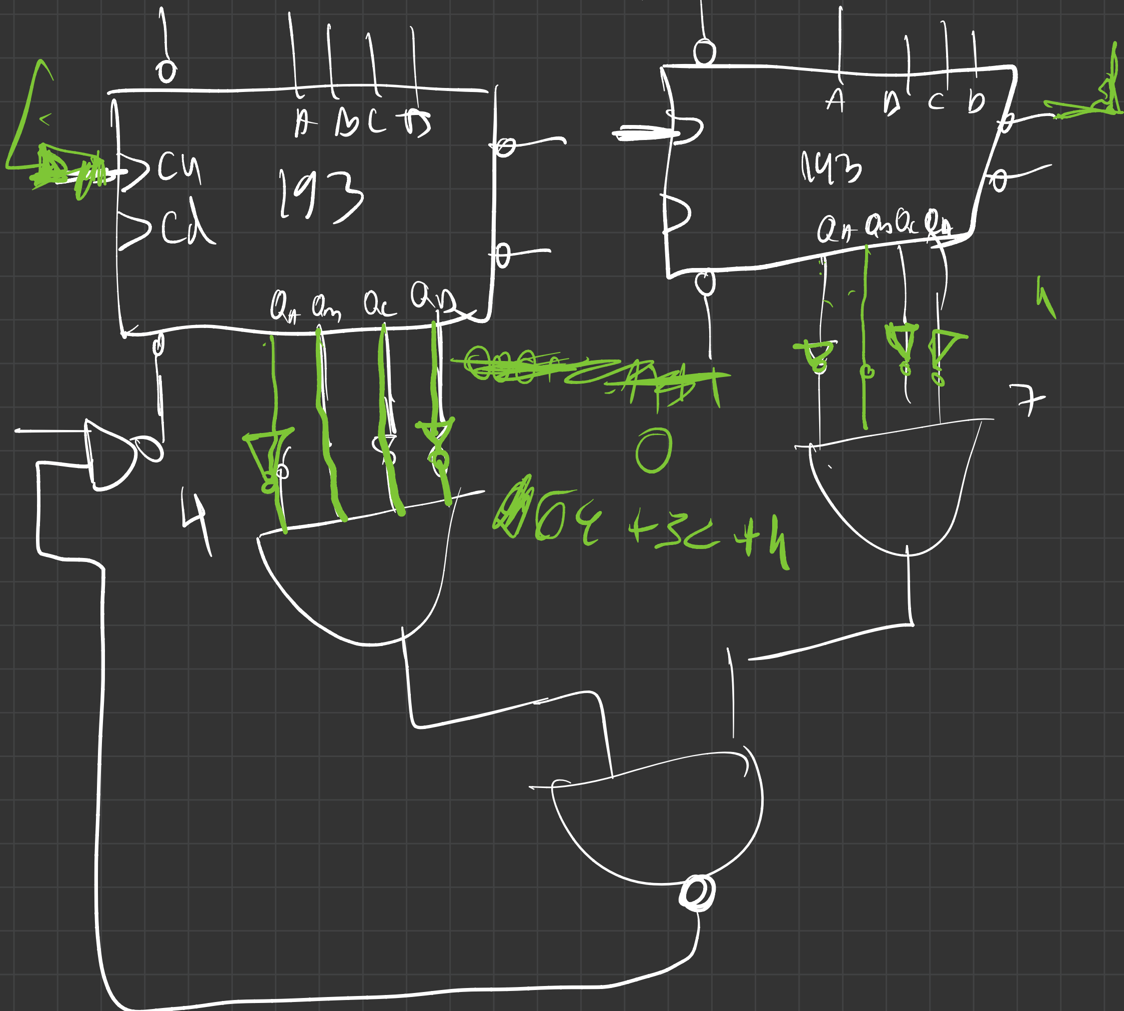
1 modulo 100 (0-99)



$99 : 16 = 8$

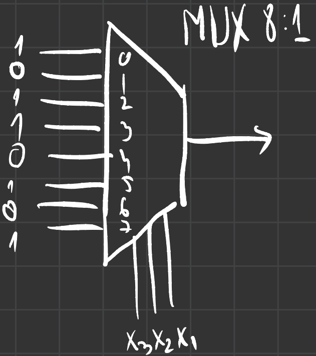
$6 \cdot 16 + 3$

1 modulo 100 (0-99)



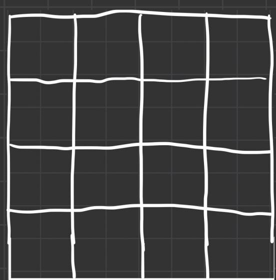
Bilet 2 Gobi

1) MUX 8 : 1 "74151"



$f(x_1, x_2, x_3) = \sum(0, 2, 3, 5, 7)$

3 selectii ABC manipuleaza intrarile



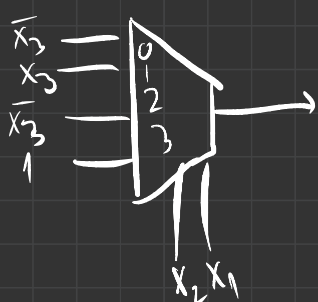
$X_3 \backslash X_2X_1$	00	01	11	10
0	1	0	1	1
1	0	1	1	0

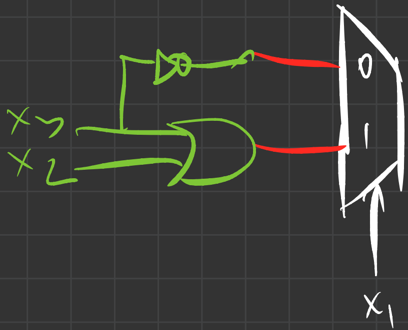
0 - $\bar{X}_3$

1 - X_3

3 - 1

2 - $\bar{X}_3$





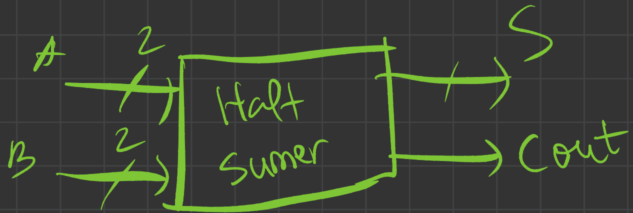
x_3x_2 \ x_1	0	1
00	1	0
01	1	1
11	0	1
10	0	1

x_3x_2 \ x_1	0	1
00	1	0
01	1	1
11	0	1
10	0	1

$0 - \overline{x_3}$

$1 - x_2 + x_3$

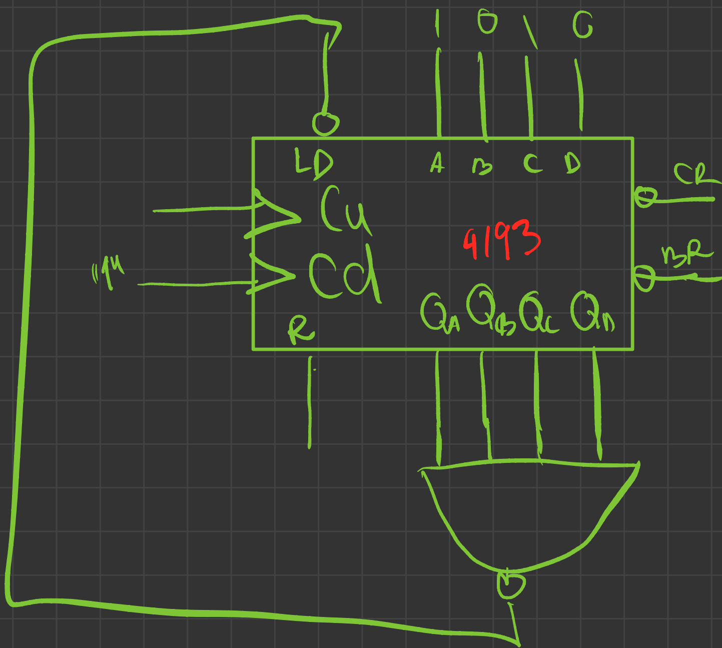
2)



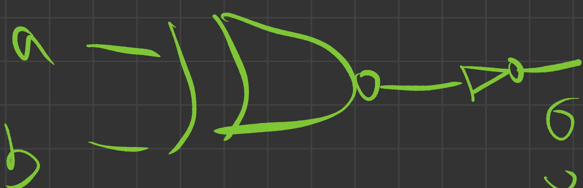
Modulo 11 = (0-10)

0-5

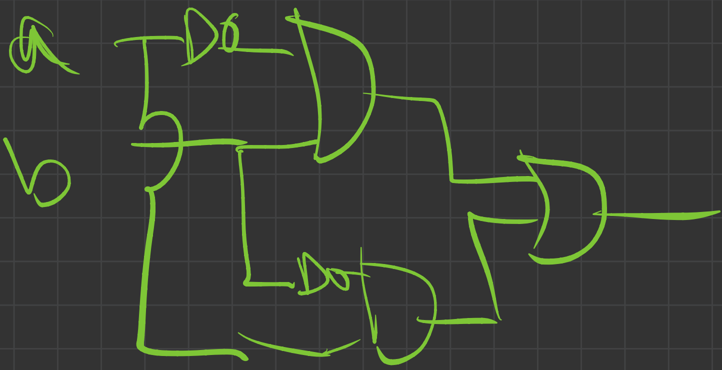
5-10



$$f = a \oplus b = \boxed{a\bar{b} + \bar{a}b}$$



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



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

$$f = \Sigma(0, 2, 3, 5, 7, 8, 9, 11, 12, 15)$$

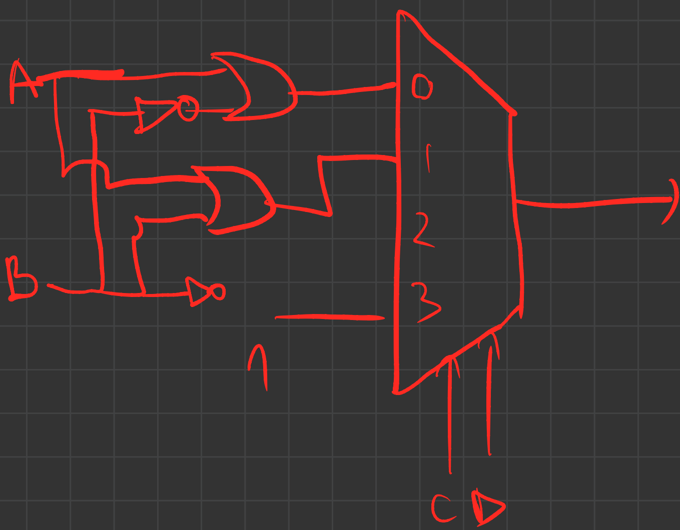
AB \ CD	00	01	11	10
00	1	0	1	1
01	0	1	1	0
11	1	0	1	0
10	1	1	1	0

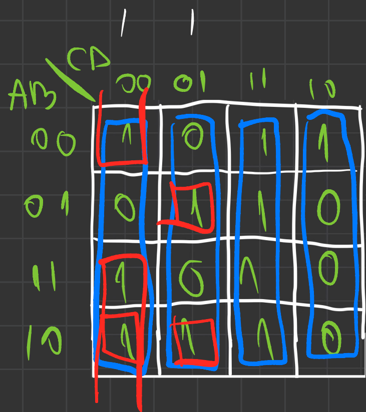
0 – $\bar{B} + A$

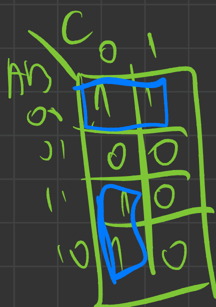
1 – $\bar{A}B + \bar{B}A = A \oplus B$

3 – 1

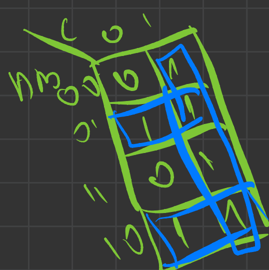
2 – $\bar{A}\bar{B}$



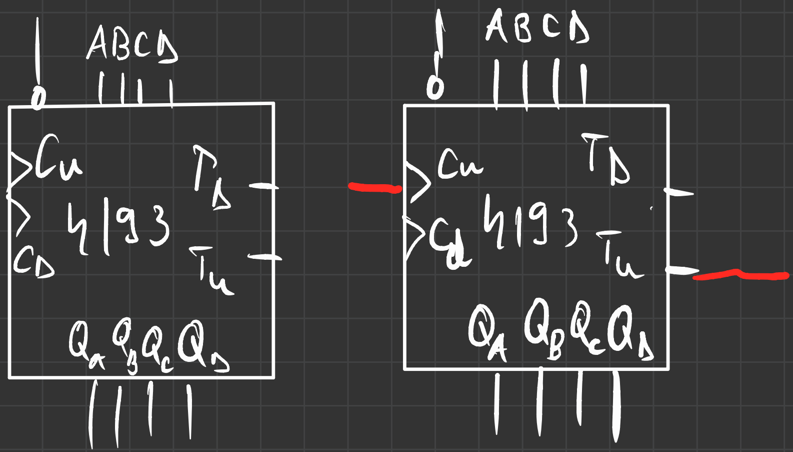


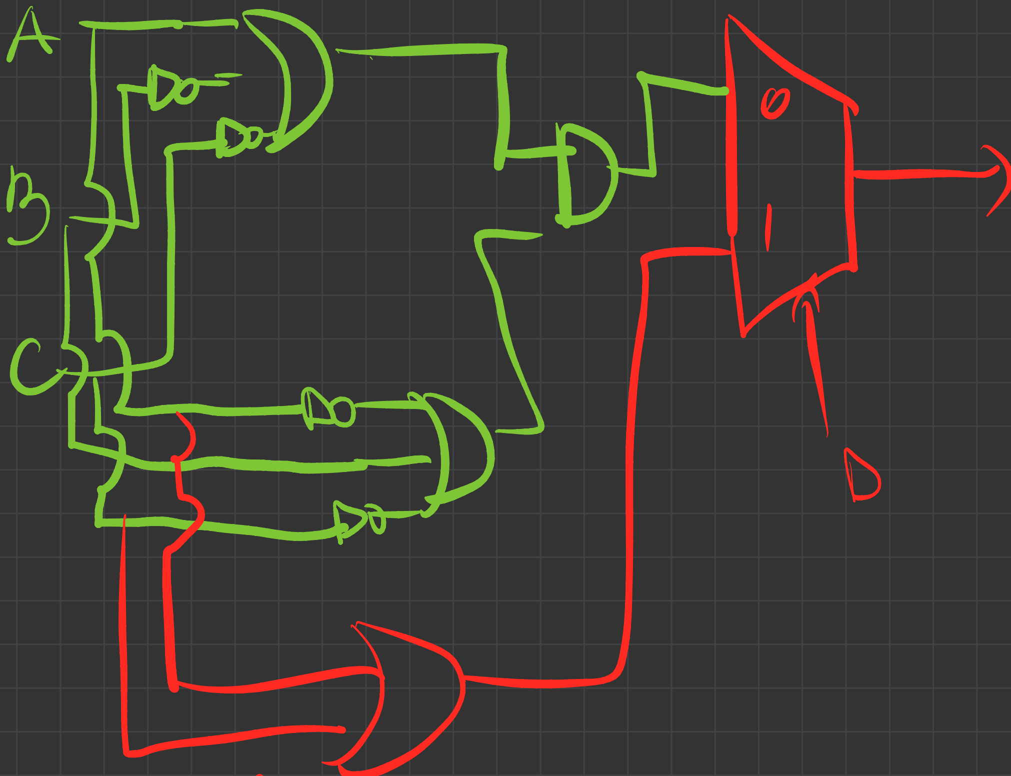


f: $\bar{A}\bar{B} + \overline{AC}$

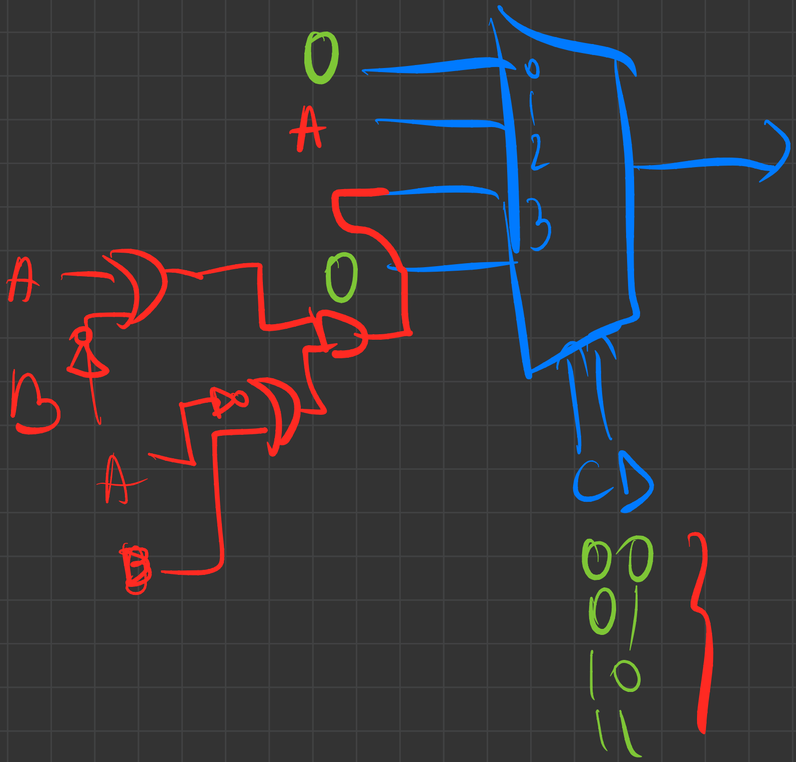


f: $C + \bar{A}B + A\bar{B}$


ABCD
Cu
4193
Cd
TD
Tu
QA QB QC QD
ABCD
Cu
Cd
4193
TD
Tu
QA QB QC QD



	0	1	3	2
AB\CD	00	01	11	10
00	1	0	X	1
01	1	0	1	0
11	1	X	1	1
10	1	1	X	0

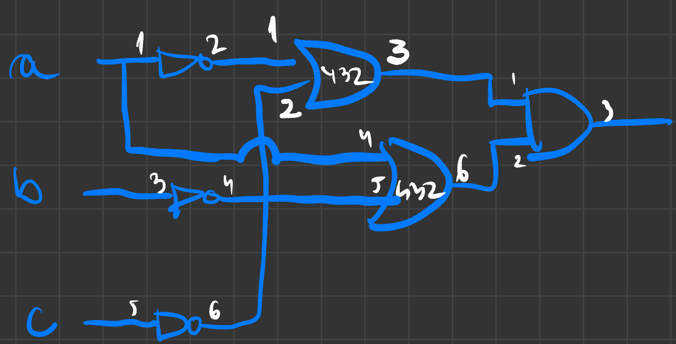

0
A
0
A
B
A
B
0
1
2
3
C D
0 0
0 1
1 0
1 1

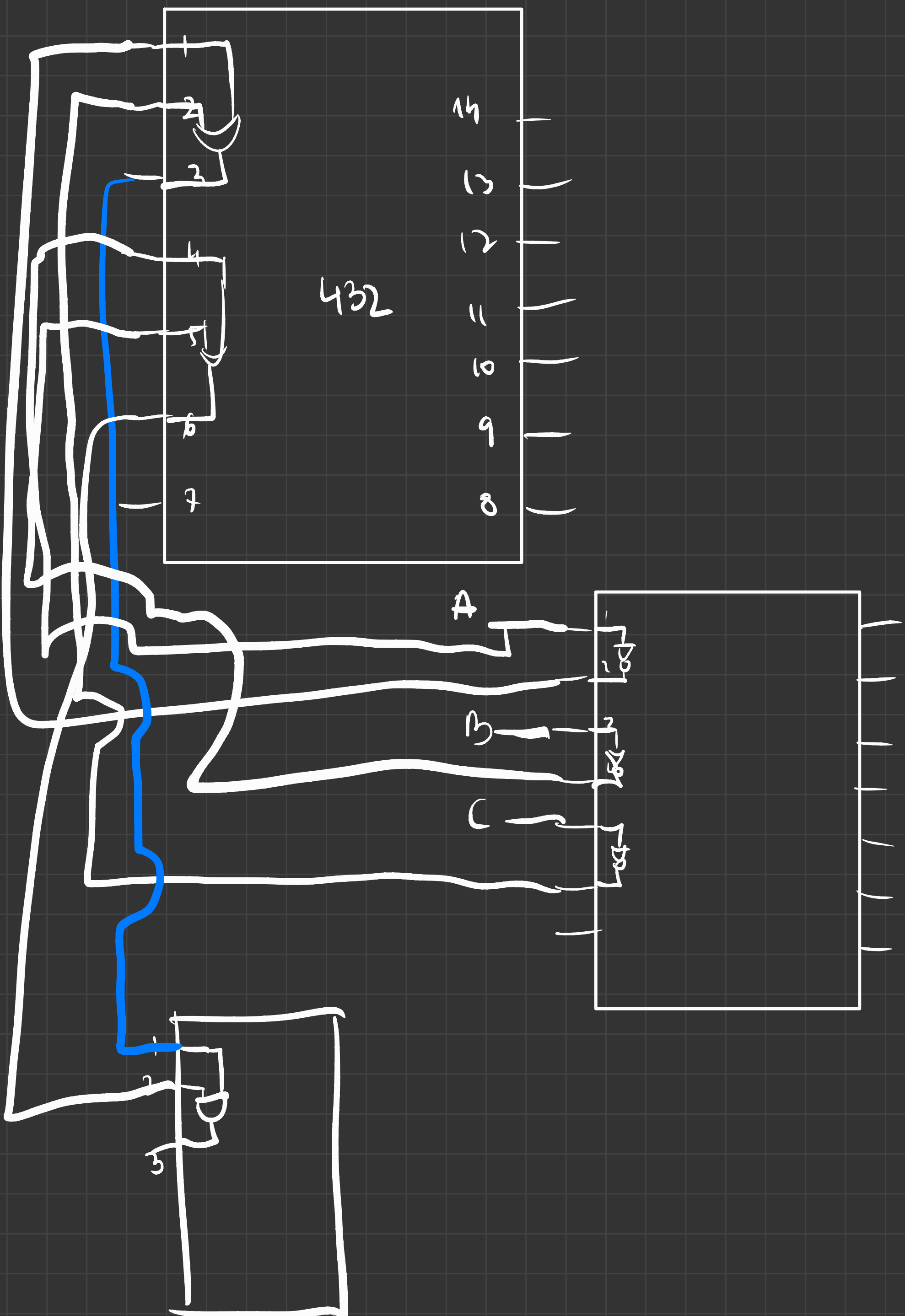
Subiect Gabi

$$f = \Pi(4,5,10,11,14,15) + \Pi_{\phi}(3,6,7)$$

ab \ cd	00	01	11	10
00	1	1	X	1
01	0	0	X	X
11	1	1	0	0
10	1	1	0	0

$$f_{CC} : (\bar{a} + \bar{c}) \cdot (a + \bar{b})$$

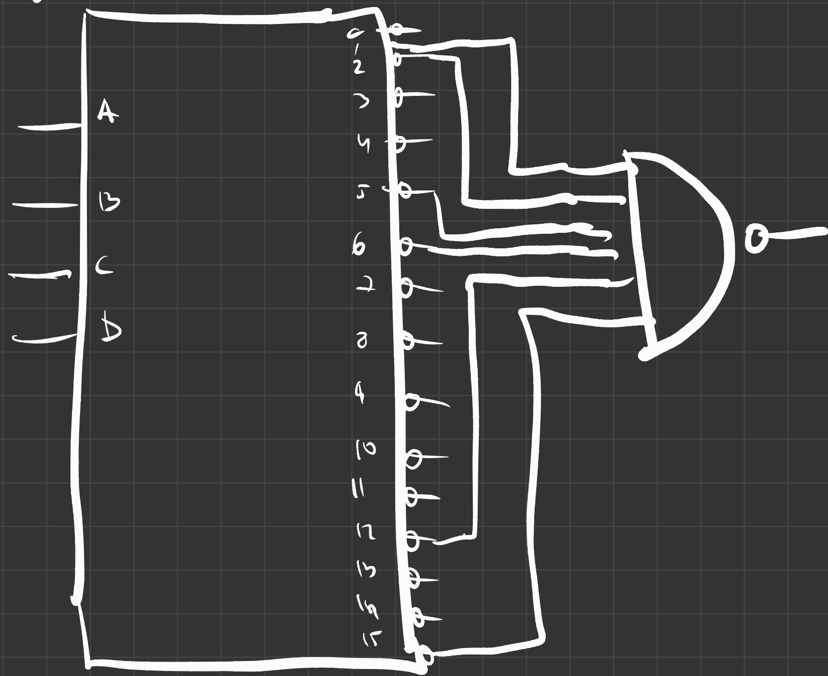




432
1
2
3
4
5
6
7
14
13
12
11
10
9
8
A
B
C
1
2
3

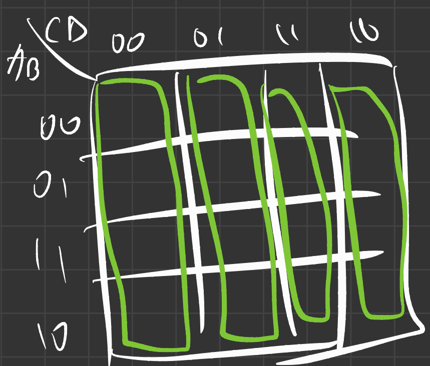
$f = \Sigma(0,1,2,5,6,12,15)$ DCD

2



2. Implementați următoarea funcție booleană folosind un multiplexor 4:1 și porți logice adiționale (dacă este cazul): f (A,B,C,D) = C+AD+AD+ CD+ BC. Desenați schema logică și oferiți explicații (unde este cazul).

A B C D

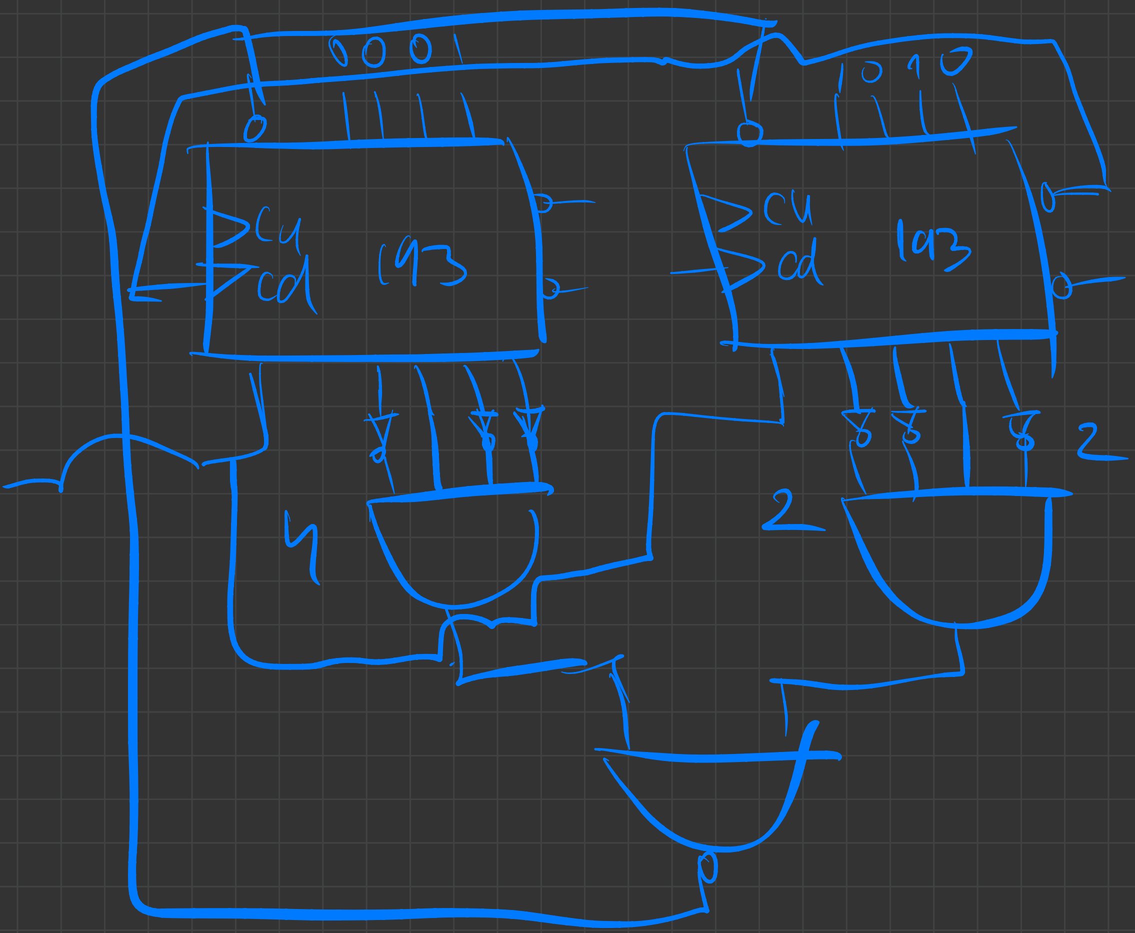


$x + x = x$

$\overline{AB}C\overline{D}$

$f = C + AD + CD + BC$

3. Proiectați un numărător binar cu bucla (50-20) folosind două numaratoare MSI, la alegere. Circuitul proiectat trebuie să aibă o intrare denumita "Init" (activă pe 0) care să aducă circuitul in prima stare din buclă (starea 50). Se cere schema logică și explicații.



$20 \div 16 = 1$ $\qquad$ $20 : 16 = 1$

$16 + 3$ $\qquad$ $16 + 3$

00000000000

00011010

$20 : 16 = \underline{1} = 2$

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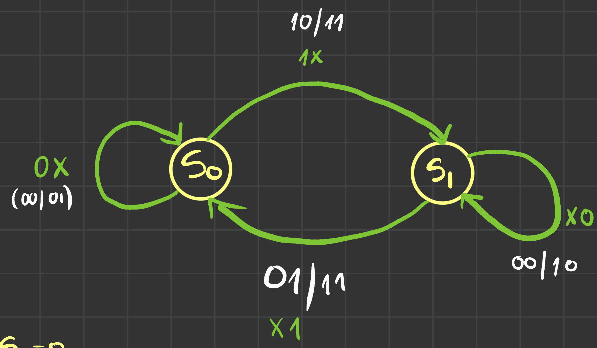
EXAMEN

for JK FF :-

Present state Q_n	input J	K	Next state Q_{n+1}
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0



$S_0 = 0$

$S_1 = 1$

State Eq :-

$$Q_{n+1} = \overline{Q}_n J + Q_n \overline{K}$$

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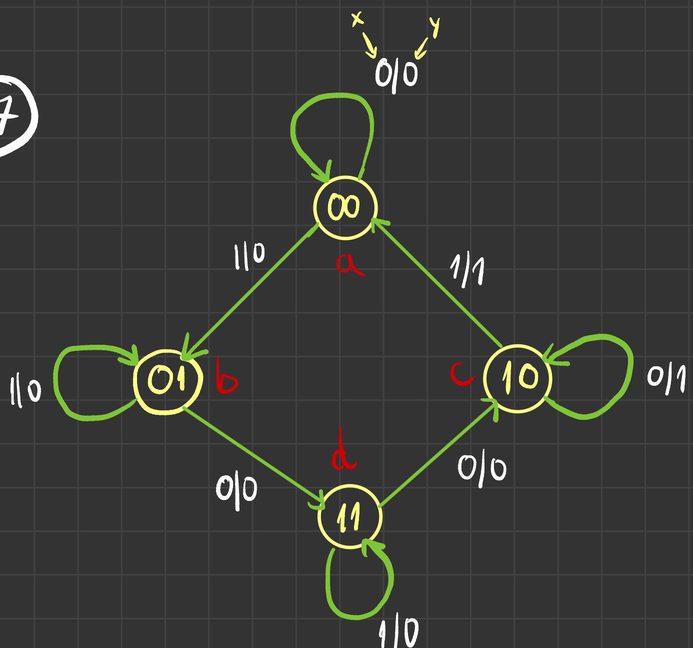


State table :-

P.S		N.S x=0		N.S x=1		Output (y) x=0	Output (y) x=1
Q_A	Q_B	Q_A^+	Q_B^+	Q_A^+	Q_B^+		
0	0	0	0	0	1	0	0
0	1	1	1	0	1	0	0
1	0	1	0	0	0	1	1
1	1	1	0	1	1	0	0

a = 00
b = 01
c = 10
d = 11

$\boxed{\text{T.FF}}$

CLK	T	Q_{n+1}
0	x	Q_n
1	0	Q_n
1	1	$\overline{Q_n}$

A → Q_A B → Q_B

Q_n	Q_{n+1}	T
0	0	0
0	1	1
1	0	1
1	1	0

Circuit Excitation Table

P.S			N.S		FF i/p		y
Q_A	Q_B	x	Q_A^+	Q_B^+	T_A	T_B	
0	0	0	0	0	0	0	0
0	0	1	0	1	0	1	0
0	1	0	1	1	1	0	0
0	1	1	0	1	0	0	0
1	0	0	1	0	0	0	1
1	0	1	0	0	1	0	1
1	1	0	1	0	0	1	0
1	1	1	1	1	0	0	0

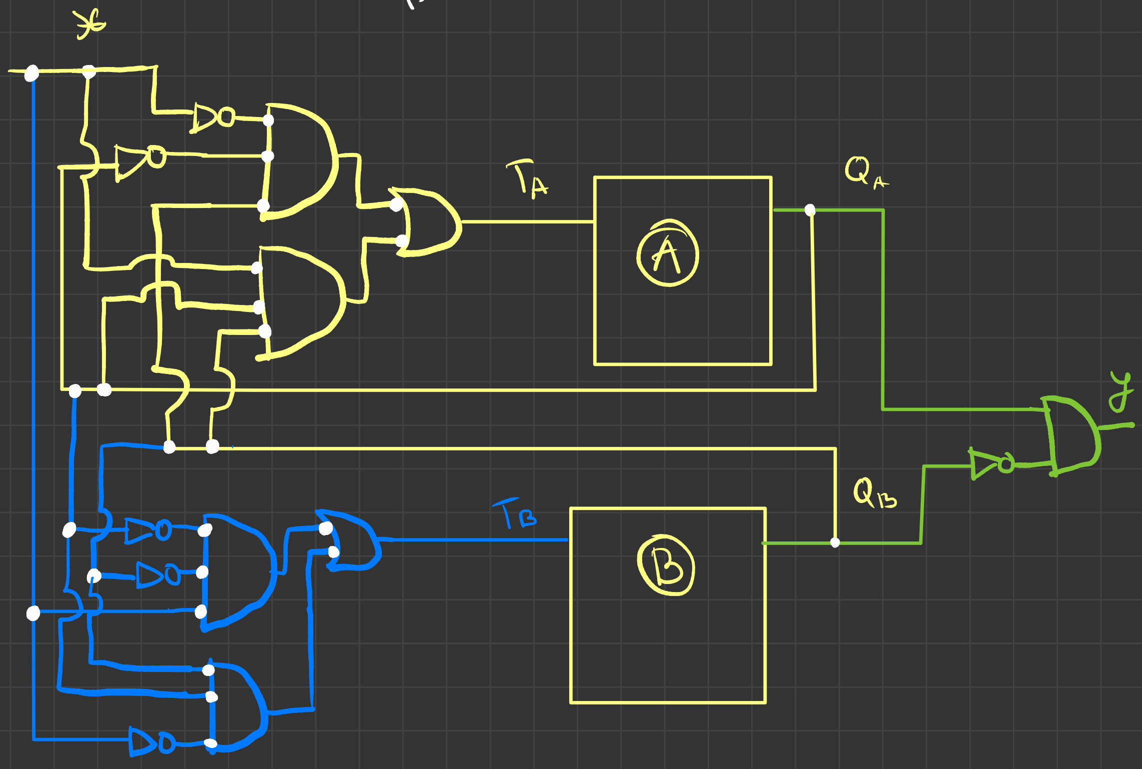
$$T_A = \overline{Q_A} Q_B \overline{x} + Q_A \overline{Q_B} x$$

$$T_B = \overline{Q_A}\,\overline{Q_B} x + Q_A Q_B \overline{x}$$

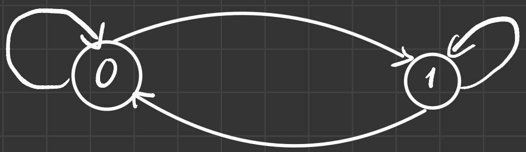
$$y = Q_A \overline{Q_B}\,\overline{x} + Q_A \overline{Q_B} x$$

$$= Q_A \overline{Q_B} (\overline{x} + x)$$

$$= Q_A \overline{Q_B}$$



Problema Net upscfever



CURS 1

Complementul unei cifre a (notat $\bar{a}$ în baza b)

$$\bar{a} = (b-1) - a$$

baza $b_1 = 3$, $b_2 = 10$, $(N)_3 = 2120.1$

$$(N)_{10} = 2 \times 3^3 + 1 \times 3^2 + 2 \times 3^1 + 0 \times 3^0 + 1 \times 3^{-1}$$

$$= 54 + 9 + 6 + 0 + 0,3 = 69.3_{10}$$

Coduri binare
- ponderate
- neponderate

Tabel:

- Întregi fără semn $[0; 2^N - 1]$
- Complement față de 2 $[-2^{(N-1)}; 2^{(N-1)} - 1]$
- Fracționare fără semn $[0; 2^N - 2^M]$
- Fracționare cu semn în Complementul față de 2 $[-2^{(N-1)}; 2^{(N-1)} - 2^{-M}]$
- Cod Gray $[0; 2^{(N-1)}]$
- Mărime și semn $[-2^{(N-1)}+1; 2^{(N-1)}-1]$

- Complementul față de 2 deplasat $[-2^{(N-1)} ; 2^{(N-1)} - 1]$
- Complementul lui 1 $[-2^{(N-1)} - 1 ; 2^{(N-1)} - 1]$
- Virgula mobilă

1. Care este cel mai mare și cel mai mic număr întreg cu semn / fără semn care poate fi exprimat pe 12 biți?

a) cu semn : cel mai mare $\rightarrow 2^{(N-1)} - 1 = 2^{11} - 1 = 2047$

cel mai mic numar $\rightarrow -2^{(N-1)} + 1 = -2^{11} + 1 = -2047$

b) fără semn : cel mai mare $\rightarrow 2^{12} - 1 = 4095$

cel mai mic $\rightarrow 0$

2. Convertiți numărul hexazecimal 68BE în binar și apoi din binar convertiți-l în octal.

$NR_{16} = 68BE \Rightarrow NR_2 = 0110\ 1000\ 1011\ 1110$

$NR_2 = 0110100010111110 \Rightarrow NR_8 = 64276_{(8)}$

3. Convertiți numărul zecimal 34,4375 în binar și hexazecimal.

$34 = 100010$

$0,4375 \times 2 = 0,875$

$0,875 \times 2 = 1,75$

$$0,75 \times 2 = 1,5$$
$$0,5 \times 2 = 1,0$$
$$0,0 \times 2 = 0$$

$$0,4375 = 0111$$

$$34,4375 = 100010,0111_{(2)}$$

$$00100010,0111_{(2)} = 22,7_{(16)}$$

4. Exprimați următoarele numere în zecimal: $N_1 = (10110,0101)_2$, $N_2 = (16,5)_{16}$ și $N_3 = (26,24)_8$

$$N_1 = (10110,0101)_2$$
$$= 1 \times 2^4 + 0 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 0 \times 2^0 + 0 \times 2^{-1} + 1 \times 2^{-2} \times 0 \times 2^{-3}$$
$$+ 1 \times 2^{-4} = 16 + 4 + 2 + 0,25 + 0,0625$$
$$= 22,3125_{(10)}$$

$$N_2 = 16,5_{(16)} = 1 \times 16^1 + 6 \times 16^0 + 5 \times 16^{-1}$$
$$= 16 + 6 + 0,0625 \cdot 5$$
$$= 22,3125_{10}$$

$$N_3 = 26,24_{(8)} = 2 \times 8^1 + 6 \times 8^0 + 2 \times 8^{-1} + 4 \times 8^{-2}$$
$$= 8 + 6 + \ldots + \ldots = 22,3125_{(10)}$$

5. Adunați și înmulțiți numerele binare 1011 și 101 fără a le converti în zecimal.

$$\begin{array}{r} 1011 + \\ 101 \\ \hline 10000 \end{array} \qquad \begin{array}{r} 1011 \\ 101 \\ \hline 1011 \\ 0000 \\ 1011 \\ \hline 110111 \end{array}$$

6. Obțineți complementul față de 1 și față de 2 ale următoarelor numere binare întregi fără semn:
a) $N_1 = 11101010$
b) $N_2 = 01111110$
c) $N_3 = 00000000$

C.2

$N_1 = 11101010$ $= 00010110$

$N_2 = 01111110$ $= 10000010$

$N_3 = 00000000$ $= 00000000$

C.1 $= 00010101$ $= 10000001$ $= 11111111$

7. Convertiți numărul zecimal +61 și numărul zecimal +27 în binar folosind reprezentarea în Complementul față de 2 (care este un sistem de numerație cu semn) și suficient de mulți biți pentru a alinia numerele. Apoi realizați operațiile binare echivalente următoarelor operații:
a) (27) + (-61)
b) (-27) + (+61)
c) (-27) + (-61).
Convertiți apoi rezultatele înapoi în zecimal și verificați corectitudinea lor.

$61_{(10)} = 111101_{(2)}$ $\quad -61 = 1000011$

$27_{(10)} = 011011_{(2)}$ $\quad -27 = 1100101$

a)
$$\begin{array}{r} 0011011 + \\ 1000011 \\ \hline 1011110 \end{array}$$

c)
$$\begin{array}{r} 1100101 + \\ 1000011 \\ \hline 10101000 \end{array}$$

b)
$$\begin{array}{r} 1100101 + \\ 0111101 \\ \hline 10100010 \end{array}$$

8. a) Convertiţi numerele zecimale 126 şi 348 în cod BCD, şi efectuaţi adunarea lor folosind codul BCD.
b) Cum se pot converti numerele din binar în BCD? Exemplificaţi pentru numărul 11111111 (255 în baza 10).

a) $126 = \underbrace{0001}_{1}\underbrace{0010}_{2}\underbrace{0110}_{6}$

$348 = \underbrace{0011}_{3}\underbrace{0100}_{4}\underbrace{1000}_{8}$

0100 0111 0100

4 7 4

$$11111111 = 15\ 15\ (EF)_{16}$$

1. Codificați cifrele zecimale 0, 1, 2, 3 … 9 cu ajutorul următorului cod ponderat: 6 3 1 -1.

	6	3	1	-1
0	0	0	1	1
1	0	0	1	0
2	0	1	0	1
3	0	1	0	0
4	0	1	1	0
5	1	0	0	1
6	1	0	0	0
7	1	0	1	0
8	1	1	0	1
9	1	1	0	0

2. Realizați conversia:

$(11010100)_4 \rightarrow$ în baza 8.

$$(0\underbrace{101}\underbrace{000}\underbrace{100}\underbrace{010}\underbrace{000})_2 = 50420_8$$

3. Realizați conversia:

$(1476503)_8 \rightarrow$ în baza 2.

$(001\,100\,111\,110\,101\,000\,011)_2$

4. Codificați cifrele zecimale 0, 1, 2, 3 … 9 cu ajutorul următorului cod ponderat: 7 3 1 -2.

	7	3	1	-2
0	0	0	0	0
1	0	0	1	0
2	0	1	1	1
3	0	1	0	0
4	0	1	1	0
5	1	0	0	1
6	1	0	1	1
7	1	0	0	0
8	1	0	1	0
9	1	1	1	1

6. Determinați bazele posibile ale numerelor implicate în următoarea operație:

$$\sqrt{41} = 5$$

baza 6

7. Realizați conversia:
$(10011100010101)_4 \to$ în baza 16.

$0100000101010000000100010001_{(2)}$

$4\ 1\ 5\ 0\ 1\ 1\ 1_{(16)}$

CODUL HAMMING

$$2^p \geq p + m + 1$$

$\left.\begin{array}{l} m=4 \\ p=3 \end{array}\right| \Rightarrow 7$ biți

$\boxed{0110} \Rightarrow m = 4$

$$2^p \geq p + 5$$

$$p = 3$$

1	2	3	4	5	6	7
p_1	p_2	m_1	p_3	m_2	m_3	m_4
1	1	0	0	1	1	0

$p_1 : \{1, 3, 5, 7\}$

$p_2 : \{2, 3, 6, 7\}$

$p_3 : \{4, 5, 6, 7\}$

	p_1	p_2	p_1
	c_1	c_2	c_3
0	0	0	0
1	0	0	1
2	0	1	0
3	0	1	1
4	1	0	0
5	1	0	1
6	1	1	0
7	1	1	1

1001

1	2	3	4	5	6	7
p_1	p_2	m_1	p_3	m_2	m_3	m_4
0	0	1	1	0	0	1

$p_1: \{1, 3, 5, 7\}$

$p_2: \{2, 3, 6, 7\}$

$p_3: \{4, 5, 6, 7\}$

8) $(16)_{10} = (100)_b \Rightarrow b = 4$

$1 \cdot 4^2 + 0 \cdot 4^1 + 0 \cdot 4^0 = 100$

$(292)_{10} = (1204)_b = 1 \cdot b^3 + 2 \cdot b^2 + 0 \cdot b^1 + 4 \cdot b^0$

$1 \cdot 6^3 + 2 \cdot 6^2 + 4 \cdot 1$

$216 + 76 = 292$

$2^p \geq m + p + 1$

$2^p \geq 6 + p$

11011

1	2	3	4	5	6	7	8	9
p_1	p_2	m_1	p_3	m_2	m_3	m_4	p_4	m_5
0	0	1	0	1	0	1	1	1

$p_1 = \{1, 3, 5, 7, 9\}$

$p_2 = \{2, 3, 6, 7\}$

$p_3 = \{4, 5, 6, 7$

0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
10	1010
11	1011
12	1100
13	1101

$P_7 = \{8, 9\}$

14	1	1	1	0
15	1	1	1	1

Quine McClusky

$$f = \sum(0, 1, 2, 3, 7, 14, 15, 22, 23, 29, 31)$$

	x_4	x_3	x_2	x_1	x_0	
0	0	0	0	0	0	0
1	0	0	0	0	1	1
2	0	0	0	1	0	
3	0	0	0	1	1	2
7	0	0	1	1	1	3
14	0	1	1	1	0	
22	1	0	1	1	0	
15	0	1	1	1	1	4
23	1	0	1	1	1	
29	1	1	1	0	1	
31	1	1	1	1	1	5

		x_4	x_3	x_2	x_1	x_0	
✓	(0,1)	0	0	0	0	–	0
✓	(0,2)	0	0	0	–	0	
✓	(1,3)	0	0	0	–	1	1
✓	(2,3)	0	0	0	1	–	
	(3,7)	0	0	–	1	1	2
✓	(7,15)	0	–	1	1	1	3
✓	(7,23)	–	0	1	1	1	
	(14,15)	0	1	1	1	–	
	(22,23)	1	0	1	1	–	

	x_4	x_3	x_2	x_1	x_0	
(15,31)	–	1	1	1	1	4
(23,31)	1	–	1	1	1	
(29,31)	1	1	1	–	1	

	x_4	x_3	x_2	x_1	x_0	
(0,1,2,3)	0	0	0	–	–	0
(0,2,1,3)	0	0	0	–	–	
(7,15,23,31)	–	–	1	1	1	3
(7,23,15,31)	–	–	1	1	1	

(0,1,2,3) – $\bar{x}_4 \bar{x}_3 \bar{x}_2$ e

(7,15,23,31) – $x_2 x_1 x_0$ f

(3,7) = $\bar{x}_4 \bar{x}_3 x_1 x_0$ a

(14,15) = $\bar{x}_4 x_3 x_2 x_1$ b

(22,23) = $x_4 \bar{x}_3 x_2 x_1$ c

(29,31) = $x_4 x_3 x_2 x_0$ d

	0	1	2	3	7	14	15	22	23	29	31
a				*	*						
b						*	*				
c								*	*		
d										*	*
e	*	*	*	*							
f					*		*		*		*

S_1 $$f = (\bar{A} + B) \cdot (\bar{A} + C + B) \cdot (A + \bar{C} + D)$$

AB \ CD	00	01	11	10
00	1_0	1_1	1_3	0_2
01	1_4	1_5	X_7	X_6
11	1_{12}	1_{13}	1_{15}	1_{14}
10	0_8	X_9	0_{11}	X_{10}

a)

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

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

14	1	1	1	0	1
15	1	1	1	1	1

b)

AB \ CD	00	01	11	10
00	1_{0}	1_{1}	1_{3}	0_{2}
01	1_{4}	1_{5}	X_{7}	X_{6}
11	1_{12}	1_{13}	1_{15}	1_{14}
10	0_{8}	X_{9}	0_{11}	X_{10}

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

c) $f = \sum(0, 1, 3, 4, 5, 12, 13, 14, 15)$

	x_3	x_2	x_1	x_0	
0	0	0	0	0	0
1	0	0	0	1	1
4	0	1	0	0	
3	0	0	1	1	2
5	0	1	0	1	
12	1	1	0	0	
13	1	1	0	1	3
14	1	1	1	0	
15	1	1	1	1	4